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Higher Education in the Arab World

Building a Culture of Innovation and Entrepreneurship

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Contents

Introduction

Adnan Badran, Elias Baydoun, and John R. Hillman

Abstract In a series of 16 chapters, this book reviews the concepts and processes required to promote and inculcate a culture of innovation and entrepreneurship in the higher-education sector. If the Arab world is to participate fully in the global knowledge economy, it requires its universities and related institutions to realise the full potential of their staff and students and to embrace opportunities for wealth creation and social advancement. Drawing on their experience, the 23 authors provide specific advice on intellectual property, university-associated business and science parks, the quality and societal relevance of teaching and research, leadership, administrative improvements to develop compensation models, opportunities for innovation, and interacting with wider society to deliver start-up businesses and links with industry and commerce. The roles of governments to facilitate innovation and entrepreneurship are also considered.

Keywords Arab universities · Innovation · Entrepreneurship · Intellectual property · Knowledge economy · Science and technology parks · Business schools

Participation in the globalised market economy and reaping the benefits of wealth creation and improving the quality of life means that all countries must invest in innovation, creativity, and entrepreneurship. Reliance on exports of natural resources or low-cost labour will condemn populations to poverty. Universities should and must play a leading role in this economic and social transformation.

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For a variety of reasons, the Arab world has not properly participated in the knowledge-based economy despite a healthy number of institutions of higher education and relatively high proportion of young people. We regard universities as the key factor in the transition of Arab economies to full participation in the global economy as well as offering peaceful social advancement from the manifold challenges they currently face. As a consequence, the Arab Academy of Sciences decided to switch focus from addressing major scientific issues to focus on the future of Arab universities. In 2018, we produced "*Universities in Arab Countries: An Urgent Need for Change"* (ISBN 978-3-319-73110-0) published by Springer. This was followed in 2019 by "*Major Challenges Facing Higher Education in the Arab World: Quality Assurance and Relevance"* (ISBN 978-3-030-03773-4) in the same series. As in our previous publications, this present volume on analysing how to build a culture of innovation and entrepreneurship in Arab higher education is based on an annual conference of the Academy involving international experts.

The geo-political importance of the Arab world should not be underestimated. As we stated before, the Arab region comprises a land area of 13 million square kilometres, stretching from its westerly edge at the Atlantic Ocean to its easterly edge at the Arabian Sea, and from the southern edge of the Mediterranean Sea south to the Horn of Africa. There are 22 Arab countries with a population of around 423 million in 2019 according to worldpopulationreview.com. The Gulf countries are major exporters of oil and gas and have substantial sovereign wealth funds. Most Arab countries, however, are classified as underdeveloped with widespread poverty, unemployment and underemployment, and political instability. Some Arab counties are suffering the depredations of war, attempted cultural genocide, population displacement, and minorities placed under pressure. No Arab country functions as a liberal democracy with strong public finances, robust civil-society institutions, and free markets. The entire region is projected to suffer negative impacts of global climate change, an aspect dealt with in our 2017 Springer publication "*Water, Energy & Food Sustainability in the Middle East. The Sustainability Triangle"* (ISBN 978-3-319-48919-3) and Chap. 6 of this volume.

Despite the sobering and challenging foregoing observations, a rapid expansion in the numbers of institutions of higher education, including universities, has taken place in the region in recent years alongside a substantial increase in the numbers of graduates. High levels of graduate underemployment and unemployment bear testament to a lack of quality assurance (QA) and limited curricular relevance to societal needs in many universities, hence the emphasis we placed on independent detailed quality-assurance reviews and analyses of curricular relevance for all levels of education. Fortunately, higher education in the Arab world is on an upward trajectory with widespread recognition and adoption of QA processes, the development of greater accountability to stakeholders, cross-border recognition of qualifications, establishing international links and initiatives, and addressing the specific concerns of staff and students. Lifelong learning, new forms of delivering information, links with industry and commerce, and an emphasis on research and development (R&D) are all being actively pursued by many Arab universities.

In this volume, a group of 23 international authors explore the background, concepts, principles, and aims underpinning the economic and social needs for innovation and entrepreneurship, and the pivotal role that universities should have in facilitating the societal impacts of their education and research. The chapters cover international perspectives, recommendations, and advice on stimulating innovation and creativity, as well as specific examples of fostering innovation in the Arab world. To date, the Arab world has a poor record of generating wealth-creating patents and copyright, contrasting with its Islamic Golden Age between the eighth and fourteenth century BCE when the region was the most culturally, scientifically, and economically advanced part of the known world.

Chapter 2 (*Hillman & Baydoun*) reviews the concepts of universities and their societal roles, and considers the definitions of innovation, creativity, and entrepreneurship. It argues that innovation and entrepreneurship can be taught in the right circumstances. The personal qualities needed to be an entrepreneur are described. An account is given of intellectual property (IP), especially patents and copyright works, together with its regulation in different jurisdictions, registration, defence, and exploitation. Governments have a pivotal role in facilitating start-up companies and the ease of conducting business. Also important is their interaction with international bodies such as the World Trade Organization and Trade-Related Aspects of Intellectual Property Rights (TRIPS), the Organisation for Economic Co-operation and Development, and World Intellectual Property Organization. Governments should assist this crucial phase of university development by a combination of adequate education and research funding together with setting up national technology foresight and related exercises, participating in regional initiatives to establish large-scale research and development facilities, and promoting competition. The main routes to successful delivery of university-derived IP arise from a melding of quality assurance, societally relevant teaching and research, accreditation, university-based and university-associated business and technology parks, and business incubators and similar structures alongside business schools. Even so, much depends on the quality, energy, experience, attitudes, and contact network of those leading these structures, and those of the associated academic staff. The roles of banks, venture capitalists, business angels, IP lawyers, and accountants in establishing a business are described, and the role and design of business plans outlined. Worrisome aspects of IP theft are described although there is little prospect of preventing it at this juncture in international relationships. Opportunities arising from the raft of transformative technologies under development are described, along with opportunities arising from international trends in convenience, fashion, design, entertainment, and diet. Climate change and the problems of water, energy, and food security offer huge opportunities for university-based innovations in STEMM subjects (science, technology, engineering, mathematics, medicine). Challenges come from (a) the level of competition; (b) dominating position of the US and Chinese tech giants absorbing talent and finance; (c) venture capital based mainly in the US and Europe; (d) US Supreme Court ruling on the patentability of software; and (e) problems of doing business in the Arab world and its attitudes to research and development (R&D) and innovation. The overview ends with guidelines on establishing a business or company, and special features to consider when doing so in the Arab world. An appendix details advice for IP guidance for staff and students, plus supplements to institution-supplied laboratory and other notebooks with instructions for (a) recordkeeping required for accreditation and IP litigation; (b) code of institutional practice; (c) institutional quality plan; (d) standard operating procedures; and (e) equipment logbooks.

Can universities in the Arab region become the engines for knowledge and innovation? In Chap. 3 (*A. Badran & S. Badran*), entrepreneurship and innovation have become the motive force of the knowledge economy for handling economic growth as well as instability in the twenty-first century. Startup companies for commercialized delivery of R&D are driving economies to compete globally in the marketplace. Although the Arab region houses more than 800 universities, the culture of building knowledge and innovation is lacking. Higher-education institutions in the Arab region may have the infrastructure and resources to support a culture of innovation, but they are not operating in synchrony to develop the necessary critical mass and remain fragmented institutions operating in isolation, while others lack proper governance processes and sound management of financial and human resources enabling them to move ideas of students and faculty to maturity. In this weak environment, institutions are not adapting effectively of transitioning from the current culture of traditional university "business as usual" into an entrepreneurial and innovative climate. To remedy the situation, institutions of higher learning need to set a policy of change to adapt the institution toward the R&D culture and to develop proactive collaborative partnerships to spark innovative ideas, incubate them in catalysing environments, and attract business firms for employing a well-educated workforce, opening new opportunities of employability, and creating wealth by value-added enterprises to raise the GDP of nations. Examples are given of initiatives in Jordan and Turkey.

Creating a culture of innovation and entrepreneurship in universities is discussed in Chap. 4 (*McKellar*). Such a culture may have two important objectives: (a) to create that culture within the academic and professional staff of the institution thus engaging the business community more effectively; (b) to incorporate the innovation and entrepreneurship of current students and recent graduates. In the US, high-growth businesses have been shown to have upwards of 95% graduate employees, 45% of whom also hold advanced degrees. In contrast, businesses that lag behind in productivity in the UK have been shown to be those with fewest graduates.

Graduates are clearly good for business and the economy, and their contribution can be enhanced further by specific enterprise and entrepreneurship education. Enterprise education might effectively change the mindset or attributes of a graduate toward improvement and innovation; this could lead to the creation of new business or improvement within a business or in a broader community, society, or environment. It is best embedded fully within curricula and can be effectively taught through experiential action learning. It is applicable across all disciplines and subject areas. Entrepreneurship education should confer the skills, knowledge, and attributes helpful for the establishment of a new business. It can be taught by traditional educational methodology including didactic lectures and may comprise bolt-on modular sessions. It is most often taught specifically within a business school and embraces essential libertarian philosophy about the freedoms to create wealth in private sector enterprise. The case supporting 'teaching' or 'education' in either enterprise or entrepreneurship is strong although it may be more appropriate to use terms such as 'nurture' or 'encourage' since both are likely to reap more fertile rewards in those already inclined towards them by culture and upbringing.

Education has evolved from that which mainly exercised the mind to think and reason with no particular objective outcome, to education for the professions, initially medical, theological, and legal but now much more comprehensively, to vocational education with sandwich and placement periods contributing to practical work-based learning, to experiential learning with simulated environments within universities and now almost by way of full cycle to degree apprenticeships and accreditation of work-based activity. As occupations evolve, and in some instances disappear, it is going to be important that vocational education embraces intellectual flexibility and effectively incorporates enterprise and entrepreneurial education to deliver a more productive society.

Science parks are considered in Chap. 5 (*Parry*) in the context of facing the next industrial revolution. That entrepreneurship gives science its modern economic value means many universities and research institutes have created Science and Technology Parks (STPs) to share the risk of starting a business by offering a range of facilities and services to micro and small companies that are trying to commercialize science in its widest sense. These are specialist locations and to make them effective in achieving their most commonly held objective of creating clusters of innovation, they need to build capacity in business incubation and its derivatives in business acceleration. In so doing, they must understand the motives and challenges that face the entrepreneurs they attract, and take a wide role in building networks that include a regional role that supports economic development in collaboration with their host organisation. This involves building a management and governance structure that is relevant to the prevailing business conditions and then ensuring their offering to entrepreneurs helps add value at a commercial level. This chapter reviews these aspects of STP planning, development, and operation. It is a fact that all the world's leading universities have STPs or similar structures.

Climate change is an existential threat to much of the Arab world with dire environmental, economic, and social consequence unless urgent mitigation and adaptation steps are taken. In Chap. 6 *(Hillman & Baydoun*) opportunities for innovation and entrepreneurship to address the existential challenge of climate change are reviewed, focusing on two themes. (a) The processes and strategies to mitigate the effects of projected climate changes arising from global anthropogenic greenhouse-gas emissions, and (b) the future security of food, water, and energy specifically in the Arab Middle East. It is appreciated that implementation of these changes will be dependent on peaceful and politically stable conditions. Also, the Region is connected to neighbouring countries and shares the atmosphere with the rest of the world so there is a need for concerted multilateral action. All forward projections are subject to numerous uncertainties including the advent of conceptually new forms of disruptive technology and the adaptive capacity of Arab nations. Although the timing and quantification of risks are unclear, a prudent approach is essential to safeguard financial stability of international markets and national economies. Background information is presented on greenhouse gases, fossil fuels, and renewable energy. Climate-change predictions at the general level and specifically for the Arab region are outlined, along with mitigation and adaption strategies and climate engineering. Specific processes and strategies for the Arab Middle East are discussed with detailed proposals for agriculture and food security, water security, energy security, industrial biotechnology, social development, carbon storage and trading, and global biodiversity. The United Nations Sustainable Development Goals are considered in relation to climate change, followed by examination of the terms sustainable and sustainability. Finally, international climate-change negotiations and agreements are briefly reviewed.

In Chap. 7 (*Morcos & Khneisser*) intellectual property rights (IPRs) are defined and described, covering in greater detail trademarks, copyright, patents, industrial designs, and geographical indications. The various protections and rights are detailed along with consideration of the relevant international law. IPRs in the Arab world are discussed followed by the crucial issues of confidentiality, infringements, and remedies. Various improvements to the IPR system are recommended.

Building the entrepreneurial mindset through experiential learning is described in Chap. 8 (*J. El-Sayed*). Entrepreneurship is a key factor in any nation's economy. In the U.S., start-up businesses are a primary driver, if not the primary driver, of both job growth and new job creation. Successful entrepreneurs have a unique entrepreneurial mindset that allows them to be successful. This mindset includes both knowledge and skills. Entrepreneurial knowledge includes business acumen like finance, product development, and marketing. Entrepreneurial skills include visioning, problem solving, creativity, risk taking, and communication. To be successful, entrepreneurial knowledge and skills must be honed through experience. Using academic reverse-design methods, higher education can create pathways that not only develop entrepreneurial knowledge and skills but also provide intentional experiential-learning opportunities to refine them into a successful mindset. This chapter presents the process for building the entrepreneurial mindset in higher-education students through the application of integrated experiential-learning techniques. A case study is provided to illustrate the process.

Building a culture of innovation and entrepreneurship through holistic development in higher-education institutions in the Arab world is considered in Chap. 9 (*M. El-Sayed*). Innovation is defined as the action of creating new ideas, products, or processes etc.; creativity is the ability to produce and perform such innovative actions. The continuous nurturing and development of the innovation ability could result in creativity as a cultural attribute. In general, most creativity-inspiring efforts are focused on cognitive abilities, creative thinking, and creative problem solving. These efforts view creativity as a rational cognitive domain process. Fewer efforts address the affective aspect of creativity by focusing on the attributes and motivations of creative individuals. Limited efforts share the process thinking with the cognitive group and the affective aspect of creativity by emphasizing the human desire for fulfilment and self-actualization. Entrepreneurship is the process of realizing an enterprise from inception to maturation. Depending on the enterprise and prevailing environment, the entrepreneur must have the affective entrepreneurial drive in the form of passion, motivation, or willingness to take risks to initiate, propel, and complete the process. In addition, the entrepreneur must have the entrepreneurial abilities in the form of the knowledge and skills necessary to discover, assess, and seize opportunities.

The learner's development in higher-education settings, including those in the Arab world, is mainly focused on cognitive-domain development. Additionally, cognitive-domain development is mostly focused on the analytical abilities with limited attention to integrative abilities. Furthermore, due to the ever-shrinking educational resource and the lack of opportunities for practice, more emphasis is usually given to theoretical knowledge than skill building in the field of practice. In industrial and technologically advanced societies, the skill building in the learner's field of choice is usually provided by the employers at early career phases. Also, the existence of industrial and technological infrastructures inspires the integrative desire and abilities needed for creative and entrepreneurial activities.

To build a culture of innovation and entrepreneurship in the Arab world, a gradual shift towards a more holistic higher-education system is essential. Consequently, balancing the learner's cognitive-domain integrative and analytical development would be a necessary step in the right direction. Also, as evident from the nature of innovation and entrepreneurship, the affective drive is a key factor for success in both endeavours. Accordingly, nurturing and developing the learner's affective domain is another vital step towards motivating the desired cultural change. Furthermore, balanced cognitive development and nurtured affective drives without the skills needed for practice in the learner's chosen field may not be enough to achieve desired results. Therefore, the development of the learner's psychomotor skills is of equal importance in the realization of the desired innovation and entrepreneurship culture.

In Chap. 10 (*Abu-Orabi, Al-Zoubi, & Aladwan*), Arab higher education is described as going through a period of transition and transformation characterised by poor quality and fragmentation. Universities have endured a series of setbacks manifested in the destitute state of scientific research. Evidence on the performance of Arab higher education, scientific research, and innovation show limited impact on socio-economic development. The concept of internationalisation of higher education and how this may present a small window in the path towards modernizing higher education, reforming universities, and empowering research and development is described.

An important aspect of academic integrity is the focus of Chap. 11 (*El-Muwalla & A. Badran*). Plagiarism is considered one of the most sensitive issues in academia. Indeed, the increase in the number of research projects conducted worldwide has made awareness of scientific honesty and knowledge of the culture of non-plagiarism a topic of utmost importance for educational institutions and fundamental to underpinning successful innovation and entrepreneurship. Nevertheless, cases of plagiarism are still recorded, intentionally or unintentionally. To this end, multiple software systems, such as Turnitin are used to detect plagiarism. Although the use of this software has become common practice in educational institutions, there are conflicting views associated with the benefits accrued from its implementation. This chapter reviews some of the supporting and opposing views associated with the use of this software, and considers how this medium can encourage scientific research of demonstrable integrity and facilitate its publication and potential exploitation.

Innovation and entrepreneurship have direct relevance to achievement of several of the United Nations Sustainable Development Goals (SDGs). In Chap. 12 (*Hamdan*), it is noted that advances in education, higher education, and information and communication technology are rightly considered to be great achievements of human endeavour. Such advances are expected to enhance aspirations essential to meet a number of the 17 SDGs set by the United Nations General Assembly in 2015, in particular SDG4: “Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all”. Needless to say, education is a fundamental goal that contributes to fulfillment of several other goals of equal importance. As such, higher education is a major factor in poverty alleviation, SDG1: “End poverty in all its forms everywhere”, through enhancing job opportunities, SDG8: “Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all”. Indeed, it has been demonstrated that illiteracy and poverty are two major factors that produce poor health and poor social development, SDG3: “Ensure healthy lives and promote well-being for all at all ages”. It is also known that low literacy impacts on mortality and quality of life. In this chapter, fundamental changes in education and higher education are outlined, particularly in innovation and entrepreneurship that are needed in order to contribute to the achievement of the SDGs. In this context, some ethical considerations are discussed, and some exemplary SDG4 innovative projects are presented.

The financing and operation of medical schools presents challenges worldwide. In Chap. 13 *(Cortas*) it is noted that the rapid pace of breakthroughs in discoveries and technology during the last half-century disrupted traditional medical-education systems. Tuition fees increased at the Faculty of Medicine in the American University of Beirut, growing from $700 per year in 1960, increasing by 2.24-fold in 30 years, by 12-fold in the next 10 years (1990–2000), while as a result of intervention, by 1.30-fold in the following 10 years, and 1.64 fold by 2019. A 55-fold increase in tuition occurred from 1960–2019 while the Lebanon GDP purchase power parity increased by about two-fold in the same period. This diminished greatly socioeconomic diversity, reduced significantly the potential pool of applicants to medicine, weeding off potential skill and talent, and changed the character of the profession. Recruiting the number of faculty members required for the changes implemented after 1991 would have necessitated an unsustainable increase of tuition fees by 1999.

As of 1995, a full strategic assessment defined clear goals and targets aligned to the missions of education, research, and patient care, focusing on human needs of all stakeholders with the objective of undertaking a major transformational restructuring that made each grow in a financially sustainable manner with a defined timeline. A Medical Practice Plan was adopted in 2002 as the centerpiece of medicine’s recovery plan, be the locomotive that drives growth and sets the foundations for growth and financial sustainability. The plan resulted in recruitment of professional change agents and physicians that increased patient workloads and revenues significantly per year as of 2002 and beyond, improving efficiency of the medical institutions. Although this chapter focuses on the major transformational changes, 1999–2009, that built the foundations, made a quantum leap forward, set the stage and developed a trend that continues to date, the experience may be helpful to the plethora of emerging universities in the Arab world and elsewhere.

Illinois Institute of Technology's experience in synthesizing a culture of entrepreneurship in its engineering curricula is outlined in Chap. 14 (*Anderson & Murad*). The authors make the point that competing in the modern world will not look like it did when the major manufacturing industries were shipbuilding, steel mills, oil refineries, and automobile manufacturers. What will the oil-exporting countries do when their wells go dry? What happens when new industries must compete against the American, German, Korean, Chinese, and Japanese companies long established with strong balance sheets, global customers, and attractive income statements? It is not too late to begin a major cultural change in universities. While this chapter addresses engineering applications, similar issues must be faced in law schools, medical schools, and business schools.

In Chap. 15 (*Zabalawi, Toglaw, & Alsarheed*) the Australian College of Kuwait (ACK) is used as a case study of the part played by faculty members in building an entrepreneurial culture in higher education. The field of entrepreneurship education has witnessed accelerated advancements in the last two decades with a trend towards a university-wide education. This chapter investigates the role of faculty members in ACK as a case study and a role model in applied education and Project-Based Learning (PBL). Then it explores the involvement of faculty members in college activities and teaching methodologies that promote a culture of entrepreneurship. Finally, it sheds the light on the personal attributes and qualities of instructors that promote entrepreneurial behaviour among the students in the college.

In Chap. 16 (*Omar Asem*) the Kuwait Institute for Scientific Research (KISR) is used as a case study for R&D challenges and opportunities in the Arab world. The Arab World has witnessed enormous growth in the past two decades in the establishment of universities and specialized research centers. Over the years, the R&D models in developed countries have undergone radical changes in terms of emergence of new institutional structure and governance, establishment of science parks, technological incubators, centers of research excellence and industrial clusters based on best practices and technologies developed by the R&D sector. However, many countries in the Arab World now have a vision that is, largely, in-line with modern global trends and based on knowledge planning. Since its establishment in 1967, KISR focused its R&D efforts in petroleum, techno-economics, oceanography and aquaculture, environment and agriculture, water resources, and building materials. More recently, the energy sector was included to conduct applied research in renewable energy, energy efficiency, and nanotechnology. Many of KISR's research recommendations outcomes were adopted by the government of Kuwait and the private sector. These include the establishment of a renewable energy park, Petroleum Research Center to serve the oil-sector companies, a water research center to assist the Ministry of Electricity and Water and commercialization of locally produced desalinated water from shallow beach wells using technology developed by the institute, in addition to establishment of protected areas, rehabilitation of damaged lands, enhancement of marine biodiversity, and aquaculture of local and other fish.

Nevertheless, research institutions in developing countries, such as KISR, face several challenges, including insufficient government R&D funding, difficulties in attracting and retaining experts and young scientists due to lack of market competitiveness, and inadequate client contributions to R&D activities. Moreover, commercialization of research outcomes has been a strategic drive; however, its implementation has been met with many challenges by the government due to the lack of a legal instrument, which caused delays in establishing these specialized companies. Political pressure has also created some hindrance to move forward in the development and funding of international strategic alliances. It has become obvious that the role of R&D in national development is not clearly understood and/or supported by the legislative sector creating uncertainty at the decision-making level. This is generally reflected in the relatively lower per cent allocation to R&D in the GDP. The outlook of KISR for 2020–2030 is to direct its R&D activities towards achieving the 'Knowledge Economy', seeking business opportunities based on its long R&D experience and expertise, driving the spirit of its staff and cultivating the culture of entrepreneurship, as well as developing a second line of leadership and young scientists.

Chapter 17 (*Bashir*) provides a perspective from the Arab world on the critical factors needed to achieve a successful technology-transfer model. Technology transfer in universities has always been akin to deployment and realization of research discoveries as market products capable of addressing technological challenge(s). In developed countries, various technology-transfer models have been introduced and adopted, and they are still evolving with measurable success. Whilst here in the Arab world, adopting a technology-transfer model that can effectively contribute to the overall innovation ecosystem is still underway with a few emerging successful study cases and stories. Now, there is a greater need than ever to capture the value of the universities' research discoveries and intellectual capabilities and transform their outputs to the betterment of society. Hence, it is becoming critical to develop a technology-transfer model that can support innovation in the Arab world capable of, not only addressing technological challenges, but also advancing the entrepreneurial and innovation ecosystems. Universities in the Arab world operate differently and exist in different jurisdictions from other parts of the world. With this understanding, this chapter highlights some common challenges that these universities, despite their operational differences, face in developing a working technology-transfer model. Challenges such as intellectual-property laws, policies, and progressive partnerships are addressed, and recommendations are provided on how these challenges can be resolved.

There is a valid argument that Arab universities will never realize their full potential for innovation and entrepreneurship as well as contributing to social advancement and well-being until and unless there are marked improvements in the standards of university governance on the one hand, and parallel changes in the standards of governments on the other. After all, national governments ultimately determine the operating environment for universities and can deliberately or unwittingly constrain and even damage development and competitiveness of both higher education and thereby the national economy. Through their taxation and funding policies and through their other economic and social policies, governments also directly affect the quality of universities, the relevance of their teaching and research, graduate employability, and the extent to which innovation and entrepreneurship can flourish. For some autocratic governments, unrestrained and intellectually buoyant universities represent a threat to their existence. Of the diverse forms of government in the world, liberal market-based economies have provided the best operating environments for universities and for their graduates and postgraduates. Political and economic stability coupled to free speech and strong measures to control corruption are of paramount importance to the efficient functioning of universities in the global knowledge-based economy. Most Arab governments face tremendous pressures simply to fund the most basic of services so rapid transformation is unlikely. Nonetheless, a development trajectory can be set for the future, and the developed world has a responsibility to assist as reasoned in the chapter "*Quality Assurance and Relevance in Academia: A Review*" in the book "*Major Challenges Facing Higher Education in the Arab World: Quality Assurance and Relevance*" mentioned above. Poorly governed and administered universities fail their staff, students, funders, and society at large; indeed, some institutions do not warrant the title university for they lack the crucial features (independently accredited quality assurance and relevance of teaching and research, demonstrably competent staff, adequate resources and facilities, efficient administration, etc.) of a modern-day university.

Our next volume will consider the issues of university governance, the roles of government, and the interdigitation between academia and government. Finally, we acknowledge with gratitude financial assistance from the University of Petra, Jordan. We thank Margaret Deignan of Springer for her guidance, help, and continuing support, and Joelle Mesmar for assistance with processing the manuscripts.

Innovation, Creativity, and Entrepreneurship in Academia: A Review

John R. Hillman and Elias Baydoun

Abstract This overview complements our two previous reviews on the future of Arab universities and on quality assurance and relevance in academia published in this Springer book series. It encompasses the concepts of universities and their societal roles, and considers the definitions of innovation, creativity, and entrepreneurship. It argues that innovation and entrepreneurship can be taught in the right circumstances. The personal qualities needed to be an entrepreneur are described. An account is given of intellectual property (IP), especially patents and copyright works, together with its regulation in different jurisdictions, registration, defence, and exploitation. Governments have a pivotal role in facilitating start-up companies and the ease of conducting business. Also important is their interaction with international bodies such as the World Trade Organization and Trade-Related Aspects of Intellectual Property Rights (TRIPS), the Organisation for Economic Co-operation and Development, World Intellectual Property Organization etc., and international indices such as the World Competitiveness Index. Governments can assist this crucial phase of university development, but should not interfere with universities, by a combination of adequate education and research funding together with setting up national technology foresight and related exercises, participating in regional initiatives to establish large-scale research and development facilities, and promoting competition. The combination of quality assurance, societally relevant teaching and research, accreditation, university-based and university-associated business and technology parks, business incubators and similar structures, alongside business schools, represent the main routes to successful delivery of university-derived IP. Even so, much depends on the quality, energy, experience, attitudes, and contact network of those leading these structures, and those of the associated academic staff. The roles of banks, venture capitalists, business angels, IP lawyers, and accountants in establishing a business are described, and the role and design of business plans outlined. Worrisome aspects of IP theft are described although there is

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little prospect of preventing it at this juncture in international relationships. Opportunities arising from the raft of transformative technologies under development are described, along with opportunities arising from international trends in convenience, fashion, design, entertainment, and diet. Climate change and the problems of water, energy, and food security offer huge opportunities for university-based innovations in STEMM subjects (science, technology, engineering, mathematics, medicine). Challenges come from (a) the level of competition; (b) dominating position of the US and Chinese tech giants absorbing talent and finance; (c) venture capital based mainly in the US and Europe; (d) US Supreme Court ruling on the patentability of software; and (e) problems of doing business in the Arab world and its attitudes to R&D and innovation. The overview ends with guidelines on establishing a business or company, and special features to consider when doing so in the Arab world. An appendix details advice for IP guidance for staff and students, plus supplements to institution-supplied laboratory and other notebooks with instructions for (a) record keeping required for accreditation and IP litigation; (b) code of institutional practice; (c) institutional quality plan; (d) standard operating procedures; and (e) equipment logbooks.

Keywords Innovation · Creativity · Novelty · Originality · Entrepreneurship · Universities · Research institutes · New growth theory · State and free-market capitalism · Intellectual property · Patent · Copyright · Business school · Business park · Technology park · Transformative technologies · STEMM subjects · Quality assurance · Relevance · Arab world

1 Introduction

Institutions of higher education including universities are undergoing profound change as a result of a combination of factors. These include competition for funding, competent students, and outstanding staff; financial viability; investments in equipment and facilities; imposition of external quality-assurance (QA) and relevance assessments; creation of, adaptations to, and exploitation of numerous transformative technologies; the need to provide value for money; and safeguarding or improving their reputation [1, 2]. Modern universities have an implicit social contract with their students, sponsors, and host nation, primarily to provide employable well-qualified and skilled graduates and postgraduates to populate the private sector and public services. Increasingly though, they are expected to demonstrate the other component of social relevance, namely to emulate well-known research universities and advanced research institutes by (a) generating intellectual property (IP) including patents and copyright works, (b) developing valuable know-how, and (c) interacting positively with existing and start-up businesses. As centers of scholarship and intellectual activities, they should be centres of innovation, creativity, and entrepreneurship. The very act of research should expand understanding and open up opportunities for innovation. Matching expectations with reality is more problematical in some countries than others. The Arab world poses unique challenges.

Globally, never has so much money been spent on research and development (R&D) in both the public and the private sectors, and never have there been so many scientists, engineers, technologists, and academics. In some areas of scholarship, there is evidence of oversupply in view of the extent of unemployed and underemployed graduates and postgraduates that are unable to adapt to market requirements or demonstrate innovative and entrepreneurial attributes. Never have there been so many bureaucrats analysing and controlling research grants and administering research. Never have there been so many people engaged in quality assurance and performance rankings of research-based organisations. Never have there been so many huge databases, or numbers of academic publications, or numbers of patents and copyright works. In the international and competitive knowledge-based economies, the need for ownership, control, and exploitation of IP drives further spending on R&D in both the public and private sectors. And so it goes on. Most appreciate that it is not simply a matter of throwing money at generating IP without having specific plans and strategies. In particular, at the heart of these plans is selecting the right people who conceive the ideas and innovations as well as appointing dynamic and, in particular, effective leaders. Possession of a high intellect does not guarantee wise decision-making. More profoundly, is the world really getting value for money for its investments, and is there a relative decline in the efficiency of innovation using the current models for supporting research and development (R&D)? More specifically for the Arab world, when will it start to match developed countries for generating globally important IP? What cultural behaviours account for its under-performance? Our view is that innovation and Entrepreneurial behaviour are unstoppable; humans have a constant drive to seek the truth and to acquire knowledge. As evidenced by historical achievements and the achievements of the Arab diaspora, Arabs in the appropriate environment are undoubtedly as capable as others for creating and exploiting valuable IP for the betterment of the Arab world and globally. The transformation to the appropriate environment starts in the universities and their host governments.

In understanding why the Arab world has been largely disconnected from active participation in the development of the globalised knowledge economy, despite the involvement of individual Arabs in other successful economies, it is clear that inter alia there is a structural problem with Arab universities in addressing societally and economically important issues relating to innovation, creativity, and fostering entrepreneurship. Arab universities tend to produce bureaucrats [3] as well as graduates that are unemployed, unemployable, and under-employed (over-qualified or inappropriately qualified for the jobs they hold). Nearly all the Arab universities have been ponderous and slow to adapt whereas they should be agents of societal change for the better, transforming lives in their host countries. Arab governments tend to be autocratic; civil-society institutions are weak; there is widespread poverty with insecure access to water, food, and energy; social unrest is widespread; hard and soft infrastructures are inadequate; and some countries are in a state of conflict [4]. A metamorphosis or transformation as profound as that occurring in the development of some members of the animal kingdom is required in both the universities and their respective government ministries (especially finance, education, industry, and employment). They have to change what they are doing and reconfigure for the Arab world to adapt and play a full role in the global knowledge-based economy.

Lessons can be learned from elsewhere. The 36 member countries in the Organisation for Economic Co-operation and Development (OECD) are mainly countries classified as developed and industrialised [5]. Their economies are increasingly based on knowledge and information compared with those economies that are reliant on the extraction of natural resources and traditional industries dependent on manual labour. Knowledge in its various forms across all disciplines provides the motive force for new industries and economically influential activities, productivity growth, and economic growth. Accordingly, the OECD regards the roles of information and communication technology (ICT), other technological advances, and learning to be pivotal in determining economic performance. The term "knowledge-based economy" arises from this fuller recognition of the place of knowledge in societal development.

The OECD is not alone in wishing to understand the dynamics of the knowledge-based economy and its relationship to traditional economics, as reflected in the "New Growth theory" or "Endogenous Growth theory" and the pioneering work of Robert Solow and Paul Romer [6, 7]. The growing codification of knowledge and its transmission through communications and computer networks, in addition to the formation and analysis of extremely large data sets ("Big Data"), are leading to the emerging "information society". The need for workers to acquire a range of skills and to continuously adapt and update these skills underlies the "learning economy". To facilitate the advancement of knowledge and technology diffusion requires better understanding of knowledge networks and "national innovation systems". Most importantly, new issues and questions are being raised regarding the implications of the knowledge-based economy for employment and the role of governments in the development and maintenance of the knowledge base.

According to Economics Online [6], a central proposition of New Growth theory is that knowledge is not subject to diminishing returns, unlike land and capital. The details provided in this reference are enlightening. In essence, knowledge is the key driver of economic development. In order to develop, therefore, economies must transition from an exclusive reliance on physical resources to expand their knowledge base, and support those institutions that help develop and share knowledge. Governments must invest in knowledge in all its forms mainly because individuals and firms at present do not necessarily have endogenous incentives to do so. For example, while knowledge is of intrinsic merit, and its acquisition does not deny anyone else or organisations that knowledge, its usefulness to individuals and industries and companies is clearly undervalued, and yet knowledge has been demonstrated countless times to generate economic growth. Government should, therefore, invest in human capital, and the development of education in general and skills specifically. It should also support, perhaps by various types of partnership, private-sector research and development (R&D) and encourage inward investment, which will therefore introduce new knowledge. Because investment in social capital is subject to market failure, New Growth theorists argue that government should allocate resources to compensate for this failure (e.g. develop new vaccines for impoverished societies). Essential utilities (especially electricity, gas, and water) are natural monopolies and in many countries are provided directly or indirectly by the public sector. However, if these utilities are under-supplied due to inadequate public funds, or mismanaged, both the private sector and society at large will suffer and growth and well-being will be limited. This is because the industrial sector relies on energy and water for production and distribution, without which it will not produce efficiently or competitively. The accumulation of private capital, therefore, depends up the correct level of expenditure by government. Similarly, New Growth theorists argue that government should also finance, or seek finance for, infrastructure projects, such as broadband and telecommunication networks, and road, rail, sea, and air transport. Such communication-related projects involve the creation of quasi-public goods, and the theory of market failure suggests that they would be 'under-supplied' without government involvement. The huge fixed costs and the difficulty of charging users prevents the private sector delivering the service adequately, and the state may choose to act like a producer and low-cost financier, and provide necessary legislation and co-ordination of these infrastructure projects. These projects also generate positive externalities, and as such justify government involvement. For example, an improved infrastructure improves the quality of life across all sectors, enhances productivity, increases the likelihood of tourist revenue, as well as reducing production costs. The issue of foreign governments or their proxy "private companies" constructing and owning strategically important infrastructure facilities (including agricultural land) is becoming commonplace in several poor countries, raising geopolitical concerns, not least when there is no reciprocity.

In order to address the many roles of higher education in contributing positively to the knowledge economy, university leaders and university sponsors should consider in detail the Twenty-First Century Skills Framework [8]. Formal education must now focus on new skills and attitudes ("future-proofing") required for the realities of the modern knowledge-based enterprise economy. In summary, individuals are required who have awareness at least, or functionality, of more than a few of a remarkably lengthy list of diverse skills that encompass: global awareness; financial, economic, business, and entrepreneurial literacy; civic literacy; health literacy; creativity and innovation; critical thinking and problem solving; communication and problem solving; communication and collaboration; information literacy; media literacy; ICT literacy; flexibility and adaptability; initiative and self-direction; cultural and cross-social skills; productivity and accountability; leadership and responsibility; and environmental literacy. We can think of no university that deliberately structures its curricula to deliver this cohort of skills, or polymath individuals that possesses all of them, but note the mention of innovation, creativity, and entrepreneurial literacy. To this long list of desirable attributes, it should be borne in mind that it is proving difficult to measure skills involving critical and creative thinking, and emotional and social intelligence [9]. Moreover, there are five major transitions that make historically based thinking and thereby conventional curricula obsolete [10]: (a) the urban-population transition whereby the majority of the global population now resides in cities and has increased purchasing power compared with their former rural existence; (b) the nutrient transition with demands for new foodstuffs and a greatly increased consumption of animal products and other high-value often processed foods; (c) the agricultural transition that brings almost all of the arable land into agricultural food and fibre production; (d) the energy transition from cheap fossil fuels to renewable-energy resources; and (e) the climate transition of increasing temperatures, weather perturbations, and increasing variability in water supplies and growing conditions for plants. In our opinion, these transitions are exacerbated by a combination of global population growth taking place at different rates in different countries; political instability affecting several developed and undeveloped countries; and prospects of international financial crises and trade disputes. In the oft-cited 2016 'Future of Jobs Report' by the World Economic Forum [11], the claim was made that the world is at the beginning of a Fourth Industrial Revolution with developments in genetics, artificial intelligence (AI), robotics, nanotechnology, 3-D printing, biotechnology etc., all interacting and amplifying one another. These technology-based developments are disruptive forces challenging existing industries, creating new products, changing patterns of consumption, and reshaping patterns of employment. They are therefore socio-economic and geopolitical drivers of change. We agree with this claim and in a previous chapter [see Table 2 in reference 4], we updated and enlarged on these technologies that we describe as societally transformative. Universities should now appreciate and adjust for the fact that employers are now looking for candidates with cognitive flexibility, judgement and decision-making skills, emotional intelligence, critical thinking, creativity, and ability to carry out complex problem solving. Many employers are either unwilling or cannot afford to train and educate graduates and postgraduates to contribute meaningfully to the economic performance of their organisations. They find most graduates and postgraduates are not "employer-ready", an indictment of the education they have received (and possible misselling on the part of the university as the value of a degree, or a misconception on the part of students as to the quality and relevance of the education offered by the university). In addition, there are too few entrepreneurs produced by universities.

2 What Are Universities and What Are They for?

Universities are usually defined as institutions of higher (tertiary) education and research, and act as repositories and custodians of scholarship and its advancement. They have powers to grant various forms of academic degrees, and conduct undergraduate and postgraduate education. They tend to hold both tangible (physical) and intangible (non-physical) assets [12]. They should enjoy academic freedom and be bastions of free speech, normally have a system of staff tenure of various types of job security, and are distinct in various ways from the society surrounding them [2, 13]. The term "academia" used in the title of this chapter refers to institutions, typically universities, concerned with studying and thinking in the pursuit of education, research, and the advancement of scholarship and its employees are described as "academics" [14].

With regard to the level of distinctiveness from the societies that surround them, they have variable levels of autonomy from their host government, and autonomy can be expected to be one of the drivers of inter-university competition. Autonomy also allows universities to manage their organisational arrangements, set standards, and select areas of study. Individual academics are able to research and develop new, sometimes societally challenging, concepts. Some universities in North America and Europe are troubled by the "snowflake" generation of student, those that are molly-coddled, easy-to-offend, hypersensitive, politically correct, and through self-censorship diminish free speech and enquiry.

Many Arab governments must perceive universities to be a threat because they severely constrain university autonomy not only by restricting funding but also by direct interference in the structure, appointments, and management of these institutions. Inter-university competition is impeded on the one hand, and the potential contributions universities can make to society hindered on the other. Most Arab universities are financially stretched; few figure in international ranking tables. Under such circumstances, academics can tend to behave as if they are civil servants. Many western governments have respected university autonomy but the advent of digitisation and other transformative technologies and actions related to the New Growth theory outlined above, mean that governments need to invest in fostering the knowledge economy. This is achieved by investing in pioneering R&D, often in conjunction with industry, as well as supporting other aspects of undergraduate and postgraduate education, in so doing there are understandable sensitive issues over autonomy compounded by the use of taxpayer's resources and the need for accountability. In future, major advances in STEMM (science, technology, engineering, mathematics, medicine) subjects will need underpinning government support because there is market failure to support longer-term innovation, and to synthesise new datasets, and maintain collections of living specimens and inanimate objects essential for the advancement of scholarship.

Globally, there is an enormous variation in the size, wealth, reputation, impacts on society, period of existence, and stability of universities. Their numbers are increasing and some are transnational. Collectively, they are big business and some leaders enjoy corporate-like lifestyles. Many universities attempt with varying levels of success to embrace the tenets of quality assurance (QA) and the relevance of their operations to society in general as well as to specific professional groups. Some universities focus on their research and have relatively small numbers of undergraduate students whereas other universities offer largely vestigial postgraduate education. There are various ownership models in both the public and private sectors; if private, that may be simply profit-generating businesses or act as a charitable organisation reinvesting profits in the institution. New models of ownership and operation are emerging as a result of digitisation and access to freely available online courses. Governments usually place direct or indirect obligations on universities to meet QA standards.

The rapidity of technological advancement means that no university can be expected to teach all subjects, or to teach to a uniformly high standard. Growing numbers of unemployed or underemployed graduates and postgraduates are manifestations of irrelevant education as well as a waste of time and resources. For much of the Arab world, the social contract those universities responsible for producing the unemployed and underemployed have with society and government, admittedly largely unwritten at this juncture, is failing. No wonder governments, students, parents, sponsors, and the public are becoming more demanding in their expectations of the value for money, quality, and relevance of the education and research offered by universities. Access to international ranking tables, opinions, and bibliometric data on the Internet are assisting interested parties to assess universities. Nonetheless, there is a general paucity of data about the real competence of universities in fostering innovation and entrepreneurship. Some universities try to buy academic esteem by enrolling eminent academics and their academic records on their staff but without those individuals and their teams relocating, i.e. a form of academic prostitution that has yet to be exposed properly by the ranking organisations. Another aspect that needs to be investigated more widely is the quest by staff members to publish their work and improve bibliometric performance, thereby increasing the likelihood of promotion and gaining tenure, actions that are approved by universities as they seek to improve their standing in ranking tables. With notable exceptions, current performance metrics mean that the urge to publish overrides opportunities for wealth creation and entrepreneurship, two attributes that will be of greater societal benefit to the host country. This attitude is changing as governments rightfully expect universities to be the "engines of economic growth" and universities need additional resources. For this to happen, though, governments must reconsider the way they interact with universities, starting with properly considered policies and having the quality of civil servants both capable and willing to implement those policies. The so-called "dead hand" of the civil service and the downsides of a public-sector ethos (e.g. excessive bureaucratic controls, suppression of innovation and resistance to change, lack of concern over national economic growth, continuing interference in operational R&D, micro-management of projects by incompetent senior civil servants, repeated demands for time-consuming and diversionary reviews etc.) afflicts all countries. At its best, the public-sector ethos is intrinsic to civilised society, with fairness, integrity, and competence at its heart. Academics wishing to publish ought first consider whether the information in the proposed publication is worthy of IP registration or wealth creation in another form. Perhaps this could be the responsibility of a section head, and the process should not affect academic freedom per se nor institutional autonomy as it is essentially an advisory step. IP registration only delays rather than stops publication. Where the university is dependent on government funding then it can be argued that the academic member of staff has a duty to investigate whether the work has potential benefits beyond simply publishing another journal paper. This is now the time when the formal relationship between the university, supervisor, and student should be properly defined in writing and include sections on innovation, entrepreneurship, and arrangements for revenue-sharing in the event of creating valuable IP. The World Intellectual Property Organization posts excellent advice online [15], and there are many examples of best practice, e.g. University of Leicester, UK [16a, b].

3 Innovation, Creativity, Novelty, Originality, and Invention in Universities and in Society

Innovation and creativity are closely aligned and variously defined. Hitherto [4], we defined innovation as the product or outcome of creativity. Both terms refer to the introduction of something new. Innovation can refer either to something entirely new or to a change, sometimes just a minor tweak made to an existing idea, product, process, or field of endeavour. Invention is closely aligned to novelty (the quality of being original) and usually refers to something entirely new; for example, types of musical composition, a lie or falsehood, a discovery hitherto unrecorded, or indeed any product of the imagination [4, 17]. Some regard creativity as less tangible than innovation, such as an idea, theory, or figure of speech – creativities that cannot be registered as copyright, but it extends into real innovation with a new musical composition or other works of art [18], whilst appreciating that in music and works of art, fashionable opinion (hence valuation) dominates. As we stated [4], in our opinion and contrary to the opinion of others [e.g. 19], creativity does not have to be useful and/or valuable; just think of many aspects of modern lifestyles. The term "innovation" has been applied to new ideas, products, algorithms, processes, concepts, diverse services, technologies, business models, and reorganisation systems. Such innovations do not always infer an improvement such as an increase in efficiency, value for money, or more sustainable use of resources. They could be the opposite but may be fashionable. Innovation and creativity can seemingly be spontaneous (and sometimes presented as such) but on further analysis normally arise from pre-existing knowledge and from conducting orderly R&D. Creativity is said to involve refashion things or ideas [20] by bending, breaking, or blending: bending refers to altering existing properties (e.g. artificial organs); breaking refers to assembling something new from existing parts of a whole (e.g. shotgun DNA sequencing); and blending refers to a mixing of multiple sources together in new ways. Ideas can come from diverse sources; in our academic experience especially from technicians and students asking apparently simple questions challenging assumptions and scientific dogma. Those individuals who can take ideas from one area of life or discipline and adapt and apply them to another are particularly prized. They also break down the almost impregnable "silos" of conventional academic disciplines that can inhibit novelty and original thinking. At its basic level, creativity has been described as a manifestation of human social development with an evolutionary premium on communication and social intelligence [21]. This common-sense reasoning emphasises the roles in creativity and innovation of teams and groupings of people, and explains why centres of scholarship, towns, and cities are at the forefront of socio-economic growth and development, generating the so-called "cluster effect". Agrarian and nomadic societies are rarely rich sources of innovation and creativity. It is axiomatic that creativity thrives in an environment where there is the freedom to make mistakes without retribution, and where rare or even unique attributes and abilities will be encouraged irrespective of social norms of appearance or unusual behaviour. The best environment for creativity is a positive one that builds self-confidence rather than an environment encouraging continuous harsh reviews and negativity so often noted in academia under the guise of "critical reviews" that lack constructive suggestions. In our careers, we have noted incidents of when substantially more time has been taken on thinking and disparagingly criticising why an experiment or building a prototype should not be done (often under health and safety, and precautionary-principle concerns) rather than on actually carrying it out and learning from any mistakes. Universities should be the birthplace of experimentation and innovative ideas and products, and where entrepreneurial behaviour is the norm; at present, they are not.

The degree of novelty can vary from the most minor short-lived invention or idea to a complete reshaping of the international economy bringing in its wake wide-ranging political and social consequences. Some innovations improve bureaucratic and business efficiency. Most of the transformative technologies we listed in Table 2 of our previous review [4] are giving rise to an explosion of innovations, businesses, and major advances in scholarship. Many of these technologies and innovations integrate different technologies with fashion and behavioural changes, e.g. smartphones and the social media. Universities need to evaluate the effects (both positive and negative) of these transformative technologies on democratic processes and governance. Innovation can bring about profound disruption to existing businesses and organisations, and consequently to significant proportions of the population. Comparison of the main stock-market listings over the past three decades demonstrate that several major companies have severely contracted and even gone out of business because they did not create, acquire, adapt to, and exploit innovation. Their leadership was clearly inept and deficient. Whole countries can be impoverished if their wealth-creation model cannot adapt to the changing realities and expectations of the market and the knowledge economy. For the most part, civilian-based innovation empowers the consumer, making life easier and/or more interesting, yet in the longer term, life may be made more complex and social interactions changed in deleterious ways.

Fresh thought needs to be given to the conduct and funding of research. Most of the world's research in universities is carried out through the medium of training research students, a trend that is also beginning to develop in specialist research institutes. Much bureaucracy is involved in awarding relatively small amounts of money of periods that rarely exceed 3 years, wholly inadequate to launch entirely new lines of research and give sound research training. Establishing teams is especially challenging. By way of example, in the UK, the research councils that once focused on major scientific issues are for the most part dissipating large numbers of relatively small individual grants, using funding that could be more efficiently and less wastefully used by individual universities with less administrative churn. Universities must have a large measure of autonomy and not be bound by the strictures of dealing with large numbers of projects, each of which requires reporting to external bodies. If a research project is nationally or regionally important, it should be properly funded over a period of up to a decade before detailed retrospective review, and provided with an accomplished leader, a critical mass of expertise, and facilities. It should not be left to the whims of relying on research students. This recommendation would facilitate effective innovation and, in an appropriate environment, entrepreneurship, too.

4 What Is Entrepreneurship and What Is Its Role in Liberal Free-Market Democracies?

According to the Online Business Dictionary, BusinessDictionary.com, entrepreneurship is defined as the capacity and willingness to develop, organise, and manage a business venture along with any of its risks in order to make a profit [22]. The most obvious example of entrepreneurship is the starting of new businesses and companies. In economic analyses, entrepreneurship combined with land, labour, natural resources, and capital has the potential to produce profit. Profit refers to the surplus remaining after total costs are deducted from total revenues; it can reduce liabilities, increase asset values, and provide resources for further investment. Entrepreneurial spirit is characterized by innovation and risk-taking, and is an essential part of a nation's ability to succeed in an ever changing and increasingly competitive global marketplace. We believe that it may soon be the factor determining the success of universities. To this definition, we make the point that making a profit is sometimes not the main driver, as is witnessed with the energy and commitment of social entrepreneurs who have a higher motive to improve the lot of less-fortunate people and communities but have an important position in the marketplace. Some entrepreneurs are deeply committed to an invention or process and are willing to make financial sacrifices in order to achieve recognition in other ways.

Entrepreneurs, even if they are not exclusively motivated by the prospect of a period of monopoly or near-monopoly profits, facilitate the processes of innovation, marketing, and commercialisation. In free-market-based economies, competition means that newer better inventions and processes supersede older existing ones. The best operating environments for innovation and entrepreneurship are liberal democracies with freer decentralised economies and robust functioning largely free markets that enable individuals to retain their liberty [23]. For the past 300 years, virtually all the gains in reducing poverty, improving the quality of life, addressing excessive social and wealth inequality, and successfully introducing new technologies originated in liberal free democracies with capitalist markets and freedom of speech. In this chapter, we define capitalism as a complex economic and political system based on private rather than state ownership of the means and operation of the means of production. From this commonly used definition arise the concepts of private property and ownership, pricing systems, competitive markets, voluntary exchange, market-determined wages and salaries, and capital accumulation. Absolute free market forms of capitalism have largely given way to mixed-market economies that operate with varying degrees of state interaction and regulation, usually to introduce welfare policies and to reduce the likelihood of exploitation, corruption, market failures, and socio-economic inequalities. Undeniably, markets need checks and balances to eliminate corruption and its associated rent-seeking behaviour, exploitation of the innocent, monopolistic behaviour, and enrichment using quasi-legal manipulation of questionable moral rectitude unbalancing the relationship between justice and the law. At present in all countries, these checks and balances are not being adequately applied as the huge international so-called "tech giants" and other rent-seeking organisations headed by the "elites" rapidly expand and exert political and financial pressures on national economies. As a back-reaction to growing inequalities, there is worrying recent evidence of populations clearly ignorant of history beginning to favour illiberal political parties that support "populism" policies such as fascism and national socialism that gave rise to dictators; nationalisation; collectivism; communism; and poverty-inducing autarky (self-sufficiency leading to isolationism). All of these policies with their self-selecting elites and imposed common goals have been tried and failed dismally, largely because they miss individualistic and competitive market dynamism. To be successful, governments have to maintain democratic values, challenging as they can be from time to time, and allow intellects, creativity, and wealth-creators to blossom. At the same time, they should squash market abuses such as corporate monopolies and rent-seeking behaviour; after all, criminals are often highly entrepreneurial. We support the analyses in The Economist of September 15th 2018 – *The Economist at 175. Reinventing liberalism for the 21st Century* – in maintaining a healthy competitive meritocracy in a market economy, and the continual reform and upgrading of policies on taxation fairness, health, welfare, education, planning, and immigration [23]. Parenthetically, the term free market used in this chapter and by many authors more generally in reality refers to a mixed-market economy in democratic societies where governments provide a legal framework and intervention to ensure high standards to prevent market failures, prevent abuse (e.g. monopolies, rent seeking, reduce negative externalities of excessive and harmful consumption), and provide social safety-net programmes.

Internationally, various forms of dictator-run state capitalism are challenging free-market rules-based capitalism. Major companies in countries such as China, Venezuela, Vietnam, Cuba, some ex-Soviet Union countries, and Russia are controlled directly by the state. These countries are mercantilist i.e. the state regulates and oversees the entire economy and aims to maximise the nation's strength by (a) limiting imports by imposing tariffs and other restrictions and (b) maximising exports [24]. It is an old-fashioned policy closely aligned to imperialism. In Russia's case, state companies may be used as political weapons (e.g. the way their energy companies are dealing with Ukraine and Georgia) rather than being engaged in real innovation, growing market share, and being entrepreneurial. In China's case, dystopian socialism-cum-Marxism has given way to several attributes of capitalism enabling a dramatic transition from widespread poverty to a dynamic wealth-creating economy, although control of the economy and its major businesses are under the direct control of the political leadership, as are many aspects of societal behaviour. There are legitimate concerns over the accumulation of debt from Chinese no-questions-asked high-interest loans to its overseas client states, many of which are democratically deficient but rich in natural resources and other strategic assets (e.g. ports, agricultural land etc.), as well as its equity-for-debt demands ("debt-trap diplomacy"). State capitalism can exist to varying extents in otherwise liberal democracies. Most countries try to safeguard their defence industries. Norway is effectively a benign state-capitalist country, and in countries like France the state interferes in and tries to protect some of its large non-defence-critical companies. Governments in free-market economies such as the USA and UK fund R&D initiatives with private companies and keep in close contact. It may be, but unlikely, that some of the state-capitalist dictator-run economies are merely in transition from a centrally controlled planned economy to the free-market condition, and their current condition and behaviour reflects the implementation of Keynesian policies. In future, the extent to which winner-takes-all, no-holds-barred state capitalism and rules-based free-market capitalism can co-exist will determine the progress of civilisation. In all economic and political systems, there is a tendency to favour incumbent businesses and companies over dynamic, often technology-based disruptive newcomers.

There are also legitimate concerns over whether market-friendly liberal democracy can adapt quickly enough so that individual freedom can be sustained in the face of imposed beliefs and elite-controlled economic systems. Trade wars over tariffs between free-market and state-controlled economies are complicated by collateral damage to industries, companies, and supply chains until a modus vivendi is attained. Amongst other reforms to liberal free-market economies, the excessive financialisation of economies needs to be addressed. This is where the financial sector greatly exceeds other sectors in the gross domestic product (GDP) of a country, and where resources are concentrated not on manufacturing and other entrepreneurial-driven economic activities for wide socio-economic benefit but on financial manipulation, money lending, domestic housing, and commercial buildings in a type of expropriating rent-seeking activity [25, 26], thereby misallocating resources yet creating a different form of elite. Few of these elite people suffered in the 2007–2008 global financial crisis although some bear personal responsibility. The financial crisis also exposed the failure of leading economists to foresee the disaster, reliant as many are on linear economic extrapolations and mathematical models replete with assumptions, omissions, and "unknowns" without allowing adequately for the complexities of human behaviour, impacts of natural and man-made disasters, climate change, and destabilising political interference. Financialisation and the behaviour of leading companies are becoming undesirable developments, diverting human endeavours from innovation, creativity, and entrepreneurship that underpin the drive for improving life for all. Other financially related areas that urgently need scrutiny are (a) those company executives that load their companies with massive levels of debt but enrich themselves with inflated salaries and bonuses while imperilling the company's pensioners; the shareholders, non-executive directors, and regulators are failing in their duty; (b) company mergers and acquisitions to eliminate competitors and carry out asset stripping as opposed to greater efficiency; (c) shortcomings and abuses of automated high-frequency share trading and shorting of borrowed shares; (d) avoiding taxes by placing profits in overseas tax havens; (e) abuse of IP or marketing licensing systems that are used to transfer profits from a country to lower-tax administrations or tax-havens; (f) regulation of tax havens and legal and accountancy firms involved in transnational asset transfers; (g) the role of the main international accountancy organisations and the credit-rating agencies and their accountability and culpability in financial crises; (h) individuals and organisations involved in online fraud; (i) the role of the central banks; and (j) the various types of market regulators. A summary of these concerns for innovators and entrepreneurs is given in Table 1.

There can be little doubt that there is a widespread developing crisis of capitalism that should be the basis of free markets. Democracy is being undermined. These markets are clearly beginning to be rigged to favour the owners and controllers of capital – the elites of the democratic world. There is increasing centralisation of markets in the hands of a few monopolistic companies that have diffuse ownership and tax-avoiding bases in tax havens. Abnormally high profits are being extracted, demonstrating that countries are failing to control oligopolistic behaviour because of political influence and carefully crafted protectionist policies. In many countries, the share of a nation's GDP issued to labour is declining along with productivity growth, highlighting the lack of competitive pressures to innovate, become more efficient, and offer true value for money. Without tough regulatory controls, modern capitalism is in danger of bringing in its wake an age of surveillance, not only where personal data are mined for the benefit of a select band of elites, but where state actors could introduce an updated version of Jeremy Bentham's (1748–1832) eighteenth-century panopticon, an institutional construction of control. In dictator-run societies lacking proper democratic values, social-media-derived forms of surveillance have more sinister implications for restricting personal freedom and access to accurate and comprehensive information. Democracies are further imperilled by political failure to strike the right balance between taxation and spending, weakening both public finances and essential public services they support. In democracies as well as countries aspiring to be democracies, innovation and entrepreneurship can be stimulated by (a) making it more difficult to obtain patents and copyright (reducing their number and complexity), restricting their duration, and make it easier and cheaper to challenge them; (b) eliminate anti-competitive practices such as requiring licences to open businesses, except for a sharply reduced number of certain key professions; (c) forcibly breaking up overly large companies; (d) monitoring and constraining lobbying of politicians; and (e) ensuring the operation of a free press and broadcasting system with protections for investigative journalists. This drive for competition will restore faith in capitalism and markets.

Table 1 Financially related issues of concern to innovators and entrepreneurs

Financialisation of economies causing short-termism and misallocation of resources that constrain innovation and entrepreneurship
Economic expropriating rent-seeking behaviour, as with high interest rates, and multiple transaction costs when financial companies merge or are taken over
Many of the major financial companies are still considered "too big to fail" and their executives "too big to jail". Most of their executives did and do not create wealth but were appointed to their positions through contact networks
Reckless and greedy company managements that build up debt but extract massive personal rewards and imperil futures of their staff, pensioners, and the company. The role of remuneration committees, and ignoring shareholder calls for salary and bonus constraints on board executives
Low levels of investments in innovation from profits made by most companies
Failure of accountants, regulators, non-executive directors, and major shareholders to control rogue or reckless company executives, as well as allow questionable accounting practises
Company mergers and acquisitions designed to close down competitors and carry out asset stripping
Covenant-light corporate loans
Vulnerabilities of high-frequency share trading and "borrowing" shares for shorting (short selling)
Tax avoidance by abuse of IP and licences to transfer profits to low-tax countries or tax havens
Tax havens and legal and accountancy firms involved in aspect of tax avoidance morally tantamount to tax evasion
Overly complex taxation systems that underpin otherwise unnecessary expensive expert accountants and lawyers to minimise tax payments
No-compensation failures of the credit-rating agencies
Vulnerabilities arising from the return of sub-prime mortgages, collateralised debt and loan obligations, and 100% mortgages
Foreign-exchange rate rigging
Shadow banking by non-banks
Competencies of those central banks in dealing with (a) fiat currencies (as nearly all currencies are); (b) bubbles of public- and private-sector debt; (c) regulating complex derivatives; and (d) dealing with quantitative easing by central banks
Replacement of the London Interbank Offer Rate (LIBOR) and potential global financial instability and disconnection between the assets and liabilities of the major banks
Online fraud and cyber attacks
Unfair trading practices, trade wars, and protectionist policies
A patronage system comprising the exchange of goods, services, and information essentially for political support, often in complex, hard-to-penetrate, and fundamentally corrupt relationships (clientelism)
Roles of the major government-related entities (the sovereign wealth funds) that deal with government-related investments (e.g. public-sector pension funds, foreign-exchange reserves, natural-resource-related assets etc.). They shape markets by affecting valuations, liquidity, governance, and access to capital. Some are used more aggressively
Ultimately, political failure to constrain corporate conduct by implementing a combination of tough regulation, encouragement of competition, and effective litigation. Lobbying, enforced arbitration, inadequate fines, overly powerful executives, and complicit shareholders need to be specifically addressed

What are the personal characteristics needed to be an entrepreneur? Clearly, entrepreneurship is a mind-set that underpins social progress. Successful entrepreneurs possess the qualities of perseverance, resilience, optimism, resourcefulness, independence of thought, excitement at forging new approaches to business, and an acceptance of ethical risk so evidently missing from large sectors of society that want governments to shoulder virtually all forms of risk, giving rise to a risk-averse mass-dependency culture. We stress ethical risk-taking because criminals and potential and actual criminals are also risk-takers. In our experience, most scientists in the public sector (including universities and research institutes) tend to be somewhat risk-averse, narrow-minded, imbued with certain public-sector attitudes, and unadventurous. They are encouraged to "focus" on relatively narrow areas of scholarship. These characteristics are reinforced by hyper-complex risk assessments, overly bureaucratic health-and-safety regulations, and inappropriate performance metrics, collectively suppressing the excitement of science specifically and the pursuit of knowledge generally. Above all, entrepreneurship represents change to the status quo, and in respect of this chapter, change is desperately needed in Arab academia and Arab societies.

Inventors may not be the best people to be entrepreneurs and rarely make the best entrepreneurs who in contrast tend to be financially and market astute. Inventors, especially those in academia, have tended to possess a single focus and lack essential business "nous" (sensu intuitive thought, practical intelligence, common sense, ability to navigate successfully opportunities and challenges). There are a few exceptions to this general view but the principle holds true.

In our private survey of generally accepted internationally highly regarded entrepreneurs, it is striking how few are academics, and how little influence university degrees had in their successes. This begs the question of the role that universities might play in raising the culture of entrepreneurship. More generally, can innovation, creativity, and entrepreneurship be taught effectively in universities? The answer is yes when there is the appropriate environment. After all, the existence of families of innovators, creators, and entrepreneurs demonstrate the value of the right environment. It is not a simple matter of "genetics" (although as life scientists we think the genes x environment (GxE) factor could conceivably be relevant but must await detailed genomics research) but one of an environment having entrepreneurial demonstration, an appropriate vocabulary, awareness, values, and opportunities. If universities appoint staff with relevant demonstrable skills along with a good contact network; use eminent guest lecturers; offer students workplace and studio placements; operate an effective business school; and have an on-site or linked business park and business-incubator facilities, then their social relevance will start to meet societal expectations. In our experience, staff members and students demonstrating entrepreneurial abilities can induce jealousy in their colleagues who are more concerned about equality of reward regardless of inequality of contribution and originality. Universities can be surprisingly resistant to change even when the stark realities of bankruptcy, poor quality, and irrelevance loom.

5 Governments Must Promote Innovation and Entrepreneurship

The biggest impedances to introducing and marketing innovation of all types may come from governments (especially those of a nationalistic and protectionist type), and to a lesser extent from civil-society pressure groups, organisations that feel threatened by the competition, as well as certain religious and political organisations. Thus, (a) laws may be changed or re-interpreted to ban certain innovations or activities; (b) resource-sapping legal and other challenges may be mounted against inventors, entrepreneurs, and companies introducing the innovation even if it is known that the challenges would fail, they are still economically damaging usually without redress, and curtail enthusiasm; (c) pressure can placed on retailers and other business customers as illustrated in campaigns by environmentalists against genetically modified foodstuffs irrespective of the scientific evidence of human and environmental safety; (d) massive discounting and advertising can be used on existing products in order to undermine sales of the innovation; or (e) competitors may be bought out and closed down. Virtually all technologies are met with some form of resistance or questioning, sometimes for good reason because virtually all technologies can be used for good or ill so their use needs to be reviewed and restricted if necessary. Other times and most usually, the resistance is simply regressively prejudicial.

All governments would like to reassure their people that all policies are based on sound evidence. This is an aspiration rather than reality. Hitherto, we have made the point that the formulation and implementation of evidence-based policies to regulate the application and exploitation of technologies are dependent on politicians with their advisors and civil servants having a working knowledge of STEMM subjects and their potential. Rarely is this the case, as the truism that perception (no matter how wrongheaded and based on ignorance) prevails over reality, especially given the power of the broadcast and social media. Academia should therefore play a major role in investigating the potential impacts of technologies as well as in their creation, and advise governments accordingly. Another major impedance to the introduction of new technologies or refinement of existing ones is the Precautionary Principle [27] when aggressively utilised by pressure groups and politicians who are variously and openly anti-science, anti-modernity, anti-experimentation, anti-corporations, anti-western, anti-American, anti-wealth creation, and anti-progress. They express volubly excessive concern about "unintended consequences", ownership of intellectual property, health and safety, and effects on the environment. Their concerns are not assuaged by (a) highly detailed risk assessments; (b) detailed health and environmental monitoring (including containment facilities); (c) legislation that can force the dismantling of monopolies and/or rent-seeking economic behaviour; or even (d) legal systems that harshly punish transgressors. These campaigners usually fail to distinguish between R&D and entry into the marketplace, dismissing the amount of time and expense involved in reduction to practice and proof of concept. We recognise, however, that many pressure groups and campaign-ing politicians are essential to help society and governments address wholly legitimate concerns over certain types of business practice, products, pollution, other environmentally damaging developments, dreadful building developments, combatting and adjusting to climate change, and conservation and protection of habitats and natural flora and fauna. Our concerns are that conversion of an innovation into society can be unjustly severely impeded, or more probable stopped, by energy-sapping excessive, time-consuming, and pointless bureaucracy that compounds the difficulties in addressing the usual legal complexities and garnering financial support faced by entrepreneurs. Countries can be severely disadvantaged in a competitive world if their governments fail to create and implement evidence-based policy.

Parenthetically, governments should review the fact that personal data, mostly accessed freely and often unwittingly from consumers and especially computer users, have now become the basis of the vast economic capital and huge competitive advantage of a few Silicon-Valley-based companies and a few politically well-connected Chinese companies, as they buy out or swamp competitors and create a socio-economic imbalance that urgently needs to be corrected [28], see also Sect. 16 Challenges. Recent reports attest to a decline in the pre-eminence of Silicon Valley as an innovation hub [29], and innovation is getting harder as the so-called tech giants mop up potential competitors and highly competent staff. Fortunately, the concept of business and technology parks, business incubators, and similar structures are becoming integral to the modern university, not least, because judgement is being passed on the social effectiveness of universities. Governments can help them succeed either directly and/or with the aid of effective market regulators able to prevent monopolies and market abuse (see Sect. 11 Science, Technology and Business Parks; Business Incubators; Technopoles' and Science Cities).

Ideally, governments should have knowledge-related evidence-based policies associated with customer-friendly administrative and funding structures as well as policies that offer robust consumer protection to help stimulate the acquisition and exploitation of knowledge and thus innovation. Robust consumer protection will help assuage concerns over any potential downsides of introducing new technologies and products, although they will never be adequate for those that invariably resent change. Such is the rapidity with which transformative technologies are progressing that governments need to modify or even introduce new policies at short notice. This means having competent and knowledgeable advisors and civil servants – all too rare in our view. Governments and their citizens can compare national adaptations to change by consulting several international innovation-related indices such as the World Competitiveness Index of the World Economic Forum [30] and the Global Innovation Index [31].

Arab governments and those in charge of Arab universities and research institutes demean and disrespect their innovators and entrepreneurs by failing to address the malign effects of corruption in all its guises [2, 4]. Special praise is well deserved for those governments and universities that actively combat corruption and those individuals that successfully navigate working environments ill-suited to creativity, integrity, meritocracy, and free speech.

6 What Is Intellectual Property?

Intellectual property (IP) is a legal concept encompassing a wide range of generally intangible intellectual creations (Table 2). According to the World Intellectual Property Organization (WIPO), IP refers to creations of the mind such as inventions, literary and artistic works, designs and symbols, and images used in commerce [32]. Although IP is protected in law for stated periods, the challenge is to strike the right balance between the interests of the innovator or inventor and wider public interests that include the need to foster an environment in which innovation and creativity can flourish.

The World Trade Organization's (WTO) Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) is designed for member states of the WTO to set minimum standards for the regulation of many forms of IP [33]. For the first time, it introduced IP law into the international trading system. There is a move towards common regional and global patent licences e.g. European Patent Office (EPO) [34]. Even so, there is not universal acceptance of IP rights and certain countries are noted for their disregard of IP (see Sect. 9 Intellectual Property Theft).

To make life difficult and costly for inventors and entrepreneurs, there is great variability between countries as to specific IP requirements. For patents, the triple components of novelty, usefulness, and non-obviousness are seemingly straightforward but can be subject to whimsical assessments in some countries. In general, there is a tendency universally towards greater rigour, and applicants are advised to seek out countries with large markets and reliable legal systems in which to register their IP.

Employees, especially those employed specifically to conduct research or create copyrighted works, may be contractually forced to assign title of their patents, copyright, inventions, and related work to their employer. In our experience, most universities around the world do not have uniform policies with respect to their staff, students, and sponsors; most are extremely relaxed at present but the situation is likely to change so as to capture more resources for the host institution and improve

Table 2 Examples of intellectual property

Patents
Copyright (see Table 3)
Trade marks
Industrial design
Plant varieties and cultivars
Trade dress (appearance of a product, building, and/or its packaging
Trade secrets
Rights against unfair competition
Publicity rights

their reputation. Sometimes, delicate negotiations are needed between organisations to assign IP rights and any income.

It is a crucial feature of understanding modern economies that company valuations depend for the most part on intangible (non-physical) assets that are problematical to insure, even if there is declared IP ownership, possession of brands, claims of specialist know-how, and heavy investments in R&D.

The rapidly growing importance of IP for universities means that they must introduce policies that provide an environment that promotes innovation and its exploitation. This means having (a) business school; (b) technology or business park; (c) engaging with internationally recognised accreditation bodies to operate to ISO 9000 standards; (d) a quality plan with a quality manager and quality representatives; (e) a code of practice to conduct research; (f) an appropriate health and safety policy; (g) standard operating procedures; (h) equipment logbooks; (i) asset registers that include institutional IP and other intangibles; (j) have procedures to deal with IP funded by third parties; and (k), most important of all, having the right leadership and staffing (see Sect. 10 Basic Requirements for Universities to Demonstrate Successful Innovation and Entrepreneurship and the Appendix).

Applied plant, agricultural, and horticultural scientists attach importance to the protection of new plant varieties and cultivars (cultivated varieties). The International Union for the Protection of New Varieties of Plants (UPOV) was established by the International Convention for the Protection of New Varieties of Plants (latest revision 1991) with the aim to protect new varieties and cultivars with a specific IP right subject to meeting four criteria: novel; distinct; uniform – show homogeneity; and stable [35]. This has given rise to the concept of plant breeders' rights. The advent of genetic modification using biotechnological techniques has led to a consensus view of combining patents and plant-breeder's rights in order to facilitate the advancement of plant biotechnology [36].

Patents protect inventions and potentially useful discoveries. Trade marks protect distinctive words, phrases, symbols, sounds, and designs used in marketing. Thus trade marks identify and distinguish the source of the goods and services of one party from those of another party. As an aside, the British-related spelling is "trade mark" as two separate words, the Canadian usage is with a hyphen, "trade-mark", and the USA uses the single word, "trademark".

7 What Are Patents?

As a noun, patent refers to a government authority or licence conferring a legal right to a designated period specifically to hold sole rights to exclude others from copying, making, leasing, selling, or importing the invention. It is a form of intellectual property that gives a limited legal monopoly. As a verb, patent refers to the processes of obtaining a patent.

According to Businessdictionary.com [37], an invention is patentable if it is novel, useful, and non-obvious. Patent details are published for the benefit of others to learn and perhaps make a stepwise improvement or entirely novel invention. To receive a patent, a patent application must disclose all details of the invention so that others can use it to further advance the technology. Inventors attempt to think of all possible variants so as to capture entire rather than a single a segment of the putative market. In many countries, patentable items fall under four classes. (1) *Machine*: apparatus or device with interrelated parts that work together to perform the invention's designed or intended functions; (2) *Manufacture*: all manufactured or fabricated items; (3) *Process*: chemical, mechanical, electrical, or other processes that produce chemical or physical changes in the condition or character of an item; and (4) *Composition of matter*: chemical compounds or mixtures having properties different from their constituent ingredients.

In most of the world, patents and other forms of IP are granted on the 'first to apply' basis, with a protection period of 7 years (India) to 20 years (European Union). In the US, they are granted for 17 years on the 'first to invent' basis. Applicants have to provide clear evidence of being the first to make the invention and be prepared to be challenged by others claiming prior creation. Responsibility of identifying, locating, and suing the patent violators, however, rests solely with the patent holder; patent law provides only means of prosecution and determination of just compensation. Bearing this information in mind, universities must enforce rigorous methods of record-keeping to ensure date priority for registering IP. For STEMM subjects, laboratory notebooks must have comprehensive records of experiments, including their design, results, and statistical analyses, with each page dated and independently countersigned (see Appendix). An equivalent system needs to be implemented for other subject areas. There is sometimes debate over the ownership of these notebooks but if provided by the university, they should remain in the ownership of the university and kept securely. We recommend that each notebook should be numbered and have a detailed advisory foreword on keeping records, including computer records and specimens, and how to register IP using the university's or research institute's stated IP system.

Patents can be awarded to an individual, group of individuals, company, or other type of organisation. The division of rewards and responsibility between the patent holders is usually subject to separate legal agreements and is subject to employment contractual terms.

The expense in terms of time and money in registering and maintaining a patent, and in contesting a patent, or seeking redress for patent infringements can cripple small organisations and bankrupt individuals unless they enlist investors. Some cash-strapped research institutes and universities are unable to defend their IP so that ownership is acquired at little cost by other organisations that avoid paying the R&D costs. Some of these other organisations have deliberate predatory policies to seek out and challenge IP ownership they consider of value held by financially weak individuals and organisations, or buy out the IP at minimal cost. There are also organisations that scour the published literature in economically buoyant subject areas and try to extract IP almost invariably revealed by universities in their quest to publish and raise their performance ranking rather than consider wealth-creating possibilities. Careful thought has to be given to where the IP is registered, bearing in mind cost, size of the market, access to funding, quality of the legal system, and duration of the protection period in which to earn royalties.

Whereas in the USA, a patent covers all of the States, this is not the case in the European Union. A **national patent** can be applied for at a patent office in any EU country or for a **European patent** through the European Patent Office (EPO) [34], but a European patent needs to be validated by the national patent office in each country where protection is required. Depending on the country's law, translations may have to be provided or fees paid by a certain date.

It is arguable that patents are too easily obtained, especially by the major companies as they attempt to set up protectionist walls against competitors. Are many of the patents awarded truly novel, useful, and non-obvious? Lax patenting regimes act against competition, the motive force behind innovation and entrepreneurship.

8 What Is Copyright?

Examples of copyright are given in Table 3 and illustrate the diversity of this form of IP. Examples of intangibles not protected by copyright are given in Table 4. Many examples relate closely to the arts, social sciences, and humanities divisions of universities, although a surprisingly small proportion is actually owned by universities. In the quest for relevance and funding, this situation is likely to change.

Copyright is dealt with differently in many countries, but the principles tend to be similar. The following accounts consider the situation in the USA, then the European Union, then in the Arab world.

8.1 Copyright in the USA

The websites of the US Patent Office [38] and Wikihow.com [39] are excellent, and for introductory material the latter is especially useful. In brief, it makes the point that copyright affords the exclusive right to make copies of the protected work, sell it, and distribute it. Copyright also allows the creation of adaptations, translations, or derivative pieces from the work, performances, and displays. The exclusive rights are subject to limitations such as “fair use”, “first sale”, certain educational and non-profit uses, backup (archival) copies of computer programs, among other things. Others may be authorised by licence to exercise some or all the exclusive rights either for compensation or as a courtesy. Others cannot be prevented from making personal copies of sound recordings that they lawfully acquired, provided it is non-commercial use of the recording device. For works created in 1978 or later, a copyright generally lasts for the duration of the last living author’s life, plus an additional 70 years. If the work was made for hire, anonymous, or created under a pseudonym, the copyright lasts for the shorter of 95 years from the first publication *or* 120 years from its creation.

Table 3 Copyright examples

Literary works, including words and phrases
Music
Choreography
Graphics, logos, maps, atlases
Publicity rights
Moral rights
Sculptures
Motion pictures
Other audio-visual works
Derivatives of protected works e.g. sequels
Original compilations of facts, field guides, jokes, etiquette, eminent individuals etc.
Instructions
Architecture plans and drawings
Translations

Table 4 Examples of intangibles not protected by copyright

Facts or concepts
Domain names
Slogans
Systems or methods of operation
Names (including band names) or titles
Works created by the US government
Works in the "public domain", i.e., having an expired or void US copyright
Ideas, dependent on the way they are expressed in writing or otherwise

There is no longer any need to renew a copyright. Works published in or after 1964 automatically have their maximum copyright term. Since the copyright to the creation will extend beyond a holder's life, consideration should be given to whom (individuals r organisations) the rights should be left. Ownership of US copyrights can be transferred to others by a written and signed document, but it will have the same duration as before transfer regardless of who owns it. Transfers may be recorded in the Copyright Office. Different rules for duration may apply to works first published in a foreign country.

Copyright can be registered with the U.S. Copyright Office by mail or online. Registration confers several advantages. A registered copyright is a matter of public record. Registered copyright holders receive a certificate of registration from the U.S. Copyright Office. Copyright must be registered before bringing a lawsuit related to infringement of the work. Works with timely registration may be eligible for statutory damages and attorney's fees if a lawsuit is won to protect the holder's rights. If the work is registered within 5 years of the first publication of the work, the registration is considered *prima facie* evidence, which puts the burden on the other party to prove that they had a copyright to the original work before the holder.

While a copyright notice is not required to protect copyright, it is a good idea to include a separate notice for several reasons. It may deter a would-be infringer from misusing the work. A notice is also helpful to sue an infringer for misusing the work. The infringer cannot argue that he or she did not know the work was copyrighted if the work bears a copyright notice. A copyright notice may also make it easier to collect damages in any potential infringement lawsuit. A copyright notice should contain: the word "copyright" or a "c" in a circle (©) as well as the date of first publication and the name of the owner of the copyright.

8.2 Copyright in the European Union

In the European Union, copyright officially comes under a general IP heading where IP consists of products, work, or processes created by the applicant and which can give competitive advantage [40]. There are 3 subcategories: (a) **industrial property**: inventions (patents), trademarks, industrial designs, new varieties of plants and geographic indications of origin. (b) **Artistic work protected by copyright**: original literary and artistic works, music, television broadcasting, software, databases, architectural designs, advertising creations and multimedia. And (c) **commercial strategies**: trade secrets, know-how, confidentiality agreements, or rapid production. As in the USA, IP can be protected by means of intellectual property rights (IPR) laid down by the World Intellectual Property Organisation (WIPO) [32]. The form of protection depends on the type of IP. **Copyright** informs others that the author(s) intend(s) to control the production, distribution, display, or performance of the copyright work. Copyright is granted automatically, with no need for formal registration, and the copyright symbol can be used immediately.

IPRs are still chiefly protected by national (member state) rather than EU laws. Defending them in each individual EU country can be complicated and costly. **Protecting IP at EU level can save time and money**. If business is conducted in more than one EU country, a European Union trademark and a registered Community design give protection in the current 28 Member States of the EU in one single registration. Trademarks or designs can be registered in any of 23 EU languages with a single application at the European Union Intellectual Property Office (EUIPO) [41]. At the time of writing, an online application costs € 850 for a trademark and € 350 for a Community design.

Counterfeiting (unauthorised imitation of a branded good) and **piracy** (unauthorised copying of an item covered by an IPR) have reached alarming proportions – with significant implications for innovation, economic growth, employment, and consumer health and safety. Depending on the law in the EU country in question and the source of counterfeit goods, the authorities to turn to are: customs, market surveillance (trading standards), the police, or the patent and trade mark offices. Customs administrations are clearly he front line of defence for IPRs at EU borders. Goods suspected of infringing IPR can be detained by lodging an application for action with the competent national customs authorities. While the request for assistance is national, requests deposited in one EU country may be granted the same legal status in all EU countries.

The EU is in the process of modifying its copyright legislation. Concerns are being raised by European parliamentarians, civil-society groups, broadcasters, and publishers about overzealous enforcement of copyright that curtails free speech, and exacerbates the fraught relationships between publishers and the tech firms, especially the US tech giants. There is a pronounced political drift in the EU towards greater control over the Internet, sometimes to prevent fake news, or to remove politically inflammatory hate speech, and to protect vulnerable individuals. There is also an element of protectionism, too.

8.3 Copyright in Arab Countries

There is an Arab Society for Intellectual Property [42] and individual countries make their details available on websites. According to Al Balushi and Hasna [43], books and other literary works are protected in the Arab world from the moment the work is created for the entire lifetime of the author plus 25, 50, or 70 years after his death. The majority of Arab countries protect books for the lifetime of the author plus 50 years after his death as a result of their international obligations under the TRIPS and the Berne Convention [44]. Bahrain, Morocco, and Oman provide a longer copyright term than the rest as a result of their signature of a free-trade agreement with the United States. The term could be more complicated for different kinds of works. For example, even though the majority of Arab countries protect photographs for the same duration as books, some countries provide a shorter term of protection for photographs that is calculated from the moment the photograph is taken or published. Users of copyright work in countries such as Bahrain, Morocco, and Oman are clearly disadvantaged by the longer terms in their countries because they have to wait for 20 years longer than their Arab neighbours before universities, students, and other users can legally copy, translate, and use old works. This 20-years difference can easily make sectors that rely on copyright, such as the education and entertainment industry, more expensive to operate than their neighbours. The authors make the point that copyright laws in the Arab world provide exceptions that allow users in certain circumstances to copy and utilise works without the permission of the author, but no Arab country has a "fair use" exception and the existing exceptions are limited and do not satisfy the needs of the users of creative works on the internet.

From our discussions, it is clear that Arab governments need to upgrade all components of their IP legislation and legal enforcement.

9 Intellectual Property Theft

For generations, good ideas and novel intentions have been copied, to the great advantage of recipient countries and aiding the advancement of society. Intellectual property rights in law are designed to provide benefit for the inventor or creator while details of the intellectual property are published for others to learn and make stepwise advancements. With the advent of the knowledge-based economy, IP has enormous value, and stealing it can save the expense and time of R&D costs and eliminates the competitive advantage of the inventor and the host country. According to the International Monetary Fund, deployment of foreign IP accounts for around 40% of the growth in labour productivity in emerging economies between 2004 and 2014 [45, 46]. The Soviet Union was notorious for stealing western IP and Russia remains a force in international economic and defence espionage. More recently, the focus has shifted on to China, the world's second largest economy, with its trading practices of forcing inward investors to share their IP with joint-venture Chinese partners, its blatant disregard of generally accepted international IP law, and high level of economic espionage. As the possessor of half of the world's IP, the USA is understandably reviewing its relationships with other countries over the use of its IP, and European countries are also concerned about the haemorrhaging of their IP. China with its massive population and enormous state-capitalist economy is beginning to generate its own state-of-the-art IP, and in any case is proving resistant to amending its trading practices. Virtually all countries are focusing on the knowledge economy with its base in intangibles (products of the mind). IP owners have to contend with the reality of (a) intangibles already cross borders in modern trading systems; (b) most of the IP firms employ nationals from countries noted for ignoring international IP agreements; (c) there can be complex transnational supply chains; (d) details of most IP are easily accessed on the Internet; critical information can be obtained from students, academics, suppliers, and freelance experts working in concert with headhunters; (e) reverse engineering; (f) using intermediaries to steal critical hardware; and (g) complex networks of client companies and countries can collectively bypass conventional IP law. Ideally but infeasible at present would be a multilateral rules-based agreement on IP recognition, registration, pricing, appeals system, and enforcement.

10 Basic Requirements for Universities to Demonstrate Successful Innovation and Entrepreneurship

Fundamental to all institutions demonstrating societal relevance of their education and research activities is a competent leadership group of senior staff that is both knowledgeable and enthusiastic about innovation, creativity, and entrepreneurship. It is not enough to pay lip service to this aspect of the social contract between the institution and society at large by making vacuous claims and renaming existing units. Independently accredited evidence is needed of generating intellectual property and specialist know-how as well as facilitating business creation and working with existing businesses and other societal groups. As outlined in reports on the future of work, it is likely that people will have several careers in their working life; therefore, "future-proofing" education is a concept under discussion in many higher-education centres. Old discipline-based administrative structures are giving way to new topic-based, cross-disciplinary campus-based and online courses in conjunction with various transformative technologies. Lifelong learning is becoming the norm so universities need to accommodate (either physically or online) students of all ages in courses of variable duration and different types of certification.

Much depends on the quality and competence of the teaching and supervisory staff. Staff incompetent or indolent in their own purported sphere of expertise should be removed; their presence is damaging both to students and the reputation of the institution. At a minimum, staff must keep up to date in their sphere of expertise, be able to recognise originality in its various manifestations, be aware of advances in other fields that interdigitate with their field of scholarship, and contribute positively to the life of the university. Nowadays, some of the staff, especially those in supervisory and leadership positions, must have an understanding of IP and unique or rare skills, and where to go in the university to seek advice and initiate registration processes. Irresponsible science [see section 7.1 in Ref. 4] must be prevented. Entrepreneurial attitudes are important, and there should be encouragement from the university for staff and students to set up businesses. In this instance, encouragement can take the form of providing advice on how to set a business in the first instance, followed by providing some or all of the capital and facilities, perhaps with a revenue-sharing arrangement perhaps in partnership with other bodies, and the ability of the innovator or entrepreneur to retain some form of employment (hence security) with the university. Failures need to be accepted and used as a source of market understanding. Obviously, the possession of a business school and a business or technology park makes these steps straightforward (see Sect. 17 Guidelines on how to Establish a Company or Business), as do the use of external mentors and guidance from professional associations.

Administration of universities is more complex than normal businesses. For example, financial management and custodianship of reserves and assets can be complex; maintenance and upgrading of diverse types of building and equipment are expensive; valuable collections and other assets pose security risks; accurate records of graduate and undergraduates need to be maintained securely; the workforce encompasses diverse skills, pay grades, pension arrangements, and types of benefit; recruitment, retention, welfare, and monitoring of performance of staff have to meet legal standards; meticulous organisation is essential for timetabling courses, use of laboratories and other facilities, examinations, ceremonies (including advice on academic dress), conferences, and administrative meetings; data on the duties and performance of individuals and groups need to be continually updated for QA and relevance assessments as well as for setting emoluments; formal agreements with host governments and agencies as well as industries and professional organisations need to be established and acted on; regular services must be offered such as transport and parking, utilities, stores, computing, secretarial support, accommodation, and attending to contractors; governing boards and senior committees must be supported; the university's statutes need to be maintained and adjusted where necessary; interactions are necessary with investors, sponsors, local authorities, government agencies, international agencies, and the administration will the first point of contact for enquiries. Modern information and communication technology is revolutionising administrative functions and administrative efficiency but does not reduce the complexity and need for other human skills. A primary role of university administration is to have mechanisms to root out corruption of the various kinds that afflict universities worldwide [4]. The relevance aspect of universities now means that administrations must offer an IP service so that the university has a record of its IP but also has links with appropriate legal entities and marketing organisations, and sometimes appropriate companies. QA tests will need to be done on these external bodies. Issues such as joint ownership of IP, registration and defence costs need to be clarified at the outset. Advice on establishing a company or business would presumably be attended to by the university's business school.

Many universities have business schools; few are outstanding, otherwise those universities would be surrounded by businesses and the universities would be replete with money. There is some truth in the dictum that those that can do, do, that that cannot, teach. This need not be the case. By appointing teaching and research staff on joint appointments in conjunction with their own of other businesses, the use of advisory committees from businesses (manufacturing industry, biotechnology, environment, computing and software design, general design, accountancy and banking, law, medicine, marketing etc.), and use of eminent guest lecturers and joint research supervisors, university business schools can realise the potential of the university's students and staff. At a minimum, teaching and supervisory staff in business schools should demonstrate entrepreneurial behaviour and have experience in setting up one or more businesses. University-based business schools should work in close liaison with university technology or business parks and business incubators, and offer training placements in these facilities as well as with outside businesses. With regard to teaching material, in addition to an explosion of popular literature and a substantial number of textbooks, there are major developments in online courses covering areas needed to initiate, operate, and grow businesses, as well as dealing with issues of funding, accounts, contracts, licences, human resources, contact networks, fraud, marketing, design, and negotiations. Teaching and research staff can supplement this material substantially with their own expertise; provide contemporaneous examples; set exercises; point out exceptions to consensus views; discuss the stages involved in the formation, operation, closure, and mergers of businesses; discuss the essential characteristics needed to be an entrepreneur; analyse risk; highlight oppor-

Table 5 Summary of essential features of universities with a successful innovation and entrepreneurship culture

Leadership knowledgeable and enthusiastic about innovation and entrepreneurship
Teaching and supervisory staff with demonstrable entrepreneurial attributes and understanding of patenting/copyright/valuable skills/brands/social trends & fashions
Administrations capable of providing advice and an IP registration process, and with links to patent lawyers and marketing specialists
Business school with functional international legal/marketing/financing linkages
Ability to reward key staff and create entrepreneurial ambassadors
Role of guest/honorary appointments/advisory panels
Formal links with certain companies (local, major, international)
Links with professions
Audit of IP/copyright/skills/related assets
Roles of host governments to remove constraints and to facilitate innovation
Provisions for lifelong learning
Government seed funding but with freedom to operate
Technology and business hubs, nodes, incubators etc. allowed to operate as a properly run cooperative symbiotic businesses and not parasitised or bureaucratically constrained by the university

tunities and challenges; consider business in social and economic contexts; point out moral, legal, and financial obligations of operating a business; use of independent audits; rooting out poor business practices and corruption; discuss alternative structures and systems; pose questions about future developments in transnational businesses; offer entry into contact networks; and consider the advantages and disadvantages of careers in businesses of all sizes.

Subject to high-quality staff, adequate resources, competent administration and visionary leadership operating with integrity and societal relevance, universities will only attain their real capabilities if the host government supports education and R&D without undue interference. Governments need to be business friendly, allowing businesses to be created expeditiously in an environment that respects international IP laws and punishes corruption of all types. Senior civil servants have to be competent and focused on improving wealth creation and the quality of life of the population. Without these conditions, the Arab world will find it impossible to play a proper role in the global knowledge economy. Ministries of education and their political masters are in urgent need of reconfiguration in ensuring the universities in their jurisdiction are of high quality and produce graduates, postgraduates, IP, and other outputs of benefit to the country. Table 5 summarises the features of universities with a successful innovation and entrepreneurship culture.

11 Science, Technology, and Business Parks; Business Incubators; Technopoles; and Science Cities

Science parks and their equivalents are conceived as centres of innovation and knowledge-based institutions and organisations. They are usually linked to universities and advanced research institutes but can also be entirely commercial operations set up by a company. They are meant to attract skilled people, especially entrepreneurs, and are centres for the exploitation of IP and certain types of advanced know-how. They are often places where start-up companies become established as well as the intellectual base of existing companies that may be small- or medium-sized businesses or even multinational corporations. An economic “negentropic” cluster effect can occur with the co-location of service providers (lawyers, accountants, travel agents, stockists etc., some of whom use technologies developed on site). Specific conditions usually apply for setting up a business on the park so as not to dilute its main purpose. The legal and functional relationships between the science park vary greatly, and need to cover such matters as governance, rent and leasehold fees, infrastructure costs, maintenance of the site, liabilities, access to universities instrumentation and other facilities, use of university staff, student training and work placements, utilities, and publicity. They are not meant to be mere publicity showpieces. They help bring about the culture of innovation and entrepreneurship needed by universities and their host countries.

Despite lavish funding and the offer of subsidies, many science parks around the world are underperforming. Much can be learned from them and the mistakes and false assumptions of the host universities. Some of the most successful science or business parks are not owned or controlled by universities. Membership of organisations that oversee science parks is helpful in identifying opportunities and problems. Sometimes the host university or research institute is deficient in relevant expertise, facilities, or reputation, in which case the host body urgently needs to reconfigure its operations. Sometimes the host institution is in an undesirable location for transport connections or because the government is not business-friendly. The success or otherwise of a science park and commercial funding reveals much about the host institution and its societal relevance. Table 6 lists the key elements of university-linked business and similar parks.

12 Criteria of Successful Innovation and Entrepreneurship in Universities

QA and relevance assessments rely initially on access to data provided by the university followed by comparative studies, veracity checks, and interviews. For innovation and entrepreneurship, however, more sophisticated checks are required to supplement the usual sort of data made available to external auditors. The QA bodies are in the process of refining their activities. In the interim, many universities and

Table 6 Key elements of university-linked business and technical parks, business incubators, and similar bodies

Covers a wide range of bodies, such as technopoles and science cities
Advantages of co-location of businesses with universities (use of space and facilities; training and work experience; income; reputation; relevance of coursework and research; economic negentropic "cluster" effect)
Roles of governments; location of government agencies; knowledge and business-friendly policies
Opportunities for siting transnational research and development initiatives (diplomatic, economic, and social-mixing benefits)
Legal relationship between the university and business/technology park
National associations of science parks; International Association of Science Parks and Areas of Innovation [47] advise on best practice and on prospective incoming businesses to prevent parasitism of university benefits, access to IP, and seeking special benefits

research institutes have commissioned independent economic appraisals, partly to justify funding from government.

Estimations of societal impacts can come from surveying: (a) IP portfolios, (b) royalty and licencing income, (c) bibliometrics, (d) businesses created, (e) awards of competitive funding, and (f) facilities provided by sponsors. More detailed analyses should be carried out on assessing: (g) the success of associated science parks and spinout businesses, (h) the career trajectories of graduates and postgraduates, (i) justification for institutional USPs – unique selling propositions – outputs and products that distinguish the institution from similar bodies and used for marketing and competitive positioning [48], (j) specific innovation- and entrepreneurship-related grants and scholarships, (k) official links with commercial and industrial companies. Detailed discussions will be needed to assess the extent to which the culture of innovation and entrepreneurship has permeated the university, as evidenced by: (l) the reward system offered to the staff, (m) reputation of the university in the business world, (n) impact analyses on the products, processes, and concepts arising from the university, (o) the attractiveness of the university to major funders of research and co-location of advanced company and government facilities, and (p) the nature of the interactions with government and the type of advice issued to government. A summary of the assessment criteria is presented in Table 7.

13 How Governments Can Provide Assistance

After a period when universities sought (sometimes unsuccessfully) to remain as detached as possible from government interference (but not taxpayers' money) and retain their all-important autonomy, a new paradigm of university-government relationship is emerging. The New Growth theory [6, 7] is not itself the reason for this shift, but the stark reality of countries having to complete in the global knowledge economy. Many areas of education and basic research cannot be left entirely to the

Table 7 Criteria used to assess the extent of a culture of innovation and entrepreneurship in a university

Royalties and licencing income
Businesses created
Reputation in leading broadsheet newspapers, authoritative economic publications, and businesses of all sizes
Responsible science so as to avoid waste and corruption etc.
Laboratory notebooks properly filled in and vetted for priority
Bibliometrics and related assessments of achievements
Independent economic appraisals of impacts locally, nationally, and internationally
Successful careers of graduates and postgraduates
Reward system to the university and its staff
Acceptance of risk
Development of USPs to distinguish its products and outputs from competitors
Additional facilities and grants and scholarships
Positive interactions with government/business/civil society

market – there is market failure for much of the population. Governments must invest in education generally, and increasingly in higher education and research. How this is done so as to avoid waste (duplication is not necessarily a waste in research) and sustain effective teaching and research yet be affordable is a challenge for most governments. The temptation is to interfere, leading to the so-called dead hand of government and civil-service incompetence with inflexibility and failure to adapt in fast-moving areas of scholarship. State-controlled universities tend to be characterised by staff (and consequently their students) imbued with the worst kind of public-sector attitudes, including entitlement. In this environment, innovation and entrepreneurship are inadvertently suppressed.

For a properly functioning relationship, governments must have confidence in the quality and relevance of the university, and the competence and vision of the leadership. Many autocratic Arab governments are suspicious or even fearful of their universities that they see as centres of unrest and revolution. Both parties would benefit from quality enhancement and the release of creative energies of the staff and students. Funding, possibly from the sovereign wealth funds, should be devolved to independent expert panels, seeking external international advice where necessary, with panel membership changing regularly, and the reasons for their decisions published. Funding allocations could be informed by national technology foresight and so-called "horizon scanning" exercises [4]. In supporting education and research programmes, government funding must be scheduled over five- to six-year planning windows and not be destabilised by annual reviews that can disrupt education and research and destroy careers. That is not to say that universities can ignore efficiency gains and adapt to new methods of education arising from the digital revolution and online courses. Universities should be subject to independent external QA and relevance assessments. Business-friendly policies are desperately needed in most Arab countries. This includes active participation in international

Table 8 Government assistance to universities

Provide stable funding, including competitively awarded research funds and scholarships to outstanding students
Assist with SWOT, foresight, and horizon-scanning exercises at national level to inform universities and industry in order to help establish joint initiatives
Insist on independent QA and relevance assessments
Introduce business-friendly policies
Offer innovation loans
Join international community in recognising, upgrading, & protecting IP
Operate through independent panels of experts that must not have entrenched membership
Facilitate regional initiatives of large-scale projects and specialist facilities

agencies that promote economic growth, including IP, and helping synthesise groups of venture capitalists. A portion of the cohort of universities should be allowed to develop into elite research-based institutions. Intergovernmental initiatives are also needed to attract advanced regional research facilities and the exchange of highly skilled personnel. These facilities will help retain outstanding academics, contribute to the advancement of knowledge, and have diplomatic benefits for the host country. Table 8 summarises government assistance to universities. See also Sect. 5 Governments must Promote Innovation and Entrepreneurship.

Related to the aspect of governments supporting either directly or indirectly university-linked science and business parks (and their equivalents), business-friendly policies are the best way to grow the economy. The ease to initiate and conduct business, removal of unnecessary licence schemes and planning restrictions, robust enforcement of contract law, elimination of corrupt practices, and fair taxation are obvious improvements. Another could be establishing free-trade zones with attractive taxation and facile immigration or residency arrangements, a development that would be appropriate for university-linked parks. There are legitimate concerns that these free-trade zones can be operated mainly to avoid the Common Reporting Standard developed by the OECD for the automatic exchange of information between international taxation authorities [49] and may be used to hide criminal activities.

14 Roles of Banks, Crowdfunding, Business Angels, Venture Capitalists, Accountants, and Lawyers in Establishing a Business

The ease with which a business can be established and operate in the formal economy varies markedly from country to country [50, 51]. Publication of these comparison indices acts as an incentive for governments to improve their commercial operating environments and aid innovation and entrepreneurship.

Some businesses function wholly or partly in the so-called informal or grey economy. According to the BusinessDictionary [52], the informal economy refers to the system of trade or economic exchange used outside state-controlled or money-based transactions. It is practiced by most of the world's population in the countryside and in towns and cities, and includes barter of goods and services, mutual self-help, odd jobs, street trading, and other such direct sale activities. Income generated by the informal economy is difficult to trace and quantify so is not usually officially recorded for taxation purposes, and is often unavailable for inclusion in GDP computations. Participants in the informal economy are not protected by government legislation although they avoid paying taxes. The size of the informal economy varies up to a maximum in poor underdeveloped or conflict-torn countries. For innovation and entrepreneurship in universities, the informal economy with its implicit illegality and lack of legal protection is to be avoided at the outset. No business can thrive and grow without official societal approval.

All businesses need initial financial support for accommodation, salaries, facilities, running and development costs, dealing with clients and customers, professional fees etc. The so-called "bank of Mum and Dad and friends", or family-and friend-derived financial support is usually insufficient for establishing a functioning company, such funding is valuable, though, in very early stages of development when the risk of failure is very high. Banks tend to be the first port of call to seek loans. In virtually all instances of raising money, a well-crafted business plan is essential. Banks are one of several different types of holders of financial intermediary assets, including savings institutions, credit unions, money-market funds, mutual funds, insurance funds, pension funds, real estate investment trusts, and finance companies. In essence, banks allocate funds from savers to borrowers, and charge interest; in so doing, they are effectively expanding the money supply [53]. The rate of interest is meant to reflect the level of risk. Even before the international financial crisis of 2007–2008, many business customers in many countries were finding it difficult to obtain loans without punitive rates of interest, short loan periods, and the need for a guarantee of substantial collateral assets, usually property or title of the business. Governments are tending to pressurise banks to support businesses and infrastructure development.

Unsurprisingly, businesses have turned to other sources of finance: seed funding, crowdfunding, angel (business angel), or venture capital (risk capital). Seed funding is variously defined, and can encompass family and friends, crowdfunding, and business angels, and involves amounts of around US$ 50,000 to US$ 2 million with an equity stake in the business. Crowdfunding is based on accumulating small amounts of money from a large number of people or businesses, and usually carried out on the Internet [54]. It seems to be a popular method of fundraising for social, charitable, and personal needs as well as for start-up companies unlisted on any stock exchange. Those that provide money often do not get repaid but start-ups sometimes offer shares so in that instance that there are prospects of returns on the investments. Crowdfunding has been described as a high-risk pre-order platform, where there's a reasonable probability that the start-up may fail to deliver, and equity is usually not acquired [55, 56]. Angel investing uses different deal structures from venture capital primarily to reduce legal costs, cut transaction overheads, and rapidly accelerates the rate at which the start-up and angel investor can agree on terms [57, 58]. Some of these alternative structures include convertible notes and SAFEs ("simple agreement for future equity"). Unlike venture capital, convertible notes and SAFEs do not actually transfer equity in the company to the investor until a later date should the company be successful and not fail. Business angels often seek to earn between 20% and 25% on their investment. Greedy and grasping investors are termed "vulture capitalists". Most investors seek physical assets as security; as a consequence businesses based on IP tend to be underinvested.

According to BusinessDictionary [59] venture capital is defined as start-up, or growth equity capital, or loan capital provided by private investors (venture capitalists) or specialized financial institutions (development finance houses or venture-capital firms). Venture capital is a type of funding for a new or growing business and usually comes from venture-capital firms that specialize in building high-risk financial portfolios. In essence, venture-capital firms transfers funding to the start-up company in exchange for equity and sometimes board positions in the start-up. This is most commonly found in high-growth high-risk (few or no assets backing the start-up) technology-based industries, and predominantly biotechnology and computer software. The start-up company issues private shares in exchange for money, thus, the venture-capital firm becomes a partial owner of the start-up. Obviously, the potential payouts must be significantly higher to justify the investment, so investors need to value the start-up [60]. Unless there are exceptional circumstances with start-ups that can confidently predict substantial profits – the so-called "unicorns" (privately held start-ups valued at over US$ 1 billion [61, 62]), venture capital is not used for extremely early funding. Venture capital also usually starts with companies that are slightly more mature, although not necessarily profitable, with higher valuations, and higher funding amounts ranging from millions up to hundreds of millions of US dollars.

The amount of funding raised depends largely on the valuation of the prospective or actual business. Obtaining a true valuation is not straightforward especially for start-up enterprises. There are different groups of advisors and various valuation methods and tools described on the Internet [60]. In summary, the main factors involved are: (a) comparisons with equivalent businesses at the same stage of development; (b) market forces operating in the relevant sector of the market; (c) value of the tangible and intangible assets; (d) business liabilities; (e) assessments of prospects; (f) confidence in the competence of the entrepreneur; (g) business plan; (h) willingness of the investor to pay a premium to secure a deal; and (i) the level of desperation of the entrepreneur to seal a deal.

Accountants have an important role in businesses of all types [63]. They are the source of financial expertise and guidance as well as preparing the accounts. Companies are obliged to maintain accurate, timeous, and complete financial records that cover payroll, credits and debits, balance sheets, cash-flow analyses, meeting "going-concern" criteria etc. Accountants are invaluable in preparing business plans that are essential in attracting funding. They are obliged professionally to comply with local and national accountancy laws and stay up to date with legal changes. Their involvement in businesses gives reassurance to investors and customers.

From the outset of establishing a business, it is imperative that expert legal advice is used. Beginning with the legal establishment (incorporation) of the business, legal advice is essential for hiring employees; avoid unnecessary taxation; formulating and negotiating contracts; obtaining IP; raising capital; forming partnerships; issuing shares and entering stock markets; protection from a range of legal liabilities; and selling or winding up the business. Selecting an appropriate suitably experienced lawyer or legal firm is often a matter of research on the Internet [e.g. 64], recommendations by owners of similar businesses, impressions made on first contact; and value for money; high-quality professional advice is needed, not routine legal "handle-turning".

14.1 Business Plan

There are many reasons why an entrepreneur should write a business plan [65–67]. It helps the entrepreneur focus, develop ideas, carry out market research, and identify business priorities. In so doing, it helps in thinking through options and identifies opportunities and weaknesses. It can assist in attracting senior staff, business partners, distributors, and customers. Crucially, it helps convince banks, investors, and other key contacts to support and fund the entrepreneur to develop the business or enterprise.

Business plans typically include eight key sections: an executive summary; a business description; details of market strategies; competitor analyses; a design-and-development plan of the products and/or services; details of the operations and management plan; financial factors; and an appendix. The section containing financial factors should include an income statement, cash-flow statement, and balance sheet. This should aim to provide an accurate and truthful picture of the company's current value, and its ability to pay bills and earn a profit.

From the usual business plan has developed several different types of business plan to meet the needs of specific sponsors. These plans deal specifically with start-ups, strategy, specific market segments, feasibility, operations, growth etc. Various background documents on business plans and free business-plan templates can be found on the internet. Various governments give helpful advice on business plans on their websites.

15 Opportunities

Never have there been so many opportunities to set up a business or a company (Table 9). They have different financial and legal structures [68–70] but both enterprises have to be registered with the taxation authorities. In most countries, a business costs less to set up than a company so it is the favoured option for many start-ups. To set up or incorporate a company can be more expensive than a busi-

Table 9 Brief selection of examples of business- and company-formation opportunities for entrepreneurs

Transformative technologies; further development and exploitation
Consultancies offering guidance on transformative technologies
Changes in societal behaviour (convenience, smartphones/dress/entertainment/out-of-home eating/new educational models suitable for lifelong learning)
Major challenges facing populations (climate change; food, energy, and water security; pollution control; waste handling and recycling; rebuilding damaged and outmoded soft and hard infrastructures; medical care; dealing with natural disasters; fraud prevention; conservation of natural flora and fauna; raising educational standards; changes in international trading rules and their enforcement
Venture capital and business angels
Government grants
Rapid business establishment and dissolution enactments

ness, but it can be structured to have limited liability so it is legally seen as being quite separate from the owner(s). Therefore, creditors would not be able to repossess personal belongings, or private assets when recouping the debt. Even so, company directors will be held accountable for breaches of the law. Importantly, companies usually have favourable taxation rates; find it easier to raise capital; can find it easier to attract government funds; have to disclose information about itself to the shareholders, regulators, and stock markets; and require expert legal and financial expertise. A small single-person or partnership business can readily convert to a formal company once it is sufficiently mature and profitable. Nonetheless, for many entrepreneurs, the existence of shareholders can dilute their enthusiasm and cause a pronounced shift in the direction of the enterprise.

For academic entrepreneurs, inspiration for innovation and setting up enterprises can arise from the entirety of the subjects, topics, themes, projects, and research in universities. There are the added advantages of internet resources, digitisation, and a rapidly expanding number of transformative technologies [Table 2 in 4]. Population growth, expansion in the proportion of people living in towns and cities, and changes in social behaviour offer opportunities for new markets. For example, smartphone apps, dietary changes and preferences, entertainment, educational systems for training and lifelong learning, clothing and footwear fashions, fitness, hobbies, general design, housing design etc. are rich sources of entrepreneurial activity. When examples such as these are considered in combination with transformative technologies and their products, there is a synergistic effect on increasing the number of opportunities. Another more important category of innovation and entrepreneurship is in dealing with the major challenges facing much of the global population. These challenges include addressing amelioration of and adaptation to climate change; food, energy, and water security; prevention of diseases and infections; devices for disabled people; renewable energy sources; rebuilding hard and soft infrastructure in areas of conflict and outmoded ones elsewhere; pollution control in the atmosphere, on land, in fresh water, and the seas and oceans; waste handling and recycling; sustainable intelligent packaging; provision of housing; improved medical treatments;

dealing with natural disasters; fraud prevention; conservation of natural flora and fauna; raising educational standards; changes in international trading rules and their enforcement etc. These opportunities (Table 9) can be aided by government grants and loans, and attract inward investors. Moreover, there is a universal drive to enable businesses and companies to be established and dissolved rapidly.

With the support, financially and/or in an advisory capacity, of a university, the innovator and entrepreneur now have golden opportunities to create valuable enterprises.

16 Challenges

To the non-enquiring mind, it may seem a difficult time to be an innovator or entrepreneur given the ever-growing degree of competition (Table 10). The amount of IP expands every year; the competition for public- and private-sector funding is increasing; surely there is a shortage of ideas and talented people; suitable up-to-date R&D facilities are in short supply; only the big companies, elite universities, and only individuals with influential contacts can succeed. Fortunately for the future of human existence and the quality of life, never have there been so many opportunities for new innovations and wealth creation. The recent transformative technologies couple to fundamental human ingenuity and quest for greater understanding offer unparalleled chances for an enterprising graduate or postgraduate to chart a new course in their life.

The scale of the competition in some areas of human endeavour cannot be ignored. The major tech companies in the USA (Alphabet – parent company of Google, Amazon, Apple, Facebook, and Microsoft) and China (Alibaba, Baidan, and Tencent) pose almost insurmountable obstacles to internet-based start-ups by ownership of critical software, advanced R&D facilities, high salaries, and competi-

Table 10 Challenges facing innovators and entrepreneurs

Sheer level of competition (ideas, funding, numbers of suitably educated and competent personnel, facilities)
Big tech companies in China (Alibaba, Baidan, and Tencent) & US (Alphabet, Amazon, Apple, Facebook, and Microsoft) create a "kill zone" around themselves because other consumer-internet-based cannot compete for salaries, facilities, and talent
Venture capital located mainly in the USA and Europe
Stresses on Arab public finances generally and on the education and research budgets specifically
Arab attitudes to R&D, innovation, business failure, and bankruptcy
Political instability
US Supreme Court ruling on the "Alice" case and the patentability of software relevant especially to start-up companies and SMEs

tion for talent. They are also able to buy out competitors. The time has come for the market-competition authorities to step in and prevent quasi-monopolistic behaviour. Some of the tax-avoidance measures by some of these companies, and other transnational companies also deserve closer scrutiny. Another problem for software developers and innovators is the effect of the US Supreme Court ruling on the "Alice" case and the ineligibility for patenting of business-method software [71, 72]. One constructive development is the EU's robust General Data Protection Regulation (GDPR) [73] that is beginning to impact on multinational data-handling companies and other organisations based inside and outside the EU's market of 500 million people, especially in the development of AI.

Innovators and entrepreneurs in the Arab world have additional challenges to contend with. Most of the venture capital is based in the USA and Europe. Arab governments, with just a few exceptions, have deeply stressed public finances and are unable to fund education and research to the extent required for their countries to enter the knowledge economy. More fundamentally, we have reason to believe that attitudes to R&D and the generation of IP are not as positive as they are to education more generally. The commitment of Arab parents to the education of their children is admirable and contrasts with much of the developed world. This somewhat reticent attitude to R&D may simply reflect the historically small number of employment opportunities for R&D in the Arab world, a position that is rapidly changing. In terms of entrepreneurship, Arabs are famous for their business and negotiation abilities. From these observations, we conclude that the future looks exceptionally bright. Casting a dark cloud over the future, however, is the threat of political and social instability, and even war. For reasons we explored hitherto [4], new multilateral initiatives are desperately needed for Arabs to enjoy a much-deserved and long-overdue prosperous and peaceful future.

17 Guidelines on How to Establish a Business or Company

In brief, there are many sources of advice on how to start a business or company. Here, we bullet point the main points that should be considered (Tables 11 and 12). More specific information is required for a specified country or even local area (e.g. individual States in the USA). In some countries such as the UK, company-formation specialists make it easy, rapid, and very cheap (around US$ 20) to set up a company. Guidance on setting up a company in the USA as a foreigner is given in Investopedia [74]. The decision where to locate the business or company depends on the ease of doing business, the customer base, the "cluster" effect, and source of expertise and employees. University business parks should offer attractive bases for start-ups launched by academic entrepreneurs.

Table 11 Guidelines on how to set up a business

Get free advice from online and from colleagues and contact networks
Those launching a start-up must have the ideas, concepts, and/or IP as well as the motivation and attributes to be an entrepreneur
Accept but quantify the degree of risk and personal liability
Identify assets, both intangible and tangible. Acquire necessary licences
Identify and estimate as accurately as possible the value of that component of the market the business will compete in
Confirm the USP and the robustness of any IP to external challenge; identify the potential sources of any challenges
Choose an appropriate market-friendly business name
Produce a professional-quality business plan
Acquire the finance without grovelling and losing control, and ensure best professional accountancy practices
With legal advice, set up the legal structure and banking arrangements; consider insurance protection
Assess actual and potential liabilities
With finance in place, identify premises and start to appoint staff, bearing in mind job specifications, quality of the appointees, and legal liabilities
Install equipment and facilities, and then start production. Keep a close eye on cash flow
Pay careful attention to pricing, and calculate full economic costs. Negotiate with suppliers and customers. Be resilient to setbacks. Customer and supplier databases are valuable. Seek supplier discounts and resist customer discounts
Marketing and public relations. In most instances, it is useful to join business contact networks (e.g. LinkedIn) and seek advice on effective advertising and marketing strategies.

Table 12 Guidelines on how to set up a company

Follow much of the guidance in Table 10 above
Remember that brands command special value and can be difficult to copy [75]
Seek professional legal and accountancy advice relevant to the country
Choose a market-friendly company name
Identify the company address
Carefully select and appoint directors and a company secretary
Think carefully of the consequences when creating shares and then seek shareholders
Produce the Memorandum and Articles of Association or their equivalent in the jurisdiction of choice [76]
Register the company for taxation and stock-market purposes

17.1 Doing Business in the Middle East

Specialist knowledge is needed in order for businesses and entrepreneurs to adapt to he prevailing circumstances of any country, none more so than the Arab countries. Several sources of general guidance are available freely on the Internet along with specific country guides [77–79]. These are invaluable for transnational operations, because they incorporate key information about the national culture, expected behaviour, holidays, social interactions, meeting senior decision-makers, having patience with bureaucracy, the role of trust etc. The Arabs comprise traditional trading societies and are noted hard negotiators.

18 Conclusions

Universities worldwide, and not only in the Arab world, must upgrade their operations to improve the quality and relevance of the education and research they purport to deliver. Given that universities should be centres of intellectual endeavour and the originators and developers of numerous societally transformative technologies and concepts, an independent onlooker might justifiably reason that universities are also centres of innovation and entrepreneurship. Similar comments can be made about public-sector research institutes. This is not the case. Profound changes are needed in the relationships between governments and universities, between universities and their undergraduate and postgraduate students, and between universities and the societies they serve. Governments need policies that promote the knowledge economy, and make it easy to create and operate businesses in corruption-free environments. They can help universities in establishing business and technology parks and by co-locating government agencies in those parks. Government funding of education and research must be both stable over the medium term (5–8 years) at least, and distributed at arms length by independent agencies and panels with membership confined to three or so years. At the same time, universities must be subject to regular independent external QA and relevance assessments. Most universities have not come to terms with digitisation and new forms of on-line education and retain rigid discipline-based administrative structures. Most fail to recognise the crucial roles of innovation, entrepreneurship, and lifelong learning in their delivery of education and research. It is not too late but there must be profound upheavals in the way Arab (and other) universities function in future.

QA and relevance assessments are in the process of becoming more sophisticated and encompassing creativity, innovation, and entrepreneurship. This means that universities will need to improve their data gathering and analysis processes. Career development of graduates and postgraduates will need to be monitored as far as possible, and encouragement given to all forms of innovation, generation of IP, and initiating start-up and spin-out businesses and companies.

The disparity in the duration in protection offered between patents and copyright is unjustified. It could be said to disrespect those in STEMM subjects compared with the arts, social sciences, and humanities that relate more closely to copyright. In our opinion, for the benefit of society the maximum should be 20 years in both cases. This usually allows for full recovery of R&D costs and the costs for preparing work for copyright, and it provides opportunity for a profit but does not hinder societal progress for a protracted period. Exceptions can be made only in rare instances.

The safeguarding of IP is one of the most serious issues affecting the operation of free markets and liberal democracies. Multilateral agreements with strict rules ought to be introduced but are currently blocked or ignored by some non-democratic countries. In the meantime, the combination of security from hacking and implementing trade penalties are the only options.

Irrespective of the challenges facing innovators and entrepreneurs, the opportunities to create successful enterprises have never been greater. As universities transform into genuinely societally essential institutions and offer business-friendly environments, entrepreneurs will become integral academic components. We urge Arab universities to follow the guidelines issued by the World Intellectual Property Organization [15]. As far as Arab countries are concerned, the benefits of liberal democracy should be embraced for the first time to allow the blossoming of innovation and entrepreneurship. They will then be fully integrated into the global knowledge economy for the benefit of all, and will successfully transcend the international “Matthew effect” of accumulated advantage (one where the rich countries get richer while the poor countries get poorer) [80, 81]. After 3000 years of disunity, democracy has not found much fertile soil to prosper in the Arab world where “strong leaders” (i.e. dictators) are favoured [82]. Modernisation and upgrading of Arab universities will surely provide that much-needed fertile soil.

Appendix: Advice to Higher-Education Institutions on Research and Work Records with Regard to Quality Assurance and Intellectual Property

This advice is for institutions yet to embark on QA and accreditation processes, and wishing to promote innovation that can lead to the generation of IP. It is more applicable to STEMM subjects but aspects could be usefully adopted in other areas of academic practice, especially when considering copyright. We thank colleagues at the James Hutton Institute (formerly Scottish Crop Research Institute and its commercial arm Mylnefield Research Services Ltd.), Dundee, UK, for development of this advice.

In order to implement the following QA and IP measures, the institution has to be able to:

- Accept the guidance of the World Intellectual Property Organization [15]
- Establish an Intellectual Property Policy [e.g. 16b]

- Produce a Code of Practice for conducting research
- Produce a Health and Safety Policy
- Develop a Quality Plan, appoint a Quality Manager, and Quality Representatives in each work area
- Start to engage with international accreditation organisations
- Prepare Confidentiality Agreements for dealing with third parties
- Supply new official Notebooks and securely store used Notebooks
- Include in the Notebooks instructions and guidance notes for making and maintaining research records, Standard Operating Procedures, and equipment logbooks
- Maintain a record in the asset registers of institutional IP (mainly patents and copyright) and valuable uncommon skills and know-how. These details will be invaluable in future QA and relevance assessments

Example of Guidance on Intellectual Property for Employees and Students
We thank the University of Leicester, UK, for this example [16].

The University owns all intellectual property (IP) or other materials developed by its employees, unless explicitly stated otherwise. In exchange, the University provides generous revenue sharing schemes for employees and their departments, should the IP be commercialised. The University does, however, waive copyright of academic outputs such as theses, journal articles, books, or book chapters.

Students are not employees of the University and therefore legally own any IP arising from their research as long as all of the creative intellectual input has been that of the student. When students have simply followed a supervisor's instructions, the intellectual input resides with the supervisor. Where the research results are clearly the output of intellectual input from both the student and supervisor then, depending on the particular circumstances, the intellectual input is jointly owned by the student and the University or each owns any IP that results from their respective creative inputs, subject to the individual circumstances of each research activity.

When a researcher is both a student and an employee (e.g. a graduate teaching assistant, an undergraduate doing hourly paid work, or a member of staff taking a part-time undergraduate, postgraduate taught or postgraduate research degree), ownership of IP will normally be determined by whether the IP was created during the researcher's duties as a member of staff or a student.

The University will decide, on a case-by-case basis, whether students should assign their IP to the University. Supervisors are responsible for ensuring that the appropriate documentation for executing such an assignment is signed in conjunction with Administration. On assigning their IP to the University, students will benefit from the University's exploitation policy on the same terms as employees.

Where funding (cash or in-kind) is received from an external body, there may be agreement that the sponsoring body has rights to ownership of IP arising from the project. The supervisor of such research is responsible for ensuring that the appropriate assignments of ownership are in place between any student and the University.

The University's IP Policy sets out the procedures to be followed should an invention or discovery be made in the course of a research project carried out as part of normal University activities. It is essential that the Administration be contacted at an early stage to obtain advice and guidance. Staff and students must be aware of the need to maintain confidentiality regarding the results of research, pending legal protection, in accordance with any instructions or advice from Administration.

There is a range of ways in which confidentiality can be compromised by disclosure of information including a discovery or invention. Disclosures may occur as a result of posters, presentations, emails, informal conversations, etc., in addition to published papers. Breaches of confidentiality may result in actions for recovery of losses from a research funder or external collaborator against the University and the individual concerned, together with a loss of income. Even if a research funder is not involved, breaking confidentiality will result in an inability to protect the IP at any time in the future. It is possible to have confidential conversations without compromising IP under the protection of a confidentiality agreement; such agreements can be prepared by Administration.

On leaving the University, any IP developed during employment that is owned by the University, or by any research funder to whom such IP has been assigned in accordance with a relevant contract or licence, remains the property of the University or funder. It should not be divulged to third parties without the permission of its owner, unless it is already in the public domain.

Where research involves collaborative working with individuals and organisations outside the University, any protectable IP developed by collaborators will be handled as agreed in the research contract. If the research contract contains a confidentiality clause, it may be possible to disclose the details of the IP to all of the collaborators; otherwise it will be necessary to keep the details to those deemed 'inventors'.

Researchers must ensure that they do not divulge information received from a third party under terms of confidentiality without written permission, as to do so may render them liable to claims by the owner of the information. Such restrictions are very likely to persist beyond the end of a research project.

General Comments for the Institution

At first, some staff can find the quality processes excessively bureaucratic, and they are undoubtedly difficult for lone individuals lacking knowledgeable colleagues in an organisation. We found that, with practice, most staff soon adapt to the quality environment. Sponsors, grant-awarding bodies, and contracting organisations welcomed the new measures. Staff became more conscious of the processes needed to generate IP. Special arrangements have to be made for isolated colleagues.

Institutional Notebooks needed for Intellectual Property Protection

- The institution should issue official record-keeping books, especially laboratory notebooks, recording on the first page the name of the institution, the notebook number, and to whom and when it was assigned. The institution should keep details of the notebook number, the assignee, and the date
- When completed, the notebooks should be returned to the institution at an appropriate time for safe keeping

- The notebooks should have numbered pages so that removal of pages can be detected
- Printed instructions for making and maintaining records should follow the first page and terminate with a statement that the instructions have been read and understood for signing and dating by the assignee
- The instructions should be followed by a table of contents
- Thereafter, every page should have a long slender heading comprising the name of the institution, a small box for entering the name of the project (or study), and another box "continuing from page" for linking discontinuous projects. At the base of each of these pages, there should be long slender box titled "Read and understood by" with two "signed" and accompanying "date" boxes (for independent witness countersigning) and another box for entering "continued on page"
- At the end of the book should be four appendices. These comprise an institutional Code of Practice, the institutional Quality Plan, Standard Operating Procedures, and Equipment Logbooks

Printed Sections in the Notebook

A. Instructions for Making and Maintaining Research Records
B. Code of Practice
C. Quality Plan
D. Standard Operating Procedures
E. Equipment Logbooks

A. Instructions for Making and Maintaining Research Records

Introduction

When completed, this notebook should provide a sufficiently complete record of your laboratory (or other work) to be understood and repeated by yourself and others. The following procedures for record creation have been designed to meet the requirements of the institution's Intellectual Property (IP) Policy, and laboratory accreditation to international standards (e.g. ISO 900, the OECD principles of Good Laboratory Practice). The design of the notebook affords maximum protection of your IP. To fulfil the requirements of accreditation and to give the notebook value as a legal document in possible IP litigation, the following practices must be followed.

General Requirements for Record Creation

Entry of Records into the Notebook

Written records must be indelible, so all records must be made with permanent ink, not pencil or washable ink. The date should be noted on every completed page.

Alterations

Alterations to written records are made firstly by crossing out with a straight line through the existing incorrect words, phrases, sentences, or paragraphs. Do not erase or obliterate incorrect entries. Do not use correction fluid or remove pages. The correct entry should then be added alongside or as near as possible using a note giving the location of the correction. In both instances, the correction should be initialled and dated. An explanation of the correction should be added if relevant.

Content of Records

Adequacy of Information

Sufficient information about materials, procedures, reagents, apparatus, diagrams, conditions, references etc. should be recorded. Entries should be made as the work is done using the past tense. Where such details are contained in existing documented methods, such as Standard Operating Procedures (SOPs) etc., then make reference to them. Scans, spectra, films, photographic series etc. should be signed and dated, and if they cannot be permanently attached to the notebook, their location should be recorded in the notebook,

Entries

Entries in the notebook should state clearly the purpose and importance of the work in addition to any results, observations, and conclusions. An apparently trivial observation may prove to be of critical importance at a later date. Entries should be sufficiently clear and complete so that another person with the necessary expertise can read and understand what has been done. Sweeping negative statements (e.g. “This procedure is of no use.”) should be avoided because they could later limit the scope of your claims. If a page of the notebook (remembering to use both sides of the pages) is not filled in completely or left blank, then a diagonal line should be drawn across the blank section.

Abbreviations and Technical Terms

All non-standard abbreviations and terms should be defined. A table should be made in the notebook for this purpose. If another person does some of the work, the data obtained by that person should be recorded in the notebook as soon as the data are received and the person must be identified. When not in use, the notebook should be kept in a secure location.

Specific Requirements for Patent Protection

USA Is Different

For patent purposes, there are various requirements for an invention

(a) In the UK and most other countries except the USA, priority of invention is determined by the “first to file” system. There are four prerequisites for a patent: (i) novelty (i.e. first to file a patent application); (ii) inventive step; (iii) industrial applicability; and (iv) not a statutorily excluded subject.
(b) In the USA, priority of invention is determined by the “first to invent” system. There are two requirements for an invention: (i) date of the invention; and (ii) demonstration that the invention works, i.e. “reduced to practice”.

Witness

The requirements above must be corroborated by a witness; the unwitnessed records or notebooks of the inventor(s) are insufficient. Dates and witnesses can help establish priority of invention and is of particular importance in the USA. Every notebook page should be read, witnessed, and dated – regularly – by somebody who understands the work, but does not claim to be a co-inventor. Completed graphs, figures, and tables should be signed and dated by the witness, Tables should have lines drawn through any blank spaces prior to witnessing. Changes made after a page has been witnessed should be initialled and dated by the inventor and the witness.

Intellectual Property Rights

Security

The notebook and its contents are highly confidential and can be of great value when seeking IP protection. The loss or theft of a notebook should be reported to the line manager or supervisor immediately.

Role of the Institution

The notebook and its contents are the property of the named institution. Under normal circumstances, it is forbidden to copy, transmit, or disclose the contents of the notebook to any third party without the express permission of the line manager, supervisor, or their nominated representatives.

IP Ownership

The contracts of employment and staff codes, and the stated relationship between the institution, supervisor, employee, and student should details the rights and responsibilities of the parties with specific reference to information, all forms of IP, discoveries, and creations.

Record-Keeping Practices

Research and other similar records must be kept in accordance with the practices detailed above if they are used to gain IP protection. Even if the work contained in the notebook does not result in IP applications, observance of these practices will provide a clear record for reports, publication or future reference.

Confirmation by Assignee

The signature and date of the assignee is required to confirm that the above instructions have been read and understood.

B. Code of Practice

Introduction

The institution has a global reputation for conducting research of the highest quality. It adopted the following Quality Policy.

- It is dedicated to achieving and maintaining the highest possible standards of quality in order to meet the needs and requirements of external accreditation bodies, its sponsors, staff, and students
- All staff and students must understand and be committed to their individual and collective responsibilities for quality
- To achieve these objectives, senior management will appraise the suitability of working practices and the training needs for existing and new employees. Through a process of continuous improvement in quality, the institution will endeavour to create an environment of mutual benefit for the staff, student, sponsors, and itself

To assist staff and students in implementing the Quality Policy, a set of guiding principles has been adopted and set out in the institution's Quality Plan. Many governments, funding bodies, and other sponsors insist on formal quality requirements before contracts and grants are awarded.

This notebook provides extra guidance as to how the key elements of the institution's Quality Plan can be implemented in practice and covers the following main themes.

1. Responsibilities
2. Health and safety
3. Training
4. Work practices (research work records, organisation of records, primary records in laboratory and other notebooks, secondary records, security and archiving, writing protocols – Standard Operating Procedures, handling of samples and materials)
5. Facilities and equipment (maintenance, correct use, logbooks)
6. Quality control (production of documents and records, quality control and performance checks, monitoring)
7. Further information

1. Responsibilities

In order to maintain a high standard of work, a team effort is required involving staff and students. All staff members have individual and collective responsibilities. They are responsible for the quality of their work and for personally following the guidelines of the Quality Plan. Senior staff members have overall responsibility for ensuring compliance with the Quality Plan within their area of activity. Some objectives of the Quality Plan will be more easily achieved if the efforts of individuals are coordinated (e.g. production of written protocols, instrument logbooks etc.). Ideally, selected individuals (Quality Representatives) within each area should be given this responsibility, with the full help and cooperation of their colleagues. These individuals will also be able to assess how effectively the principles of the Quality Plan are being met.

The institution has a Quality Manager who provides advice and assistance on quality-related matters but does not have direct responsibility for implementation of the Quality Plan other than areas of work covered by official laboratory accreditation according to ISO 9000.

2. Health and Safety

The institution has a formal Health and Safety Policy. The use of correct health and safety measures is a legal requirement and evidence of good working practice.. High standards of laboratory and workplace tidiness and cleanliness are essential. Before starting work, staff and students should ensure that the relevant health and safety information (e.g. risk assessments, safety data sheets etc.) and equipment (e.g. protective clothing, eye baths, medical kits etc.) are readily available and understood. For radioactive sources and substances, the correct official radiological protection measures should be followed. Dangerous organisms should only be handled according to official and legal conditions in accredited contained facilities. All individuals have a duty of care towards their colleagues.

3. Staff Training

All staff must have the appropriate qualifications, knowledge, and training for the type of work they undertake. Supervisors of students must ensure specific training is given to their students. Staff members are advised to keep their biodata up to date and include attendance at training sessions. Staff members have contracts of employment that should define their responsibilities, authority, and conditions of employment. A skill and technique-based Training Record for all staff should be retained centrally in order to comply with independent accreditation requirements.

4. Work Practices

Quality Assurance can be built into any work activity no matter how complex by sub-dividing the activity into manageable portions and by ensuring that at each stage the correct work practices are used at all times. In the context of research, this usually includes some or all of the following aspects.

Research and Work Records

Record keeping is the key to ensuring quality of work. Good record keeping gives confidence whereas poor records lead to chaos. The principles of data collection are (a) incomplete data leads to suspect results; (b) scientific conclusions must be supported by the data; (c) well-organised and cross-referenced data help accurate reporting of data; (d) incorrectly stored data may be lost or unreadable and are therefore worthless. “You cannot write up what you didn’t write down”.

For organisation of records, the records must be well cross-referenced so that all records relating to the work can be readily located. Therefore, records must be uniquely identified by means of a title, code or number, file name, date, named person etc. or a combination of these identifiers. Elements of these should be repeated in other related records so that the link between them is clear. The identity and location of work records should be noted, usually in a laboratory or equivalent notebook or entries in other logbooks, proformas, computer files, derived hardcopy etc.

Laboratory and other notebooks are the property of the institution and not the holder. Staff and students leaving the institution permanently must return their notebooks before departure. Such staff and students may be allowed to make copies for their personal use with the approval of their line managers or a senior member of the management. The notebooks serve as the primary record of research and other activities, detailing materials, methods, reagents, diagrams, conditions, references etc. Reference should also be made to other secondary records (photographs, traces, printouts etc.). It is bad practice to record experimental and observational information on unattached loose sheets, "post-its", and loosely in files. Entries should be made in the notebook as the work is done, and dated and signed as appropriate. A third party should witness records if they are to be submitted for IP protection.

Secondary records include those on pre-printed proformas etc. and those created by computer and imaging systems. Where such items require approval, authentication, authorisation, checking etc., they should be signed and dated as necessary. Computer-based records fall into two general categories. The first are records created automatically by the data-capture device (e.g. GC, GC-MS. HPLC etc.) that are saved on raw data files or as direct output, and generally cannot be modified by the user. The second are user-generated records (e.g. word-processor files, data generated from raw data by subsequent manipulation) that can be modified. These may be retained electronically or as hard copy. Wherever possible, electronic records should indicate the date of creation or last modification, and the identity of the creator. Data-capture systems usually have this as a built-in feature. Hard copies should be signed and dated either electronically or by hand.

With regard to security and archival arrangements, experimental and observational data usually represent a great deal of hard work, time, and money, and should therefore be protected. Also, the data and other information may be confidential. It is therefore essential that work records are complete and stored securely. Accidents do occur in laboratories, instrument rooms, and workshops. Electronic records should be backed up regularly and duplicate copies made on appropriate storage media. Computers should be password protected with installed virus and malware scanning. Work records should be stored in lockable filing cabinets, cupboards, or desk drawers, with selected important hard and electronic copies stored away from laboratories, reagent storerooms, and workrooms. The identity of the records should be listed.

Written Protocols (Standard Operating Procedures)

In most laboratories and workrooms, there will be procedures that are carried out frequently, and it can be convenient to optimise the procedures and prepare a written outline or protocol. Reference can then be made to these written protocols or Standard Operating procedures (SOPs) in the notebooks without having to repeat full details every time. Written protocols are particularly useful in staff and student training. SOPs should always be prepared where possible, especially for routine activities of low variability. They can also be generalised, perhaps listing a number of alternative actions for different situations allowing for wider applicability. SOPs should be of a form that cannot be changed easily by unauthorised persons. A general outline of a suggested format for SOPs is outlined in section 19.4.2. For areas of work covered by formal accreditation, SOPs must be written to a standardised format, similar to the suggested format. Details of experimental procedures used for more variable, indeterminate, and exploratory activities should be clearly written in the notebook (primary research record) with appropriate reference to original literature, relevant SOPs, and all the experimental data. New SOPs can then be written when new experimental procedures have been tested and are in routine use.

Handling of Samples and Materials

Most work activities involve the handling and processing of samples, reagents, and other materials. It is important to ensure the integrity of such samples etc. and to avoid accidents, contamination, and loss. Therefore, all samples and experimental materials handled within the workplace should be clearly identified and labelled, and should be stored and handled correctly in the most appropriate storage conditions (freezers, containers, growth rooms, controlled atmosphere and temperature conditions etc.) Identification information should be firmly attached, and may have relevant work records attached. It is usually advantageous to keep a chronological or other record of reception and analysis/processing of samples etc. within the workplace. This is a specific requirement of formal quality systems such as ISO 9000. A logbook of sample reception can be created giving details of sample type and identity code, date received, process(es) to be carried out and date completed, and identity of the responsible person. Periodic checks should be carried out on the equipment used to confirm it operates properly (e.g. freezers, refrigerators, controlled environment rooms, fume cupboards, laminar air flow cabinets, centrifuges, scintillation counters etc.). Graphical records of the performance of refrigerators, freezers, growth rooms, glasshouses etc. will be needed for formal accreditation purposes.

5. Facilities and Equipment

The use of faulty equipment or its incorrect use can be dangerous as well as compromise the veracity of the work. All facilities and equipment should be suitable for the type of work and function correctly. Faulty equipment should be removed from the workplace, failing which it should be clearly labelled “Do Not Use”. Do not rely on word of mouth to inform colleagues. Equipment should be maintained depending on individual circumstances. Some items will be covered by service contracts with regular preventative maintenance. Other, often smaller, items may be used until they break down or fail to meet performance specifications. A written service and maintenance history should be created, detailing dates of serving and routine maintenance. See section on Equipment Logbooks.

Staff and students using equipment must be trained. Simplified instructions for use must be prepared in the form of a SOP. These are not intended to serve as a guide for untrained staff and students but to serve as an aide memoire for trained personnel and to assist in training. Generally, a checklist-type format is most useful.

Instrument logbooks must be used to provide a chronological record of use of typically larger items in a multi-user environment noting who, when, and for what duration the equipment was used. Equipment logbooks should be hardbound with numbered pages, usually hand-written but can consist of pre-printed pages bound in an appropriate manner; loose-leaf binders are not acceptable. Suggested content for an instrument logbook and details of how to produce custom-designed hardbound logbooks are given in the section Equipment Logbooks.

6. Quality Control

Production of Documentation and Records

All staff and students are responsible for making their own research and work records, and ensuring they are made in the correct way. Staff working in a specified area are responsible for preparation of any documentation used, including data-recording sheets, pre-printed forms, SOPs, Logbooks, checklists etc. Production and distribution of these documents should be controlled by the designated responsible person(s)m usually the author and/or Quality Representative(s). Other persons using the documentation can suggest alterations and amendments, but only the responsible persons can make changes and issue new copies. Manual alterations to documents are not allowed without prior approval to ensure several different copies of the same protocol are not in use at the same time. Superseded copies of documentation should be collected and disposed of.

Quality control and performance checks are essential. The performance of equipment should be routinely checked at regular intervals e.g. when used for measurement of physical properties (e.g. mass, temperature, radioactivity etc.) and when the accuracy of measurement is critical, or for separation, transformation, or identification of compounds and elements (e.g. GC, HPLC, GC-MS, NMR, EPR etc.). The appropriate standards, reference, or calibration materials should be used and limits for acceptable performance defined in SOPs. Records should be made of performance checks, including operator, date, and identity of the standards, reference, or calibration materials. Appropriate quality control measures should be taken during conduct of the work. For example (a) use of replication, sample blanks, standards etc.; (b) verification of correct content, format, and function of documentation and software; and (c) records of quality control measures should normally form part of the experimental results.

With respect to monitoring, if staff members follow the principles outlined herein, then their work should be of an acceptable high standard. In essence, reliance is placed on staff and their supervised students to judge how well their own work measures up to the principles. Nevertheless, some form of independent monitoring of conformance with the general principles of quality is beneficial, and is obligatory in accredited workplaces. An independent observer should carry out a brief assessment within each area, reporting back any problems, deficiencies in existing practices, possible improvements, and evidence of best practice. All findings should be followed up. From time to time, staff and students should get together to discuss quality-related matters, including the outcomes of monitoring. All the above can be done effectively on an informal basis. In areas covered by formal certification of accreditation, however, there is a formal programme of internal Quality Audits and Reviews. Audits, review meetings, production of reports, and identification of corrective and preventative actions occur at regular intervals. In addition, the certification body carries out an on-going programme of surveillance with regular on-site external audits (every 6 months for ISO 9000). Sponsors, grant-awarding bodies, and contracting bodies can also insist on their own quality audits.

7. Additional Information

Documentation (SOPs, Log pages etc.) used within areas covered by ISO 9000 certification is widely available as models. All of the matters covered here are described in the institution's Quality Manual and available online from the institution's website. The Quality Manual is based on the general requirements of international quality systems and simplified where appropriate.

C. Quality Plan

- The following lists a number of Quality Assurance measures that are applied in the laboratories and workplaces in the institution
- All staff and their supervised students are responsible for the quality of their own work activities. Senior staff, line managers, and supervisors are responsible for ensuring the overall quality of work in their own area of responsibility
- Quality representatives have the responsibility for coordinating the implementation of these measures
- All staff must be adequately trained for the work they do
- All staff and supervised must have an institutional notebook that should be used in the correct manner to record the conduct of their work
- Written protocols (Standard Operating Procedures; SOPs) for routine laboratory and workplace activities should be prepared. They should be in a form that cannot be easily changed by unauthorised persons
- All equipment must be functioning correctly when used, and should be used in the appropriate way
- Equipment must be appropriately maintained as determined by individual circumstances. Unserviceable or incorrectly functioning equipment must not be used
- Records of maintenance and servicing must be kept
- Staff and supervised students should be trained in the correct use of equipment
- Simplified instructions (SOPs) for operating the major items of equipment must be prepared
- Instrumentation logbooks must be used to record use of major items of equipment

- Equipment logbooks must be hardbound, have numbered pages, and can be entirely handwritten (legibly and indelibly) or they can consist of pre-printed pages bound in an appropriate manner
- Experimental and observational data etc. must be clearly recorded in the appropriate medium (e.g. official notebook, data-recording forms, and computerised data-recording systems)
- The data and information must be inter-related by use of appropriate means of identification

D. Standard Operating Procedures (SOPs)

Introduction

SOPs should be kept up to date and available where the procedure described is being applied. They should be as simple as possible. For long and complex work activity it may be best to sub-divide the work into a number of short SOPs. It is not normal practice to prepare SOPs for one-off or rarely used procedures. SOPs should be prepared by the individuals carrying out the procedure, using the language and style at the author's discretion subject to the needs of the principle users and permission of the supervisor. Changes to SOPs must only be made by the responsible person. It is likely that similar documents will be prepared in several work areas in the institution so it should be possible to operate a standard format.

Suggested SOP Format

- Each SOP should have a tittle page with (a) a concise title and a SOP code (e.g. location of work area, subject identifier etc.). The Quality Representative in each area should maintain a master list of all SOPs and their codes. (b) A version number, indicating revisions. (c) Document file name. (d) Identifier of the author, approval of content by a knowledgeable colleague, and authorisation for use by the line manager or senior member of staff. The relevant person(s) should sign and date the title page. These functions can be combined if necessary. (e) Date of implementation subject to authorisation
- Section 1: Introduction. This covers purpose, scope, responsibilities, hazard warnings or safety precautions, and principle
- Section 2: Procedure. This covers inputs to process (reagents, materials, apparatus required); outputs from process (nature of results, products of process); control mechanism (quality-control measures); and procedure (list of actions performed). Some of these items may be omitted depending on the nature of the procedure
- Appendix if necessary

- It is recommended that each principle section should begin on a new page and section pages should be numbered as in the form e.g. Page 1.2 of 1 (i.e. page 2 of Section 1). This makes it easier to update parts of the SOP without reprinting the whole document. Each page should also indicate the current (most recent) version number, and the SOP title and code in order to prevent possible mix-up of pages from different SOPs

E. Equipment Logbooks

Primary Content of Logbooks

The type of information recorded will depend on the nature of the activity, but will typically include some or all of the following.

- Date of use and identity of user
- Identification (usually a numbered code) and details/description of any materials/samples processed
- Procedure employed, especially if there is multi-option capability
- Data files/directory (where the raw data are stored in computer files)
- Additional information for details not recorded elsewhere

Additional Information for Inclusion

- Instructions for the use of the logbook
- Location and identification of the equipment (manufacturer, type, model, serial number, date of manufacture)
- Service/maintenance arrangements and history
- Identities of the persons responsible for the equipment, and list of authorised users
- Project or contract numbers where relevant

The logbooks should be durable and hardbound. Channel-binding machines are suitable for hard-binding custom-designed pre-printed sheets with a provision for page numbering.

References

1. Badran A, Baydoun E, Hillman JR (eds) (2018) Universities in Arab countries: an urgent need for change. Springer. https://doi.org/10.1007/978-3-319-73111-7. ISBN 978-3-319-73110-0
2. Hillman JR, Baydoun E (2018) The future of universities in the Arab region: a review. In: Badran A et al (eds) Universities in Arab countries: an urgent need for change. Springer, pp 1–53. https://doi.org/10.1007/978-3-319-7311-7_1

3. Waterbury J (2019) Reform of higher education in the Arab world. In: Badran A et al (eds) Major challenges facing higher education in the Arab world: quality assurance and relevance. Springer, pp 133–166. https://doi.org/10.1007/978-3-030-03774-1_7
4. Hillman JR, Baydoun E (2019) Quality assurance and relevance in academia: a review. In: Badran A et al (eds) Major challenges facing Arab higher education in the Arab world: quality assurance and relevance. Springer, pp 13–68. https://doi.org/10.1007/978-3-030-03774-1_2
5. The Organisation for Economic Co-operation and Development. https://www.oecd.org/about/
6. New Growth Theory (2018) Economics Online. http://www.economicsonline.co.uk/Global_economics/New_growth_theory.html
7. Cortright J (2001) New growth theory, technology and learning: a practitioner's guide. Review of economic development literature and practice: no. 4. Impressa Inc. Oregon and U/S. Economic Development Administration. http://philo.at/wiki/images/Growth-theory-cortright.pdf
8. P21 Partnership for 21st Century Learning. http://www.p21.org/about-us/p21-framework
9. Sidorkin AM, Warford MK (eds) (2017) Reforms and innovation in education, Science, technology and innovation studies. Springer, Cham. https://doi.org/10.1007/978-3-319-60246-2_1
10. Rogers P, Daines S (2014) A safe space for humanity: the nexus of food, water, and climate. Asian Development Bank Briefs No 20 https://www.adb.org/sites/default/files/publication/41595/safe-space-humanity-adb-brief-020.pdf
11. The Future of Jobs. World Economic Forum. http://reports.weforum.org/future-of-jobs-2016/
12. Intangible Asset (2018) Investopedia. https://www.investopedia.com/terms/i/intangibleasset.asp
13. http://www.enqa.eu/indirme/papers-and-reports/occasional-papers/ENQA%20Excellence%20WG%20Report_The%20Concept%20of%20Excellence%20in%20Higher%20Education.pdf
14. https://www.merriam-webster.com/dictionary/academia
15. Frequently Asked Questions: IP Policies for Universities and Research Institutions. Key issues and core concepts. World Intellectual Property Organization. http://www.wipo.int/about-ip/en/universities_research/ip_policies/faqs/index.html
16. (a) Intellectual property (2018) University of Leicester, UK. https://www2.le.ac.uk/offices/researchsupport/integrity/code-of-conduct/4-during-research/4-1-intellectual-property; (b) Policy for the Treatment and Governance of Intellectual Property (2018). University of Leicester, UK. https://www2.le.ac.uk/offices/red/documents/commercialisation/IP%20Policy.pdf
17. https://www.merriam-webster.com/dictionary/innovation
18. https://en.wikipedia.org/wiki/Creativity
19. Mumford MD (2003) Where have we been, where are we going? Taking stock in creating research. Creat Res J 15:107–120. https://doi.org/10.1080/10400419.2003.9651403
20. Brandt A, Eagleman D (2017) The runaway species: how human creativity remakes the world. Catapult. ISBN-13-9781936787524
21. Wilson EO (2017) The origins of creativity. Liveright (WW Norton & Company). ISBN-13-9781631493188
22. http://www.businessdictionary.com/definition/entrepreneurship.html
23. The Economist at 175. Reinventing liberalism for the 21st Century (2018) The Economist. September 15th 2018, pp 45–54
24. Mercantilism (2018) Investopedia. https://www.investopedia.com/terms/m/mercantilism.asp
25. Kruger AP (1974) The political economy of a rent-seeking society. Am Econ Rev 64:291–303
26. Dabla-Norris E, Wade P (2001) Rent seeking and endogenous income inequality. International Monetary Fund IMF working paper WP/01/15. https://www.imf.org/external/pubs/ft/wp/2001/wp0115.pdf
27. The Precautionary Principle. World Commission on the Ethics of Scientific Knowledge and Technology (2005) United Nations Educational, Scientific and Cultural Organization (UNESCO). http://unesdoc.unesco.org/images/0013/001395/139578e.pdf

28. Free exchange. The digital proletariat. Finance and economics. The Economist. January 13th 2018, p 69
29. Peak Valley. The Bay Area's primacy as a technology hub is on the wane. Don't celebrate (2018) The Economist. September 1st 2018, p 9
30. Global Competitiveness Index (2017–2018) World Economic Forum https://widgets.weforum.org/global-competitiveness-report-2017/
31. The Global Innovation Index https://www.globalinnovationindex.org/analysis-indicator
32. What is Intellectual property? World Intellectual Property Organization (WIPO). http://www.wipo.int/about-ip/en/
33. Trade-Related Aspects of Intellectual Property Rights (TRIPS). World Trade Organization. https://www.wto.org/english/tratop_e/trips_e/trips_e.htm
34. European Patent Office https://www.epo.org/index.html
35. The International Union for the Protection of New Varieties of Plants (UPOV) (2019) https://www.upov.int/about/en/upov_system.html
36. Plant breeders' rights (2019) Wikipedia https://en.wikipedia.org/wiki/Plant_breeders%27_rights
37. Patent (2018) BusinessDictionary.com http://www.businessdictionary.com/definition/patent.html
38. United States Patent and Trademark Office. https://www.uspto.gov/ https://www.copyright.gov/registration/
39. https://www.wikihow.com/Copyright-Material-(US)
40. Intellectual property rights. European Union. https://europa.eu/youreurope/business/start-grow/intellectual-property-rights/index_en.htm
41. European Union Intellectual Property Office. https://euipo.europa.eu/ohimportal/en
42. Arab Society for Intellectual Property. http://www.aspip.org/Default.aspx?&lang=en
43. Al Balushi R, Hasna S (2015) Understanding Copyright in the Arab World. Global Voices 27/4/2015. https://globalvoices.org/2015/04/27/copyright-term-arab-world/#
44. The TRIPS Agreement and the Conventions referred to in it. World Trade Organization. https://www.wto.org/english/tratop_e/trips_e/ta_docs_e/1_tripsandconventions_e.pdf
45. World Economic Outlook. Uneven Growth; Short- and Long-Term Factors (2015) International Monetary Fund. https://www.imf.org/~/media/Websites/IMF/imported-flagship.../ft/.../_text-pdf.ashx
46. An empire of the mind. Schumpeter. The Economist September 15th 2018, p 74
47. International Association of Science Parks and Areas of Innovation. https://www.iasp.ws/
48. Unique selling proposition (2018) Whatis.com. https://whatis.techtarget.com/definition/unique-selling-point-USP
49. Common Reporting Standard (2018) Organisation for Economic Co-operation and Development. https://www.google.com/search?q=common+reporting+standards&ie=utf-8&oe=utf-8&client=firefox-b
50. Doing Business (2018) Reforming to create jobs. World Bank Flagship Report. http://www.doingbusiness.org/content/dam/doingBusiness/media/Annual-Reports/English/DB2018-Full-Report.pdf
51. Ease of doing business index. World Bank Group. https://data.worldbank.org/indicator/ic.bus.ease.xq
52. Informal economy (2018). BusinessDictionary.com. http://www.businessdictionary.com/definition/informal-economy.html
53. Beattie A (2018) The role of commercial banks in the economy. Investopedia. https://www.investopedia.com/articles/investing/062513/role-commercial-banks-economy.asp
54. Crowdfunding (2018) Investopedia. https://www.investopedia.com/terms/c/crowdfunding.asp
55. Problems with Crowdfunding: 7 Hazards to Look Out For. Floship.com. https://www.floship.com/7-potential-problems-with-crowdfunding/
56. Key Challenges and Drawbacks with Crowdfunding (2018) The Small Business. https://www.thebalancesmb.com/key-challenges-and-drawbacks-with-crowdfunding-4116031

57. Definition of angel investment (2018) Financial Times lexicon. http://lexicon.ft.com/Term?term=angel-investment
58. Angel investor (2018) BusinessDictionary.com. http://www.businessdictionary.com/definition/angel-investor.html
59. Venture capital (2018) BusinessDictionary.com. http://www.businessdictionary.com/definition/venture-capital.html
60. Espinal CA (2018) How does an early-stage investor value a startup? Seedcamp. https://seedcamp.com/resources/how-does-an-early-stage-investor-value-a-startup/
61. Unicorn (2018) Investopedia. https://www.investopedia.com/terms/u/unicorn.asp
62. Unicorn (finance) (2018) Wikipedia. https://en.wikipedia.org/wiki/Unicorn_(finance)
63. What does an accountant do? (2018) CareerBuilder LLC. https://www.careerbuilder.com/advice/what-does-an-accountant-do
64. What Start-ups Should Know About Hiring a Lawyer (2018) Themuse. Daily Muse Inc. https://www.themuse.com/advice/what-startups-should-know-about-hiring-a-lawyer
65. Business Plan (2018) Investopedia. https://www.investopedia.com/terms/b/business-plan.asp
66. Business Plan (2018) Entrepreneur Europe. https://www.entrepreneur.com/encyclopedia/business-plan
67. Business plan. Wikipedia. https://en.wikipedia.org/wiki/Business_plan
68. Company (2018) BusinessDictionary.com. http://www.businessdictionary.com/definition/company.html
69. Business (2018) BusinessDictionary.com. http://www.businessdictionary.com/definition/business.html
70. Business. Wikipedia. https://en.wikipedia.org/wiki/Business
71. Supreme Court of the United States. Alice Corporation Pty. Ltd. v. CLS Bank International et al (2014) https://www.supremecourt.gov/opinions/13pdf/13-298_7lh8.pdf
72. Software patents under United States patent law (2018) Wikipedia. https://en.wikipedia.org/wiki/Software_patents_under_United_States_patent_law
73. 2018 reform of EU data protection rules. European Commission. https://ec.europa.eu/commission/priorities/justice-and-fundamental-rights/data-protection/2018-reform-eu-data-protection-rules_en
74. Mandelbaum RJ (2018) Starting your Own U.S. Business as a Foreigner. Investopedia.com. https://www.investopedia.com/articles/personal-finance/032615/starting-your-own-us-business-foreigner.asp
75. Gieske C (2017) The economic importance of brands – seven reasons why brands (still) really matter. British Brands Group and Zeitgeist 365. https://www.britishbrandsgroup.org.uk/2017/08/15/the-economic-importance-of-brands-seven-reasons-why-brands-still-really-matter/
76. Articles of association. Wikipedia. https://en.wikipedia.org/wiki/Articles_of_association
77. Doing Business in the Middle East (2018) Istizada.com. http://istizada.com/doing-business-in-the-middle-east/
78. Doing business in the Middle East (2018) PWC. https://www.google.com/search?q=doing+business+in+the+middle+east&ie=utf-8&oe=utf-8&client=firefox-b
79. Seven Tips for Doing Business in the Middle East. Arab Business Review. http://www.arabbusinessreview.com/en/article/seven-tips-doing-business-middle-east
80. Hemperstall K (2018) What are the Matthew effects? National Institute for Direct Education. https://www.nifdi.org/news-latest-2/blog-hempenstall/399-what-are-these-matthew-effects
81. Matthew effect (2018) Wikipedia. https://en.wikipedia.org/wiki/Matthew_effect
82. Mackintosh-Smith T (2019) Arabs: a 3,000-year history of peoples, tribes and empires. Yale University Press. ISBN 978-0300180282

Can Universities in the Arab Region Become the Engines for Knowledge and Innovation?

Adnan Badran and Serene Badran

Abstract Entrepreneurship and innovation have become the power of the knowledge economy for handling economic instability in the twenty-first century. Startup companies for commercialized delivery of R&D are driving economies to compete globally in the marketplace. Although the Arab region houses more than 800 universities, the culture of building knowledge and innovation is lacking. Higher-education institutions in the Arab region have the infrastructure and resources to support a culture of innovation, but they are not operating together to develop the critical mass among fragmented institutions that operate in isolation, while others lack governance and sound management of financial and human resources to move ideas of students and faculty to maturity. In this weak environment, institutions are not adapting effectively of moving from the current culture of traditional university "business as usual" into an entrepreneurial and innovative climate. To remedy the situation, institutions of higher learning need to set a policy of change to adapt the institution toward the R&D culture and to develop proactive collaborative partnerships to spark innovative ideas, incubate them in catalyzing environments, and attract business firms for employing a well-educated workforce, opening new opportunities of employability, and creating wealth by value-added enterprises to raise the GDP of nations.

Keywords Entrepreneurship · Innovation · Knowledge economy · Startup companies · Commercialization R&D · Arab university culture · University environment · Educated workforce · Employability of graduates

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1 Introduction

Nowadays, the success of higher education can be measured in terms of how deep is the relationship between the university and entrepreneurship. Knowledge drives innovation, but proper education is a must to create critical thinkers, enquirers, explorers, and motivators who are able to shift knowledge to technology and commercialization. In the past, universities lived in an ivory-tower operating environment without bridging with the **"market place"**; nowadays, such universities are rapidly becoming an outdated model. The university should be the hub for creating knowledge through research and disseminating it through education and technology transfer, delivering innovators and entrepreneurs, who may become the vehicles of development and self-employment, opening new opportunities for others to work through startups and SMEs.

Although Steve Jobs, Mark Zuckerberg, and Bill Gates were college dropouts, they were nonetheless exceptional and well educated. The greater the quality and relevance of higher education through higher-education institutions (HEIs), the greater is the resultant social and economic success [1].

Transformation processes are needed to empower students and staff to demonstrate multidisciplinary approaches toward innovative creativity of teaching, research, and societal engagement. HEIs have to take the lead in piloting new curricula, developing new activities to stimulate entrepreneurial mindsets, supporting startups, and linking with businesses and commerce. Erasmus+ provides a platform for linking European with Arab universities in collaborative research leading to commercialization [2].

Evidence-based practices toward value-creating of knowledge resources for innovation become relevant for policy makers in higher education to trigger a change in the organizational structures of universities toward building a knowledge-economy based on human capital resources [3].

Entrepreneurial skills are learnt from experience in an inducing environment where free critical thinking is promoted. Campus life acts as a catalyst to create a culture of innovation to inspire creativity and teamwork and cannot be taught in a simplistic one-go environment.

Undergraduate and graduate youth should form the intensive brain capital supported by high-quality learning with stated intended learning outcomes (ILOs). With proper leadership on the campus and an inviting ecosystem, communities of students with a passion for business and innovation must be cultivated. From expansion of their numbers, they will engage with the market place to solve problems and create startups, and thereby reshape and enhance the economy [4]. In many countries, funding of research by government should be targeted to commercialization to maximize the benefit to both the university and the public [5].

Research in universities provides the fuel for future inventions. If we neglect basic research today, the inventors of tomorrow will not have the basic knowledge to invent and solve problems. Some innovations from research can be implemented rapidly in the marketplace, particularly in the fields of biotechnology, healthcare, nanotechnology, information technology, and artificial intelligence.

Stakeholders generally expect to have tangible outcomes arising from R&D expenditure at public universities. Taxpayers are impatient of spending money without improving their quality of life. Universities have to do some practical R&D if they want to continue receiving funding for research in basic science, humanities, and social sciences.

Universities in the Arab region are mostly teaching universities, where research is done for promotional purposes of faculty members without an aim of commercialization or linking with industry. The perception gap between academia and industry is so wide that there is virtually no funding from industry to academia and no relevance of faculty research to the needs of industry.

The problem here is how to engage university-industry partnerships for collaborative opportunities to advance the innovation-based economy facilitating university-industry linkages for supporting technology-licensing to commercialize products, inventions, and services.

Universities in the Arab region have to identify and support entrepreneurship on campus, helping startups and building successful business models, and changing the culture of public and private universities. In so doing, they will engage with the surrounding communities in building incubation and science-based business parks alongside graduate startups.

Arab universities have moved up in ranking among world ranked universities, due to number of research papers published in peer-reviewed journals, but failed in the delivery of science applications to the marketplace. The Arab region is dependent on imported technology from industrialized countries and certainly is good consumer, while endogenous technology is still traditional and hi-tech industry is almost absent.

2 University in Action: What Needs to Be

To be innovative in thinking, teaching, and research, universities in the Arab region have to be interconnected for creating multidisciplinary research teams.

Entrepreneurs will be vital economic and social engines to create jobs, generate ideas, and attract investment and thus inspire other gifted individuals to follow in creativity and solving problems. A cultural ecosystem needs to be created and supported financially. Inducing legislation should be established with recognition of institution leaders.

Universities should empower students and staff to demonstrate enterprise, innovation and creativity-learning, and social engagement, and to engage with industry and to provide inducing learning and research environments.

3 How to Initiate Innovation

First of all, a country-specific policy has to adopted for higher education and should be disseminated to every university and research center. Universities should develop a strategy of innovation and plan of action for its R&D priorities. Then, teamwork around each priority needs to be established to ensure a critical mass of competencies involving an interdisciplinary approach.

Timetabling and funding of R&D of those priorities must be guaranteed by the institution or the funding agencies. Outcomes should be analyzed for commercial value and feasibility, and viable innovations then turned into incubation.

4 How to Develop Innovation

In principle, the outcomes of R&D are best developed through an incubator facility to innovate into one or more businesses. Thereafter, startup companies with venture capital will carry out the task of commercialization often creating small and medium enterprises (SMEs) in business parks associated with the university. Once they mature, SMEs will graduate into larger companies and move out of the university park, typically to industrialized business zones.

In Hungary, HEIs developed a value-creating use of knowledge resources for innovation and entrepreneurship. They have engaged public-policy actors with leaders of HEIs, and generated an organized culture and new approach of higher education and research for students and staff who are engaged with business. They have received support from the Organisation for Economic Co-operation and Development (OECD) and European Commission through the Tempus and Erasmus programmes [6]. They have developed a proactive approach to integrating new teaching into the curriculum to stimulate entrepreneurial mindsets for startups, and engaged with business at local and global levels. They have built a culture of creativity to deliver the various vehicles of development. Through science, some universities became the engines for national economic and social development [3].

5 How U.S. Universities Stimulate Innovation

Technology transfer with technology-licensing offices has been established in most U.S. universities to commercialize the output of research. There is a focus among universities to identify scholars and support entrepreneurship on the campus for startups.

The culture of U.S. universities among graduates and alumni has been in creating business outlets in their specializations. Caltech and Stanford outlets of R&D for commercialization were in the Silicone Valley that contributed to the wealth of the nation through science in building the knowledge economy. U.S. universities adopting the model of collaboration between academia and startup companies that have based themselves in science parks affiliated with universities and have spun off 5000 startups in the knowledge economy. There are other examples such as: University of Florida Innovation Hub, Nebraska Medical Center for Entrepreneurs and Innovation, University of Pittsburg courses in business innovation and commercialization, University of Colorado at Denver Innovation and Entrepreneurship Center, Bangalore IIT Science Park in India, MIT and Harvard Cambridge Square in Boston, Toronto Triangle, Kuala Lumpur Science Corridor, Chinese Academy of Science research centers for R&D incubators and Science parks, Techno-city in South Korea etc.

6 World Universities of Excellence for Creating Knowledge and Innovation

6.1 Harvard University

Harvard in Cambridge-Boston is a private Ivy League research university founded by John Harvard in 1630. It maintains worldwide leadership in creating knowledge and innovation. It has an endowment of $38 billion with 22,000 students, 15,250 of which are graduate students. Wealth of its graduates equals the total wealth of 90 countries in the world (2018). Nine of its graduates became presidents of United States and 30 foreign heads of states, 158 of its faculty and graduates received the Noble Prize. 188 of living graduates of Harvard are billionaires (2017) and its graduates have founded a large number of companies worldwide. Harvard has the largest academic library in the U.S. with 18 million volumes. Harvard students and alumni have won 48 Pulitzer Prizes, and 108 Olympic Medals. It is ranked within the best 10 universities in Shanghai, Times and QS ranking of top world universities in 2019 [7].

6.2 Massachusetts Institute of Technology (MIT)

Massachusetts Institute of Technology (MIT) founded in 1861, in Cambridge-Boston has endowments of $ 16 billion (2018), and it has been a technology-driven university of research, innovation, and startups. Their graduates are creative thinkers, innovators, and entrepreneurs and are truly a major vehicle of development. The institute is classified as a Land-Grant, Sea-Grant, and Space-Grant university and is a private research university.

MIT graduates created 23,800 companies employing 3.3 million people and their aggregated annual revenues were $ 1.9 trillion equal to the 10th ranking economy nation among OECD countries. MIT produces 169 patents per year, the highest in the world; 93 of its graduates received the Noble Prize, 58 received National Science medals, and 25 National Technology Innovation Medals. Its students number 11,574 of which 6972 are graduate students. It has been ranked by Shanghai, Times, and QS within the world top 10 universities in 2019 [8].

6.3 Stanford University

Stanford University in California is a private research university, and founded by Leland and Jane Stanford in 1885, helped in incubating giants like Hewitt-Packard and Google and helped create Silicone Valley which revolutionized America in technology. Stanford's endowments are $ 26.5 billion and its students number 16,520, 9437 of which are graduate students. Stanford is known for its academic strength, wealth, and proximity to Silicone Valley. Some 83 Nobel Laureates, 27 Turing Award Laureates, and 8 Fields Medalists have been affiliated with Stanford as students, alumni, and staff. In addition, Stanford is particularly noted for its entrepreneurship and is one of the most successful universities in attracting funding for start-ups. Stanford alumni have founded a large number of companies, which combined produce more than $2.7 trillion in annual revenue and have created 5.4 million jobs as of 2011, roughly equivalent to the 10th largest economy in the world and similar to MIT. Stanford is the alma mater of 30 living billionaires and 17 astronauts, and is also one of the leading producers of members of the United States Congress. It has been ranked by Shanghai, Times, and QS within the top 10 world universities in 2019 [9].

6.4 University of Cambridge (UK)

University of Cambridge (UK) founded in 1231 and has endowed fund of £ 12.2 billion, and with 19,955 students, 7610 of which are graduate students. Some 118 of its graduates and faculty members received the Noble Prize. It has graduated 15 British Prime Ministers and 13 foreign heads of states and monarchs. The university is closely linked with the development of the high-tech business cluster known as 'Silicon Fen'. It is a member of numerous associations and forms part of the 'golden triangle' of English Universities and Cambridge University Health Partners, an academic health science center. Cambridge has helped spawn more than 3000 startup companies since it founded its own science park. It has been ranked by Shanghai, Times, and QS within world top 10 universities in 2019 [10].

6.5 University of Oxford (UK)

University of Oxford (UK) is a collegiate research university and is the oldest university in the English-speaking world, was founded in 1096 and since then built 38 self-governing colleges, has endowment funds of £ 6.1 billion, 23,195 students, of which 10,941 are graduate students (2018). It operates the world oldest museum and the largest university press in the world.

Oxford produced 69 Noble Prize Winners, 3 Fields Medalists, 6 Turing Award winners and with its alumni, won 160 Olympic medals, and produced 27 British Prime Ministers, and has been ranked by Shanghai, Times and QS within the top world universities in 2019 [11].

6.6 Imperial College London (UK)

Imperial College London (UK) is a public research university established in 1907; it has endowment fund of £ 157.1 million and a budget of £ 1.027 billion (2018). Its students number 17,690, 8170 of which are graduate students. It has produced 14 Noble Prize Winners, 3 Fields Medalists, 1 Turing Award, 74 fellows of the Royal's Society, 87 fellows of the Royal Academy of Engineering, 85 fellows of the Academy of Medical Sciences, and it has been ranked by Shanghai, Times, and QS within the 10 top world universities in 2019 [12].

6.7 Caltech-California Institute Technology

Caltech-California Institute Technology is a private research university founded as vocational school in 1891, then it turned to its present name in 1921, has endowment fund of $ 2.93 billion. Its students number only 2233, of which 1285 are graduate students (2018). It has produced 73 Noble Prize winners (chemist Linus Pauling, the only individual who won 2 unshared Noble Prizes), 4 Field Medalist, and 6 Turing Awards. It has been ranked first in the U.S. for percentage of its graduates pursuing PhDs. It has been ranked by Shanghai, Times, and QS within the 10 top world universities in 2019 [13] (Tables 1, 2, and 3).

Also, there are excellent universities in the world who have excelled in technology and innovation such as Berkley, Pennsylvania, Cornell, Princeton, Yale, Columbia, Michigan, UCLA, Brown, Duke, Carnegie Mellon, and Indian Institutes of Technology in the U.S. as well as others in Japan, Switzerland, Sweden, South Korea, Singapore, Ireland, Finland, France, UK, U.S., and elsewhere.

Table 1 World university ranking: Shanghai ranking, 2018 [14]

Rank	University	Location
1.	Harvard University	United States
2.	Stanford University	United States
3.	University of Cambridge	United Kingdom
4.	Massachusetts Institute of Technology (MIT)	United States
5.	University of California, Berkeley	United States
6.	Princeton University	United States
7.	University of Oxford	United Kingdom
8.	Columbia University	United States
9.	California Institute of Technology	United States
10.	University of Chicago	United States

Table 2 World university ranking: times ranking, 2019 [15]

Rank	University	Location
1.	University of Oxford	United Kingdom
2.	University of Cambridge	United Kingdom
3.	Stanford University	United States
4.	Massachusetts Institute of Technology	United States
5.	California Institute of Technology	United States
6.	Harvard University	United States
7.	Princeton University	United States
8.	Yale University	United States
9.	Imperial College London	United Kingdom
10.	University of Chicago	United States

Table 3 World university ranking: QS ranking, 2019 [16]

Rank	University	Location
1.	Massachusetts Institute of Technology (MIT)	United States
2.	Stanford University	United States
3.	Harvard University	United States
4.	California Institute of Technology (Caltech)	United States
5.	University of Oxford	United Kingdom
6.	University of Cambridge	United Kingdom
7.	ETH Zurich – Swiss Federal Institute of Technology	Switzerland
8.	Imperial College London	United Kingdom
9.	University of Chicago	United States
10.	UCL (University College London)	United Kingdom

7 Diffusion from Technology to Innovation

Technology emerged from knowledge creation and is the main driver of innovation, slowly in the beginning, but tending to diffuse rapidly afterward, as shown in the S-curve in Fig. 1. Apparently, there is a life cycle of rapid increase in revenues then followed by eventual decline, unless and until new technologies emerge.

8 World Ranking Innovation Countries

The innovation index in ranking countries is based on high tech, manufacturing, patents, R&D, and higher education in term of quality and relevance. Germany and South Korea are leading the world in innovation.

Table 4 shows the innovation index of leading countries in innovation [17].

9 Comparison of Two Universities in the Middle East in Science & Technology Innovation (2019)

There are two English-speaking universities in the Middle East where they have started with the same objectives of technology-based universities to deliver quality and relevance of learning and R&D leading to entrepreneurship and innovation. One is Jordan University of Science and Technology (JUST) in Jordan and the other is Middle East Technical University (METU) in Ankara, Turkey. Let us compare these two academic institutions in teaching, R&D, and innovation:

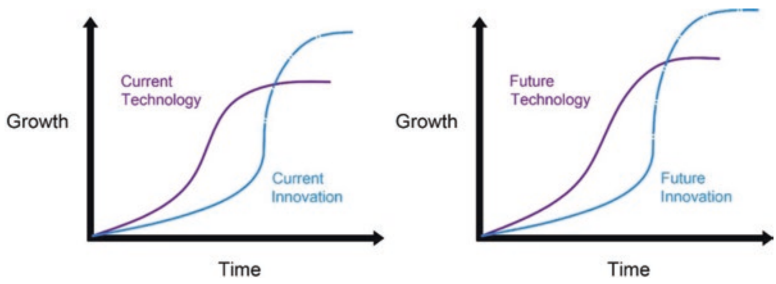

Fig. 1 Graphs illustrating diffusion curves from technology to innovation

Table 4 Bloomberg innovation index 20, 2019 [17]

Rank	Country/territory	Index
1.	South Korea	87.38
2.	Germany	87.3
3.	Finland	85.57
4.	Switzerland	85.49
5.	Israel	84.78
6.	Singapore	84.49
7.	Sweden	84.15
8.	United States	83.21
9.	Japan	81.96
10.	France	81.67

9.1 Jordan University of Science and Technology (JUST)

Jordan University of Science and Technology (JUST) was created in 1976 as part of Yarmouk University in Jordan and then separated in 1986. Its enrollment is of 25,354 undergraduates and 2300 graduate students in an area of 1200 hectares (2019). It is a public university with instruction in English. Its endowment is $ 72 million and considered to be the top research university in Jordan. It has been accredited by U.S. Engineering Accreditation Commission EAC of ABET. It accommodates a 5 MW research reactor, IBM-CloudBurst platform, Biotechnology Center, and Innovation Center. It has been ranked 4th in the Arab region (Times 2019) and 351–400th among world universities ranking. **Although the university created a techno-park, it has failed to deliver innovation, entrepreneurship, and startups. The reason behind this was a weak governance and discontinuity of leadership.**

9.2 Middle East Technical University (METU) in Ankara, Turkey

Middle East Technical University (METU) in Ankara, Turkey was created in 1956 and has 23,800 undergraduates and 7200 graduate students in an area of 4500 ha. It is a public university with instruction in English. Its endowment is $ 400 million and considered as top research university in Turkey. It has been accredited by U.S Engineering Accreditation Commission, EAC of ABET and was ranked 1st in Turkey and was ranked 600–800th among world universities (Times 2019). The university created METU-Technopolis Science Park and succeeded in graduating 240 startups SMEs contributing $ 3–4 billion to Turkey's economy. About 65% of these are specialized in information and communication technologies, 25% in electronics, and 10% in other sectors such as aerospace, environment, biotechnology, nanotechnology, and advanced materials. The Incubation Center at the

METU-Technopolis serves currently 38 start-ups and micro-sized companies, most of which started their life as spin-offs from METU research projects. **The reason behind this success was stable governance and continuity of leadership.**

10 Techno-Science Business Parks in Jordan (2019)

Jordan is situated in the heart of the Middle East; uniquely positioned as a regional entry-point to North Africa, the Gulf countries. Jordan's comparative location allows for diversification and expansion into increasingly affluent markets, and its free-trade agreements have given Jordan access to a market of large consumers [18, 19].

Besides its strategic location, Jordan is characterized by moderation and security in a region prone to actual and potential volatility.

It is a free-market-oriented economy, with outward-oriented economic policies and a private-sector-led approach. Jordan experienced an ongoing privatization of major state-owned enterprises and implemented significant advances in structural and legal reforms. Jordan's human capital marks its strongest asset, and invests in its human resources and generated a competent workforce, while keeping its labor costs competitive in the region.

Jordan has limited natural resources but promising human resources that could become rich national human resources. It has 30 public and private universities with 282,403 students and 10,812 faculty members in teaching and research (2019). Jordan is taking a robust reform scheme in reforming education, starting with student-centered early childhood up to higher education, enquiry-based education, stimulating-critical thinking, discovery with intended learning outcomes (ILOs), and competency. However, linking higher education and research with industry and social needs remain the challenge of universities and research institutes to close the gap between academia and the marketplace.

Therefore, Jordan has created two science business parks to incubate the delivery of R&D from universities and research centers. Business Parks are aiming to bridge research institutes with hi-tech-based companies abroad to enhance innovation and thereby the Jordanian knowledge economy. The overall objective is to open new employment opportunities in technology-based industries, and raise the nation GDP. These two techno-parks are:

10.1 King Hussein Business Park (KHBP)

A high-quality mixed-use landmark complex in Amman, housing over 75 international and local companies, over 100 startups and employing over 4000 people. King Hussein Business Park (KHBP) [18] offers more than 120,000 sq. m of ready-to-use office space integrated with commercial, retail, amenities, and public outlets.

A master plan was set in place to accommodate more businesses, attract investors, and add more missing elements of entertainment, residential, and complimentary components to the current business compound.

In its current phase KHBP has succeeded in attracting key international, regional and local companies, and startups reaching a 95% occupancy, thereby fostering its standing as Jordan's dynamic and vibrant business hub and an incubator of creativity and innovation. Accordingly acting on the high demand by international and local companies, KHBP is moving forward with expansion plans through the preparation of a Strategic Conceptual Master Plan, over 1.4 million sq. m of land, creating a development opportunity of over 3.5 million sq. m of a mixed innovative business park.

It will be providing a platform for the future growth and development of Jordan and enhancing its competitiveness in attracting quality investments. Future phases of development will ensure that KHBP will remain an active and vibrant urban community, integrating its international-standard office spaces and business environment with mixed-use development and support areas that are equipped with an extensive ICT infrastructure. It is now the home to over 40 major companies with branches located in Amman such as Hewlett-Packard, Rubicon LG, New Think Festival, and Zain Innovative Campus (ZINC) and others.

KHBP houses currently the following research institutes, learning and training infrastructure, funding resources, and venture capital banks (2019):

- Crown Prince Foundation
- CISCO
- German Jordanian University
- Jordan Bromine Company
- SITA
- Cheil
- Mastercard
- USAID
- Microsoft
- Seven Circles
- Arabia Weather
- ORACLE
- Kingdom Group
- Samsung
- Ericsson
- Oasis 500
- King Abdulla II Fund for Development
- Kbw-LITEON
- CRDF-Global
- King Abdulla II Centre for Excellence
- Arabia Cell
- IATA
- Bayer

- MBC Group
- Samsung R&D Institute, Jordan
- Migrate
- Al Faisaliah Healthcare System Co. (FHS)
- EHS-Hakeem
- Al-Mamlaka TV
- German Jordanian University-Consultation & Training Center
- Bank al Etihad
- Al Raya Group
- Umniah-Data Center
- Jordan Ahli Bank-Data Center
- NAMA
- Aramex
- Al Hussein Technical University
- Unilever
- Al Haq
- Gaming Lab
- Iman 1
- Al Wakeel

10.2 Al-Hassan Science City Houses the Following Technological Universities and Leading Science Institutes (2019)

- Higher Council for Science and Technology (HCST).
- Princess Sumaya University of Technology (PSUT).
- Royal Scientific Society (RSS).
- Human Resources Development Center.
- National Statistic Center.
- Arab Thought Forum
- National Center of Information Technology.
- National Geographical Center.
- Islamic World Academy of Science.
- iPARK

10.2.1 iPARK Overview

The iPARK Business Incubator was established by the Higher Council for Science and Technology (HCST) in May 2003, and was accommodated in the Royal Scientific Society (RSS) campus surrounded by the University of Jordan (JU), Princess Sumaya University of Technology (PSUT), and research and training institutes.

iPARK has continuously helped companies to become market leaders. Today, graduated companies are collectively valued at over USD 50 million, and provide thousands of high valued jobs. iPARK was the first technology-focused incubator in Jordan. It takes the R&D delivery of universities and research institutes, to incubate for startups.

Both iPARK and HCST supported other incubators in national universities including Jordan University (JU), Yarmouk University (YU), University of Petra (UOP), and JIC network of 12 incubators. iPARK is a founding member of the Arab Business Incubator Network under the World Bank.

iPARK specializes in enabling and accelerating the growth of startup companies through its effective incubation facilities, globally recognized entrepreneurship programs, commercialization and intellectual property expertise, matchmaking opportunities with serious investors, and unique industry networking events [19].

The University of Petra is part of the Tech-Transfer Network managed by IPCO @ iPARK. Furthermore, IPCO @ iPARK conducted the following tasks in 2019:

- Assessed 15–20 innovations.
- Drafted 5 patents for filing as international patents.
- Advised and supported the adjustment of the university IP policy.

10.2.2 iPARK in Numbers (2013)

Number of Parks	• 3 iPARKs in the North, Center, & South of Jordan, 1 iPARK powered incubator in AMMAN funded by Google.
Number of incubates	• Total number of incubated & graduated startups reached 200+ startups
Number of jobs created	• 2,000+ jobs
Number of technologies assessed	• IP team assessed 800+ technologies and patent requests
Number of patents awarded	• 100 patents for inventors and researchers awarded.
IP policies drafted	• 20+ organizations and universities drafted their IP policies

10.2.3 Sample of International Customers-iPARKS, Jordan (2013)

11 Universities in the Arab World Must Invest in R&D

The Arab world has always valued the creation of knowledge: this is where algebra and Arabic numerals were invented, and is the home of the world's first university and hospital. But addiction to oil with its huge income has not helped in building human capital through investing in research and innovation. Arab countries allocate between 0.3% and 0.73% of their GDP in R&D as compared to EU at 2.0%, US at 2.8%, Japan and South Korea 3.4%, and Israel at 3.8%. The formula is well known for developing the knowledge-economy successfully by producing R&D through collaboration between industry, entrepreneurs, and academia. The chemistry between those players tend to spark innovation, generating giant startups, and changing the industrial and economical landscape of the Arab region.

However, there are new trends of some universities undertaking new approach to R&D leading to innovation. The Lebanese University with CERN have a joint venture to produce more efficient irrigation systems that cut irrigation costs from $500 to $80 per hectare and cut water consumption. Another one is the invention of electromagnetic diabetes monitoring device, which was developed by Maroun Semaan

Table 5 Dimensions and mechanisms of academic entrepreneurship [21]

Dimensions	Mechanisms
Organizational creation	Start-up companies
	University spin-offs
	Joint venture
Organizational renewal	Research groups
	Research centers
	Technology transfer Schemes
Organizational innovation	Patenting
	Licensing
	Design rights

School of Engineering and Architecture and the Faculty of Medicine at the American University of Beirut (AUB) [20].

Malaysian Universities developed an integrated framework for academic entrepreneurship and innovation in higher education, taking into account linkages between government, university, and industry [21]. Malaysian universities are no longer viewed only as the creator of knowledge and produce only the human capital and industry workers, but in the twenty-first century, Malaysian universities have to pursue academic entrepreneurship and innovators to deliver engines of sustainable technological development for economic growth (Table 5).

12 Reforms of Arab Education: Innovation from Schooling to Learning

Arab education needs to engage with the concept of innovation to empower the generation and deployment of knowledge in pluralistic societies. Holistic approaches of education to meet today's labor market will be based on less teaching and more on the fundamentals of learning to engage schooling with social participation and active citizenship encompassing human rights and values of democracy.

Two obstacles stand in the way of achieving a good performance of quality education; one relates to the status of the teaching profession and the other relates to overall governance of the education system. Schooling does not attract the best talented teachers of subject skills and pedagogy pay-wise and in social status.

Centralized systems of authoritative curricula, textbooks, and what to teach leave no room for debates and critical thinking. Teachers are transmitters of information and students are examined of how much they have absorbed. Students have no choice but to become "blind initiators" or "rejecters" of foreign ideas. The outcome will be disengaged citizens and angry rebellions of potential emigrants wanting to leave their society behind [22].

Arab educators agree that education should lead to outcomes of constructive citizenship. Students should become the vehicles of change to become reflective learners, innovative and critical thinkers, and promoters of ethical social responsibility. Upgraded education requires a new learning ecosystem that is student-centered, with problem-based learning and real-world learning that spark innovation and entrepreneurship.

Philosophy and logics, world history, and other learning materials are absent from most Arab curricula. Utilization of smart phones provides new learning tools for students to think “outside the box” and look for new ways of developing skills beyond the classroom, where equity of access to knowledge is provided to all. Probably, we have to train a new generation of teachers who overcome the traditional way of teaching enabling them to move into technology-based-learning, blended-learning utilizing multi-media, and interactive debate on problem-solving.

The University of Petra (UOP) in Jordan has started a business incubator called SIQ and put forward an operation framework and business plan with SPARK to incubate startups that (a) works on software development solution; and (b) provides marketing and media services. Excelling students and UOP graduates are teaming up for startup companies related to these fields at SIQ.

Also, the UOP Pharmaceutical Center (UPPC) has built a distinguished hub for advanced pharmaceutical research labs and training to deliver custom-designed consultations, undertakes research and other training to meet the demands of pharma-clients to stay on the cutting edge of new pharmaceutical technologies and quality assurance to conform with international standards using experienced scientists and experts. The R&D center is undertaking collaborative research with drug industries.

In addition, an innovation center at the ICT college was created with incubator ecosystem framework for students, graduates, and staff for startups (University of Petra-SIQ Business incubator ecosystem framework) [23].

13 Building a Culture of Innovation

The words creativity and innovation are commonly used by higher-education institutions but are hardly implemented. As centers of knowledge, universities have to create the so-called ecosystem of innovation and entrepreneurship on the campus, or otherwise they would fail their mission. The complex challenge to prepare future generation will not be solved by traditional instruction in the class room, but will be by creative participation to create ideas.

Creativity is defined as a function of knowledge and imagination to create new ideas. It leads to discovery, invention, and reasoning. Isaac Newton (1687) a physicist, discovered the mathematical description of the fundamental force of universal gravitation and the three laws of motion. In 1898, Marie and Pierre Curie, chemists, discovered polonium and radium in pitchblende, and coined the term radioactivity. Creativity led Alexander Graham Bell to invent the telephone, but it would have been invented without Bell, since the underpinning science was there, but the process would have taken longer.

Creation, which is the climax of creativity, can be illustrated by the play Othello, the Elizabethan drama would not have been written without Shakespeare. Similarly, Guernica would not be created without Picasso. Creativity is not taught but fostered through an inducing innovative ecosystem or environment [24].

Innovation can be incremental or radical. Innovation involves finding entirely new ways to do things. If we look at Dell or Amazon, their great innovations are in business models rather than in new products. Most larger organizations may be good at incremental but not at radical innovation.

The World Bank (WB) in 2015 indicated that innovation and entrepreneurship are the key to address major development and they spur productivity and economic dynamism. Between 2000 and 2013, the WB invested $18.7 billion in innovation projects [25].

Research outcomes from new novel companies started by young people contributed to net employment growth and enhanced competitiveness and productivity by introducing new products. These in turn opened new markets, particularly in developing economies. Firms are likely to succeed within healthy innovation ecosystems which are based on human capital, R&D, financial venture capital, an industrial base, appropriate legal and regulatory environment, buoyant business and innovation cultures, and high quality networks. Comprehensive innovation policies would integrate these elements to yield productive interactions essential for successful startups.

The WB has set a strategy for entrepreneurial assessment summarized in the following:

- Identifying current performance and opportunities.
- Designing targeted solution.
- Strengthening policy design and governance.
- Engaging globally with stakeholders.

An evidence-based analysis of Ireland's higher education transformation using the OECD-European HEI-innovate guidance for innovation and entrepreneurship, demonstrated that higher education played a critical role in the Irish economy based on engagement agenda with industry and local communities, the emergence of new learning environments and research team (OECD, 2017) [2]. Trinity Colleges Dublin entered into 100 research agreement with industry and it accounts for one-fifth of all spin-out companies from Irish higher-education institutions in ICT, nanotechnology, and medical devices. Trinity's innovation strategy reflects commitment for harnessing creativity in providing the best educational environment for learning the skills of business and entrepreneurship. Trinity is developing an incubator hub where techno-cultural and scientific ecosystems merge in creating values and sustainable jobs [26].

14 How to Enhance a Vibrant Innovation and Entrepreneurship Ecosystem in the Arab Region

With an enormously large young generation in the Arab region and quantitatively large infrastructure of schools, colleges, and universities, it is clear that synthesizing rich human resources through reforming education is the only way to overcome unemployment and poverty. Arab youth comprise 60% of the total Arab population of around 384 million, and by 2020, the Arab region has to create 75 million jobs, just to keep employment close to current levels.

Policy makers, business leaders, academia, and civil society are called on to collaborate with clear plans for job creation. The key to job creation will be fostering a business environment to spread innovation and spur economic activity through startups. The Forum of Young Global Leaders at the World Economic Forum (WEF) at the Dead Sea with Booz and company have put a visionary plan to engage the youth in innovation and entrepreneurship for startups to open new horizon for work for economic development of the MENA region [27].

Entrepreneurs will be vital engines to drive the transition. Their efforts would create jobs, generate ideas, attract investment, and inspire others. There are gifted individuals that we need to hunt for, to create the innovative ecosystem. They need recognition from the region's leaders.

Young Global Leaders at WEF in the Dead Sea (October 2011) concluded that there are 10 imperatives to build a sound entrepreneurial ecosystem leading to innovation in the MENA region:

1. Offer a helping hand. Established entrepreneurs should give time, advice, and seed funding to aspiring entrepreneurs.
2. Change behaviors and evolve the culture. Discuss entrepreneurship every day and generate a hub around a handful of success stories.
3. Bring entrepreneurship to the classroom. Everyone in high school and university should learn entrepreneurial principles.
4. Bring entrepreneurship to the office. Companies should encourage employees to unleash their own talent.
5. Do not imitate Silicon Valley. Identify and leverage your country's own unique resources.
6. Welcome new ideas. Engage domestic and foreign workers to encourage a free flow of expertise and enterprise.
7. Break the stereotype. Great entrepreneurial ideas can come from anyone in any industry.
8. Embrace the diaspora. Tap successful entrepreneurs living abroad for their advice and connections.
9. Eliminate red tape. Governments should give many kinds of support to all types of entrepreneurs.
10. Expand the venture capital (VC) model. VCs need to go beyond funding and provide a support structure for entrepreneurs.

15 Conclusion

In this contribution, we pointed out the landscape of quantitative higher education spreading all over the Arab world, but the delivery of rich human resources of entrepreneurship leading to innovation and startup companies is a prerequisite to overcome unemployment and poverty.

Although R&D outputs of universities are on the increase as indicated and cited in international peer-reviewed journals, much of the R&D lacks application to industry and the marketplace. Collaboration between academia and industry is crucial for problem-solving and increasing the potential of human capital in the knowledge economy to provide wealth and higher GDP.

The region has great potential through its youth, exceeding 60% of Arab population of more than 384 million, but it has to come from profoundly reforming education from early childhood to build creativity, critical thinking, an enquiry-based and student-centered education to spark the mighty minds to become inventors, problem-solvers, and disciplinary and multidisciplinary leaders to bring ideas and innovations to establish startups.

Policy-makers, academia, and business leaders must identify what motivate people to start up a business. Then they should identify what hinders the creation of a healthy entrepreneurial culture leading to an ecosystem of innovations and they should assist in weeding out obstacles by introducing facilitatory legislation and regulatory frameworks, improved infrastructure, improved education from schools to academia, new research centers, state-of-the-art R&D, equity investors, adequately financing SMEs, professional marketing, etc.

The region with the potential of its youth and with investment in the knowledge economy will undoubtedly become a dynamic global center for entrepreneurial ventures and innovations. Big ideas may come in the future from the Arab world as it used to be in older times.

References

1. Michelacci C (2015) Are they all like Bill, Mark, and Steve? The Education Premium for Entrepreneurs (PDF) EIEF. Retrieved 27 Nov 2015
2. OECD Website (November 29, 2017) Supporting entrepreneurship and innovation in higher education in Hungary. www.OECD-ilibrary.org
3. HEInnovate (2017) https://heinnovate.eu/en
4. Times Higher Education World University Ranking (2019) Why universities should encourage student entrepreneurship. https://www.timeshighereducation.com/student/advice/student-blog
5. Thorp H (2015) Why we need innovation and entrepreneurship in higher education. https://holdenwu.wordpress.com/2015/08/08/why-we-need-innovation-and-entrepreneurship-in-higher-education/
6. Ministry of Higher Education (2018–2019). http://www.mohe.gov.jo/en/pages/BriefMohe1.aspx

7. Harvard University (2019) Cambridge-Boston. https://en.wikipedia.org/wiki/Harvard_University
8. Massachusetts Institute of Technology MIT (2019) Cambridge-Boston, MA, U.S. https://en.wikipedia.org/wiki/Massachusetts_Institute_of_Technology
9. Stanford University, U.S. (2019). https://en.wikipedia.org/wiki/Stanford_University
10. University of Cambridge (2019). https://en.wikipedia.org/wiki/University_of_Cambridge
11. University of Oxford, U.K (2019). https://en.wikipedia.org/wiki/University_of_Oxford
12. Imperial College London, U.K (2019). https://en.wikipedia.org/wiki/Imperial_College_London
13. California Institute of Technology, U.S (2019). https://en.wikipedia.org/wiki/California_Institute_of_Technology
14. Academic Ranking of World Universities (2018). http://www.shanghairanking.com
15. Times Higher Education World University Ranking (2019). https://www.timeshighereducation.com/search?e=404&search=world%20university%20rankings%202019%20world
16. QS World University Rankings (2019). https://www.topuniversities.com/university-rankings/world-university-rankings
17. Bloomberg Innovation Index (2019). https://datawrapper.dwcdn.net/3hi4O/2/
18. King Hussein Business Park KHBP (2019). http://www.businesspark-jo.com/en-us/KHBP-Community/Tenants
19. Royal Scientific Society (RSS) of Jordan (2013). http://www.ipark.jo/iparkjo/Default.aspx
20. Sehnaoui N (September 2005, 2017) The Arab world needs to get back to R&D basics. https://gulfnews.com/business/analysis/the-arab-world-needs-to-get-back-to-rd-basics1.2085132
21. Yusof M et al (January 2012) Academic entrepreneurship and innovation in higher education: an integrated framework for Malaysian universities. http://www.wseas.us/e-library/conferences/2010/Tunisia/EDUTE/EDUTE-04.pdf
22. Muasher M, Brown NJ editors Carnegie (2018) Engaging society to reform Arab education: from schooling to learning. https://carnegieendowment.org/2018/10/11/engaging-society-to-reform-arab-education-from-schooling-to-learning-pub-77454
23. University of Petra Startup Incubation Quarter (SIQ) (2019) SIQ-SPARK project report. University of Petra, Amman, Jordan. https://www.uop.edu.jo/en/Academics/FAFS/BusinessIncubator/Pages/default.aspx
24. Mansouri A (December 19, 2015) Building a culture of creativity and innovation in higher education institutions. https://www.linkedin.com/pulse/building-culture-creativity-innovation-higher-ali-mansouri/
25. The World Bank (July 8, 2015) Innovation and entrepreneurship. http://www.worldbank.org/en/topic/competitiveness/brief/innovation-entrepreneurship
26. Trinity College Dublin (2017) Strategy for innovation and entrepreneurship. https://hea.ie/assets/uploads/2017/04/TCD-Appendix-Innovation-and-Entrepreneurship.pdf
27. Aikman D, Dusek M, Banerji S (October 2011) World economic forum report accelerating entrepreneurship in the Arab world. http://www3.weforum.org/docs/WEF_YGL_AcceleratingEntrepreneurshipArabWorld_Report_2011.pdf

Building a Culture of Innovation and Entrepreneurship in Universities

Quintin McKellar

Abstract Creating a culture of innovation and entrepreneurship within the university sector may be considered to have two important objectives: the first is to create that culture within the academic and professional staff of the institution thus engaging the business community more effectively. This aspect has been considered previously in a 'Higher Education in the Arab World' conference (McKellar Q, Business engagement is no longer an optional extra for universities. In: Badran A, Baydoun E, Hillman JR (eds) Universities in Arab countries: an urgent need for change. https://doi.org/10.1007/978-3-319-73111-7_6, 2018) and has been shown to be critical to the innovative health and financial sustainability of the university sector. The second objective is even more important. It involves the innovation and entrepreneurship of the current students and recent graduates produced by universities. In the US, high-growth businesses have been shown to have upwards of 95% graduate employees, 45% of whom also hold advanced degrees (Volkmann C, Wilson K E, Mariotti S, Rabuzzi D, Vyakarnam S, Sepulveda A, Educating the next wave of entrepreneurs: unlocking entrepreneurial capabilities to meet the global challenges of the 21st century. A report of the global education initiative for the World Economic Forum. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1396704, 2009). On the other hand, businesses that lag behind in productivity in the UK have been shown to be those with fewest graduates (Wadhwa V, Aggarwal R, Holly K, Salkever A, The anatomy of an entrepreneur: making of a successful entrepreneur. https://www.kauffman.org/~/media/kauffman_org/research%20reports%20and%20covers/2009/07/makingofasuccessfulentrepreneur.pdf, 2009).

Graduates are clearly good for business and the economy, and this presentation will make the case that their contribution can be enhanced further by specific enterprise and entrepreneurship education. Enterprise education might effectively change the mindset or attributes of a graduate toward improvement and innovation; this could lead to the creation of new business or improvement within a business or in a broader community, society or environment. It is best embedded fully within curricula and can be effectively taught through experiential action learning. It is applicable across all disciplines and subject areas. Entrepreneurship education should

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confer the skills, knowledge and attributes helpful for the establishment of a new business. It can be taught by traditional educational methodology including didactic lectures and may comprise bolt-on modular sessions. It is most often taught specifically within a business school and embraces essential libertarian philosophy about the freedoms to create wealth in private sector enterprise. The case supporting 'teaching' or 'education' in either enterprise or entrepreneurship is strong although it may be more appropriate to use terms such as 'nurture' or 'encourage' since both are likely to reap more fertile rewards in those already inclined towards them by culture and upbringing.

Education has evolved from that which mainly exercised the mind to think and reason with no particular objective outcome, to education for the professions, initially medical, theological, and legal but now much more comprehensively, to vocational education with sandwich and placement periods contributing to practical work-based learning, to experiential learning with simulated environments within universities and now almost by way of full cycle to degree apprenticeships and accreditation of work-based activity. As occupations evolve, and in some instances disappear, it is going to be important that vocational education embraces intellectual flexibility and effectively incorporates enterprise and entrepreneurial education to deliver a more productive society.

Keywords Entrepreneurship · Innovation · Knowledge exchange · Business schools · Incubation · Spin-outs

1 Introduction

Knowledge, understanding, and intellectual curiosity are, of themselves, of great worth. They add to human wonderment, confer satisfaction, and are the basis of civilisation. Purists argue that knowledge, understanding, and curiosity are both sufficient reason and a noble purpose for a university education and that the more utilitarian outcomes of education such as getting a job, increasing wealth, productivity, and prosperity are, while pleasant outcomes, not the main motivator. This legacy extends back to Aristotle who suggested that from the liberal arts, "nothing should accrue of consequence" and John Henry Newman whose view was that "liberal education and liberal pursuits are exercises of mind, of reason, of reflection" [1]. The prejudice against utilitarian courses was manifest in the UK in the early Twentieth Century when Her Majesty's Treasury precluded such courses as medicine and technology from the public funding offered to the "new" universities in civic centres such as Birmingham on the advice of the old universities of Oxford and Cambridge.

It would, of course, be a tragedy if universities failed to induce wonderment in their students. Nevertheless, Lord David Willetts, former Minister for Universities in the UK, makes a compelling argument for the economic and non-economic benefits to both the individual and society that can be conferred by a university education [16]. Some of these benefits will appear obvious to those embracing the utilitarian view of education, such as higher employment, earnings and productivity. However, individually, graduates are also healthier, have longer and happier (at least less depressed!) lives and, despite, occasional excessive behavioural tendencies to the contrary, they drink less alcohol, smoke less, and are less obese [2, 3]. While Willetts allocates these latter attributes to individual non-economic benefits, the benefits of better health, even over a longer lifespan, are likely to have profound economic impact on health services, which are buckling under the weight of unrealistic expectation across the globe. Many of the most prestigious courses in universities, such as medicine and law, are highly vocational and patently utilitarian. Indeed, as we explore the evolution of university education towards more recent innovations such as degree apprenticeships, we might reflect that we have come full circle since these subjects were historically taught at the feet of their masters as true apprenticeships.

Despite the evidence and the progress, there is still reluctance to deliver education, which might stimulate attributes specifically to benefit business, such as enterprise. And there is definitely resistance to the even more radical prospect of educating towards the establishment of business in whatever form that education might take; beyond the specific education offered in our Business Schools. The case for encouraging entrepreneurship in our universities is supported by a concerning decline in business start-ups in many developed economies. It has been estimated by the Fraser Institute that the number of start-ups created between 2001–07 compared to those created between 2008 and 2014 had fallen by 18.6% in the United States, 20.3% in Australia, 8.5% in Canada and 7.5% in the United Kingdom [4]. Before considering how higher education might more effectively contribute to business start-up and evolution it is worth considering in more detail the evidence that this would be a good thing for the economy, and more broadly, for society.

2 The Economic Case

Significant changes in the global economy since the 2007 global recession have led to declining traditional labour markets and a global economic restructuring, creating the gig economy of freelance workers previously employed in manufacturing. In many places, this has been accompanied by calls for a systematic and coherent transformation of the pedagogic frameworks that underpin education across all sectors. In the UK, many higher-education institutions are focusing more actively on entrepreneurial development activities in the wider curriculum and seeking robust pathways for students to mobilise and explore any innate entrepreneurial skills they possess. The University of Hertfordshire has a project-based programme called PINTRA which aims to create an enabling environment to address this need. Projects are developed in conjunction with local, national or international partners and students. For example, the University of Hertfordshire Student Enterprise and Incubation unit created a joint venture consortium to develop a digital productivity solution to low and mid-range productivity in small and medium enterprises (SMEs) called PBOOST SME Toolbox.

There is a clear correlation between the number of graduates that a business employs and its prosperity as judged by growth. In the US, the highest-growth businesses have upwards of 95% graduate employees and, perhaps, as we look to a future in which jobs are likely to be even more intellectually demanding it is interesting to note that these high-growth businesses already employ some 45% of their workforce with advanced degrees [5]. Notably, the opposite has been shown to be true in the UK where those businesses with poorer productivity are those with fewest graduates [6]. More specifically, a 1.0% increase in the number of graduates produced has been shown to impart a 7.5% increase in productivity within 3 years [7]. Furthermore, individual graduates are 20–48% more productive than non-graduates. While correlations between graduate numbers and business success or productivity do not prove cause and effect they are, through their consistency, quite compelling. Furthermore, in a recent economic impact study carried out by Oxford Economics on behalf of Universities UK, it has been shown that higher education confers an uplift in human capital on those who graduate compared with non-graduates and that projected over the working lifetime of those graduating in the UK in 2014/15, this increased the UK's stock of human capital by some £63 billion [8].

The relationship between university education and graduate productivity could, of course, be entirely independent of any enterprise or entrepreneurial education delivered throughout a degree. Indeed, it would be surprising if broader aspects of university education to develop intellectual flexibility, critical thinking and in the case of more vocational courses such as engineering or medicine, the acquisition of higher-level skills did not in themselves contribute to higher levels of productivity.

3 Political Context and Policy-Framing Environment

Entrepreneurship is recognised at governmental level as a potent positive civic motivator and contributor to economic development. The Organisation for Economic Co-operation and Development (OECD) and the European Commission have recognised the role which universities play in stimulating entrepreneurship but have focused on school level education which they recognised as having a critical role in developing the attitudes, knowledge and skills essential to entrepreneurship. However, they identified that the most compelling factor in developing entrepreneurship was to have a parent that was an entrepreneur and that the earlier people are exposed to entrepreneurship the more likely they are to embrace it [9–11]. Furthermore, it has been suggested that it may take around 10 years to learn how to think creatively and therefore to acquire some of the fundamental skills or attributes underpinning entrepreneurial effectiveness [12]. This is not surprising given the long-standing view that the development of dextrous skills takes up to 10,000 h [13].

In the UK, government has produced reports demonstrating the impact and importance of enterprise education in higher education and has produced a comprehensive guidance on Enterprise and Entrepreneurship through the Quality Assurance Agency (QAA) and has also appointed a Chief Entrepreneurial Adviser within the Department for Business, Energy and Industrial Strategy (BEIS) to encourage good practice in entrepreneurship in higher education [14–16]. The government has also reviewed and revised the way in which data on graduate outcomes are gathered and analysed, with the intention that the new Graduate Outcomes survey may be able to differentiate those who have started their own businesses or are in self-employment. UK higher education is likely to be subject to a Knowledge Exchange Framework (KEF) which will create a third pillar of HE outputs balancing the Research Excellence Framework (REF) and the Teaching Excellence Framework (TEF). The KEF is likely to inform on allocations of Higher Education Innovation Funding (HEIF) or its successor and is likely to include and support enterprise and entrepreneurship activity. At the time of writing, the metrics being proposed to determine KEF rankings include: research partnerships; working with business; working with the public and third sector; skills, enterprise and entrepreneurship; local growth and regeneration; intellectual property and commercialisation; and public and community engagement, although it is not yet clear how these will be objectively measured.

Despite the obvious good intentions of the UK government to support entrepreneurship some of their most active policies have the potential to do just the opposite. Initiatives to encourage apprenticeships and even degree apprenticeships including the introduction of a levy to support their delivery and the embrace of a target of three million apprentices are likely to deliver a highly skilled but less-entrepreneurial workforce. Apprenticeships by definition deliver education in the workplace to those who already have jobs. The educational component of an apprenticeship programme is highly defined and specifically targeted at the delivery of skills and knowledge required for an occupation. End point assessments are uniform nationally and unlikely to encourage imaginative curricula with different outcomes. Even at degree level, the education is targeted at a specific occupational outcome most often as an employee. There is sound evidence to support the necessity for upskilling, which will undoubtedly be delivered by the apprenticeship programme but predictions about the changing complexion of the workplace, likely changes in and loss of occupations and a requirement for flexibility and transferable skills make the wisdom of compartmentalised learning questionable. At a very minimum having curricula that might deliver critical thinking and intellectual flexibility within apprenticeship standards would be wise.

The QAA (2018) observes: ‘Analysis by HEFCE shows entrepreneurship is becoming better recognised as a career choice for students, with 4,160 new graduate start-ups in 2014–15. Meanwhile, the 2017 CBI/Pearson Education and Skills Survey found that 40% of recruiters were dissatisfied with graduates’ business awareness. Furthermore, the 2015 Dowling Review [17] emphasized the importance of training in areas such as Intellectual Property and raising commercial awareness among both students and researchers. In addition, both Lord Young’s report, Enterprise for All: The relevance of enterprise in education, and the All-Party Parliamentary Group for Micro Businesses report, An Education System fit for an Entrepreneur, call for Enterprise and Entrepreneurship Education to be embedded into the curriculum across all disciplines and all levels of education' [18].

It is of some concern that a recent survey by the National Centre for Entrepreneurship in Education [1] indicated that while entrepreneurship provided by universities had increased over the past 3 years, institutional policies relating to entrepreneurship have reduced. Furthermore, those offering funds for staff to undertake continuing professional development (CPD) in enterprise have virtually halved. Nevertheless, the survey indicates increased support for the actual creation of new ventures and start-ups. Not surprisingly, the report recommends the adoption of entrepreneurship strategies within universities and indicates that support for CPD for staff in universities should be prioritised. It further recommends that universities might consider how they may utilise students to engage with schools to encourage entrepreneurship.

4 Enterprise and Entrepreneurship

Education to deliver enterprising graduates has the broad objective of encouraging the capacity to create ideas and the attitude and competence to make the ideas reality. These objectives might be appropriate to any course of study and are attributes to which all graduates might aspire. Entrepreneurial education has a rather more specific objective to encourage graduates to establish a business or more broadly an enterprise that could have a profit motive or might contribute to society in other ways and may be termed a social enterprise.

Entrepreneurial education *through doing* will provide the most relevant and realistic experience. Starting a business or creating a venture is likely to provide effectiveness in delivery, will be moulded by reflection and enhanced by drawing on knowledge of theory and practice already acquired. It is likely to support the evolution to the fully autonomous entrepreneur. In order to encourage students to start their own enterprise, universities may provide incubator facilities and offer an environment of innovative fermentation.

The evidence supporting enterprise and entrepreneurial education is substantial. However, although they are often used together and even interchangeably, they are not the same thing. Enterprising individuals are resourceful, have novel ideas, and show initiative. Education may enhance an individual's enterprising behaviours and attributes and is likely to involve learning toward a changed mindset with focus on improvement and innovation. This may, of course, contribute to the creation of new business or improvement within a business or even out with business in a social environment or community context. Given its focus on behavioural change, enterprise may more effectively be taught through experiential action learning methods.

It is, of course, highly applicable across all disciplines and can be embedded in the curriculum of any school or faculty of a university.

Entrepreneurship more specifically relates to the creation of a new business and entrepreneurship education to the learning of skills, knowledge, and attributes necessary for the establishment and development of a business. It may be taught by didactic methodology, although the behavioural aspects no doubt benefit from experiential learning. Furthermore, it may be delivered as a bolt-on module to any course of university study but it is most often taught within a business school or by the faculty of a business school, as well as effectively utilising the experiences of entrepreneurs as visiting faculty.

In the UK, there is evidence to suggest that enterprise and entrepreneurial education contribute to business creation. The gross annual value of student start-ups and spin-outs for 2013 was £2.7 billion and it was anticipated that for surviving businesses this would be an annual and, it is assumed, increasing contribution. Two-thirds of those starting these businesses indicated that their university experience had positively influenced their motivation to create a business [19]. Graduates have also increased their propensity to start-up businesses. In the UK in 2002/03, 732 graduate businesses were established and some 323 were thought to have survived for more than 3 years. By 2014/15, these numbers had grown to 10,956 active graduate companies of which 4474 survived for at least 3 years [20].

Those graduates establishing their own businesses also earn more. On average, a graduate with their own business will earn £27,242 6 months after graduation whereas someone in employment will earn £24,056 and this differential is still present 3 years after graduation by which time the business owner will earn £31,229 and the employee £28,463 [18]. Degree level graduates are twice as likely to become high-value entrepreneurs, defined by the Social Market Foundation as entrepreneurs that had the widest effect on the UK economy [21]. It is also recognised that start-up businesses tend to have direct positive effects on employment growth, thus contributing to the social fabric as well as economic success of a region or country [22].

There is therefore good evidence that enterprise education enhances students' and graduates' intention to start-up business and the evidence that business start-ups contribute positively to economic prosperity is compelling, yet the Department of Business, Innovation and Skills (now the Department for Business, Energy and the Industrial Strategy) found the hard evidence linking enterprise and entrepreneurial education to actual business start-up inconclusive [23].

The UK Government commissioned the Wilson Review on University – Business collaboration that made several recommendations regarding enterprise activities, many of which are reflected in the work of the University of Hertfordshire. For example, the Review states that graduates are needed 'who seek knowledge and skills that are relevant to their future careers and who are confident in their ability' [24]. This is a significant focus for both the Careers and Employment Service at the University of Hertfordshire but also for developing a pedagogic framework which engenders a coherent understanding on the part of students of their role in the future supply chain and the importance of a focus on enterprise and employability. The underlying ethos of the University has been developed to ensure that students from diverse backgrounds, abilities, and learning styles can enhance their confidence levels and explore any innate entrepreneurial capabilities and/or entrepreneurial opportunities. The teaching and learning structures that complement this, endeavour to create a fertile environment for exploring ideas and developing relationships. They also recognise career aspirations and opportunities for lifelong learning and professional development, on local, regional, national and international platforms.

5 Business Schools

It is not surprising that business schools have embraced enterprise and entrepreneurial education energetically given their raison d'être to deliver business education in its broadest sense. In the UK, some 325,000 students study business and management and this equates to approximately one-fifth of all students taught [25]. Furthermore, there are strong associations between the entrepreneurship and leadership skills taught in business schools and the productivity, employment, growth, and turnover of businesses [26].

Business schools teach the core elements of entrepreneurship, including finance, marketing, leadership, and management and have now evolved to deliver a range of support initiatives from work placements and industrial consultancy to business mentoring from alumni fellows or, as promoted by the Nottinghamshire Business School students: "learn the theory, practice the theory, and experience and observe the theory in real world applications" [27]. Many universities now offer seed funding for students to establish early stage ventures and offer the infrastructure to support the businesses in an encouraging environment [28]. At UH, students all qualify for up to £2000 to explore and test their business ideas; there is also a smaller option known as the Enterprise Summer Awards of £600 each, to allow for focused research projects to develop emergent ideas. Further, every year the Graduating Class qualify for the Graduate Entrepreneurship programme which offers £3000 bursaries to develop business ideas.

Business Schools have established specific centres for entrepreneurship such as the Hunter Centre for Entrepreneurship in Strathclyde Business School, which delivers teaching designed to enhance entrepreneurial behaviour and also undertakes research into entrepreneurship [29]. Through knowledge exchange activity it shares good practice with business and it has demonstrated 20–30% growth in companies that participated in its entrepreneurial CPD programmes within 6 months of participation.

Many universities throughout the UK have engaged effectively with business through voucher schemes. These may have attracted government funding or are funded directly from university resources and while they have been used for a range of activities including consultancy on product and system design, they have also been used to deliver entrepreneurial teaching [7].

6 Incubation

The Centre for Entrepreneurs (CfE) suggest that while it is undoubtedly beneficial to engage undergraduates in business development and to provide facilities for student incubation, it might be more effective for universities to direct their energies in incubation support at their graduates. They reason that undergraduates are developing the knowledge, skills, and attributes essential to their subject or discipline (even in the business school) and simply do not have the time required or dedication essential to establishment of a business. Furthermore, the enterprise and entrepreneurial education delivered at university is likely to form a solid foundation on which to establish a business but may be best delivered before the full focus on business establishment begins. This may be seen to conflict with the mantra of "experience" or "learning through" during the undergraduate entrepreneurial education experience. In reality, both perspectives have merit; the undergraduate educational experience will be enhanced by learning through doing and the establishment of enterprises will require the full-time dedication of the graduate and will be enhanced by the experience gained during the undergraduate practical experience.

There is good evidence to suggest that graduates are more likely than undergraduates to establish successful businesses but that should come as no surprise given the stage of career development implied [18, 30]. For both the prospective undergraduate or graduate entrepreneur, tangible support extending from access to finance to an affordable workspace undoubtedly encourages initiative and also enhances success and sustainability of a venture. The CfE has suggested that the support offered through undergraduate entrepreneurial education should be extended to graduates who they believe should be offered intensive programmes in entrepreneurship, mentoring, as well as the physical support of an incubator [18]. The benefits to the parent university are improved graduate employability, closer links with and connection to emerging businesses and an ability to more closely monitor and assess the success of provision or intervention.

While it would be difficult to justify spending undergraduate tuition fees on incubators for graduate start-ups, there is a very strong case for the use of government funding such as Higher Education Innovation Funding (HEIF) in the UK since the benefit of enterprise activity to society is substantial. However, through building an effective input/output paradigm for student enterprise and the role of incubation a more coherent assessment of how and where to invest funding for promotion of enterprise and employability will evolve.

7 Incubation at the University of Hertfordshire

Business Incubator: Creating Entrepreneurs Through Our Community of Practice

The University of Hertfordshire has opened its doors to external start-ups through its Business Incubator. Companies trading for less than 12 months are eligible to apply to become members, gaining access to hundreds of academic experts and their evolving research, seminars, mentors and marketing support.

The University has created a community of practice designed to connect innovative entrepreneurs who can feed off each other's ideas and expertise to drive their own ventures forward. Members can make use of a dynamic open-working environment and have direct access to workshops, practical advice from University staff and networking opportunities. They sit alongside, and share best practice with, University of Hertfordshire students and graduates, with 20 dedicated work spaces for student and graduate start-ups. Around 50 new graduate businesses are supported each year.

Incubation is underpinned by various funds on a competitive basis. These include the Enterprise Fund (up to £2000 to kick start a new business), funds for students taking a year out for a self-employed placement (up to £2600), Summer Awards (up to £600 to test out a business idea over the holiday period) and the recently introduced Graduate Entrepreneurship Programme which offers £3000 to 10 first-degree graduates each year, in addition to mentoring, business plan support and advice on investment pitching.

The University of Hertfordshire also runs a business start-up challenge award, Flare, which offers student entrepreneurs the support, advice and training they need in areas like proposal writing, planning, finance and marketing, and the opportunity to win up to £8000. With more than 100 entrants each year, Flare has awarded more than £190,000 to student start-ups since it started in 2005.

The incubation process at the University of Hertfordshire recognises the potential of effective incubation to act as a tool for creating a seamless interface between the classroom, the start-up eco-system and the world of work, building coherence between enterprise and employability. Allowing students to engage in a project-based approach to building employability skills, application of theory, and to develop an understanding of the world of work is key. To support incubation, the Enterprise Team has developed Project Intrapreneurship which has supported the first joint venture between student enterprise and University of Hertfordshire Incubation SMEs in PBOOST. This demonstrates how effective business development can support a curriculum based exercise, a brief assessment of the PBOOST process shows potential for teaching: opportunity sourcing, joint venturing, submission development and budget development. This is not an exhaustive list but does demonstrate the underlying potential of this approach for embedding entrepreneurship in the classroom and to address the divide between theory and practice. The idea of an either-or approach implied by the CfE is no longer necessary or desirable, as many of the university graduates are likely to be employed by small businesses that need staff already equipped with the attributes and skills necessary to contribute to the business endeavour.

8 Conclusions

Creating a vibrant and effective student enterprise eco-system demands that universities recognise that it can no longer be business as usual. In the past decade, the key change in UK higher-education sector has been the introduction of fees. The sea change that this generated has now become a central factor in students' application of a cost-benefit analysis of investing in a higher education. Effective student enterprise is mission critical for many prima facie reasons including the emergence of the 'gig-economy' that will become more ubiquitous. This is one of the reasons why the Enterprise Team at the University of Hertfordshire has as its starting point a workshop called 'Your Life is Your Business'. Building a recognition of the role and responsibility of an emerging knowledge worker calls for students who understand the changing trajectory from classroom to employment, be it self-employment or as an employee. The University of Hertfordshire incubation process while meeting the conventional objectives of incubation is also working towards a seamless interface between the classroom and the world of work, to ensure that student enterprise becomes a viable and rewarding process from both a pedagogic and professional development perspective.

Ultimately, developing entrepreneurial mindsets is an essential characteristic of any Twenty-first Century educational environment; the entrepreneur "introduces a new good or a new method of production, opens new markets, or discovers a new source of supply, or carries out a new organization of an industry…upsets the conventional way of doing things" [31]. Universities, who have always enjoyed upsetting conventions, should not be afraid to expand their remit beyond the world of knowledge creation and education. Klaus Schwab, Executive Chairman of the World Economic Forum, has stated that 'entrepreneurship is the engine fuelling innovation, employment generation and economic growth', and taking into account 'the power that education has in developing the skills that generate an entrepreneurial mindset and in preparing future leaders for solving more complex, interlinked and fast-changing problems', then it becomes clear that enterprise education is important' [12]. Indeed, it is no longer just important but essential for both universities and the world that they wish to shape.

References

1. NCEE (2018) Inspiring entrepreneurs in education: enterprise and entrepreneurship in higher education 2018. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/440927/bis_15_352_The_dowling_review_of_business-university_rearch_collaborations_2.pdf
2. Bynner J et al (2003) Revisiting the benefits of higher education. Bedford Group for Lifecourse and Statistical Studies. https://dera.ioe.ac.uk/5167/1/rd05_03.pdf
3. Kuntsche E, Rehm J, Gmel G (2004) Characteristics of binge drinkers in Europe. Soc Sci Med 59(1):113–127
4. Lutke T (2018) How to save entrepreneurship in The World in 2019. The Economist Press Limited, London
5. Volkmann C, Wilson K E, Mariotti S, Rabuzzi D, Vyakarnam S, Sepulveda A (2009) Educating the next wave of entrepreneurs: unlocking entrepreneurial capabilities to meet the global challenges of the 21st century. A report of the global education initiative for the World Economic Forum. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1396704
6. Wadhwa V, Aggarwal R, Holly K, Salkever A (2009) The anatomy of an entrepreneur: making of a successful entrepreneur https://www.kauffman.org/~/media/kauffman_org/research%20reports%20and%20covers/2009/07/makingofasuccessfulentrepreneur.pdf
7. Ulster University Business Institute. https://www.ulster.ac.uk/business/business-institute/services. Accessed 8 Apr 2019
8. Newman JH (1996) In: Turner F (ed) The idea of a university (Rethinking the Western tradition). Yale University Press, New Haven
9. Dunn T, Holte-Eakin D (2000) Financial capital, human capital and the transition to self-employment: evidence from intergenerational links. National Bureau of Economic Research (working paper 5622) (June 1996). http://www.nber.org.uk/papers/w5622
10. Lindquist MJ, Sol J, Von Praag CM (2015) Why do entrepreneurial parents have entrepreneurial children? J Labor Econ 33(2):269–296
11. Universities UK (2015) The funding envronment for universities 2015: the economic role of UK universities. Universities UK, London
12. QAA (2012) Enterprise and entrepreneurship guidance: guidance for UK higher education providers www.qaa.ac.uk/publications/information-and-guidance/publications?PubID70
13. Gladwell M (2008) Outliers: the story of success. Little, Brown and Company, Boston
14. Department for Business, Innovation and Skills (2015) Enterprise education impact in higher education and further education. https://www.aoc.co.uk/sites/default/files/ENTERPRISE%20EDUCATION%20IMPACT%20IN%20HIGHER%20EDUCATION%20AND%20FURTHER%20EDUCATIONFull_Report.pdf
15. Simonton DK (1999) Origins of genius: Darwinian perspectives on creativity. Oxford University Press, Oxford
16. Willets D (2017) A University Education. Oxford University Press, Oxford
17. Dowling A (July 2015) The dowling review of business-university research collaborations. Department for Business, Innovation and Skills. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/440927/bis_15_352_The_dowling_review_of_business-university_rearch_collaborations_2.pdf
18. Yoshioka M and Patrikalakis M (2017) Putting the Uni in Unicorn: The role of universities in supporting high-growth graduate startups. Centre for Entrepreneurs, London
19. PACEC (March 2015) Research to assess the nature and annual value of student start-ups: undertaken on behalf of HEFCE. http://dera.ioe.ac.uk/22402/1/2015_student_start-ups.pdf
20. The HE-BCI survey examines the exchange of knowledge between universities and the wider world, and informs the strategic direction of 'knowledge exchange' activity that funding bodies and higher education institutions (HEIs) in the UK undertake. https://re.ukri.org/knowledge-exchange/the-he-bci-survey/
21. Social Market Foundation (2014) Venturing fourth: increasing high-value entrepreneurship

22. Gilbert B, McDougall P, Audretsch D (2006) New venture growth: a review and extension. J Manag 32(6):926–9250
23. Witty A (2013) Encouraging a British invention revolution: Sir Andrew Witty's review of universities and growth. Department for Business, Innovation and Skills. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/440927/bis_15_352_The_dowling_review_of_business-university_rearch_collaborations_2.pdf
24. Wilson T (2012) A review of business-university collaboration. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/32383/12-610-wilson-review-business-university-collaboration.pdf
25. Chartered Association of Business Schools (September 2016) Business Schools delivering value to local and regional economies. https://charteredabs.org/wp-content/uploads/2016/09/Chartered-ABS-Delivering-Value-Report-2.pdf
26. Hayton J (March 2015) Leadership and management skills in SMEs: measuring association with management practices and performance. Department for Business, Innovation and Skills Research Paper Number 211. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/418404/bis-15-204-leadership-and-management-skills-in-sme.pdf
27. Nottingham Business School. http://www4.ntu.ac.uk/nbs/. Accessed 8 Apr 2019
28. The Oxford Seed Fund. https://www.sbs.ox.ac.uk/research/centres-and-initiatives/entrepreneurship-centre/oxford-seed-fund. Accessed 8 Apr 2019
29. Strathclyde Business School. https://www.strath.ac.uk/business/. Accessed 8 Apr 2019
30. NCGE (2008) Developing entrepreneurial graduates: putting entrepreneurship at the Centre of Higher Education. https://ncee.org.uk/wp-content/uploads/2018/01/developing_entrepreneurial_graduates.1.pdf
31. Braguinsky S, Rose DC (2009) Competition, cooperation, and the neighboring farmer effect. J Econ Behav Organ 72(1):361–376
32. McKellar Q (2018) Business engagement is no longer an optional extra for universities. In: Badran A, Baydoun E, Hillman JR (eds) Universities in Arab countries: an urgent need for change. https://doi.org/10.1007/978-3-319-73111-7_6

Science and Technology Parks and Universities – Facing the Next Industrial Revolution

Malcolm Parry

Abstract Entrepreneurship gives science its modern economic value. To drive this model many universities and research institutes have created Science and Technology Parks (STPs) that are managed 'place based' developments that help to share the risk of starting a business by offering a range of facilities and services to micro and small companies that are trying to commercialize science in its widest sense. These are specialist locations and to make them effective in achieving their most commonly held objective of creating clusters of innovation they need to build capacity in business incubation and its derivatives in business acceleration, understand the motives and challenges that face the entrepreneurs that they attract and take a wide role in building networks that include a regional role that supports economic development in collaboration with their host organization. This involves building a management and governance structure that is relevant to the prevailing business conditions and then ensuring their offering to entrepreneurs helps add value at a commercial level. This chapter reviews these aspects of STP planning, development and operation in the context of university hosts.

Keywords Science technology parks · Entrepreneurship · Universities · Fourth industrial revolution · Innovation systems · Start-ups · Business incubation · Business accelerators · Origin of tenants · Governance · Management

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1 Introduction

The latter part of the twentieth century and early twenty-first century has been a period in which entrepreneurship has given science – including social sciences, technology, and engineering – an increasing level of economic significance [1] and consequently a significant impact on geo-economics.

One implication of this statement is that universities need to ally their teaching and research to the entrepreneurial process to ensure that they remain aligned with changes in the social, technology, and business environment, to which they are expected to contribute. It is also clear that the potency of this science-entrepreneurship relationship is likely to increase as the knowledge-economy (Fig. 1) gathers momentum and develops innovation platforms that drive technological advances, widely defined as the fourth industrial revolution (Fig. 2). The value of entrepreneurship will also be likely to increase because the exponential growth of the power of these technologies will enable them to drive into new area of science and the fall in their cost will create new market opportunities for their use. A further economic and social value of this revolution is that there is the potential to catalyze a more sustainable social and economic path for development, presaged in Europe by the Lisbon Strategy [2] and considered to be fundamentally important by the United Nations' 17 sustainable goals [3].

Global economic dynamics have stimulated the demand side of the science-entrepreneurship relationship. These dynamics include an increase in the size of the world market for goods, which has come from a world population growth from 3 billion in 1960 to 7.7 billion in 2018 [5]; and an estimated increase of 1.7 billion [6] new workers that joined the global work force between 1980 and 2010, with most of these in lower income countries as a result of urban drift and the associated move from agricultural work to manufacturing. There has also been a trend of increasing capacity of higher education. It is reported that in China alone the numbers graduating each year increased from 830,000 in 1998 to 6.8 m in 2012 [7] and it is estimated that, of the world population in 2020, there will be some 840 m people with post-secondary education [8].

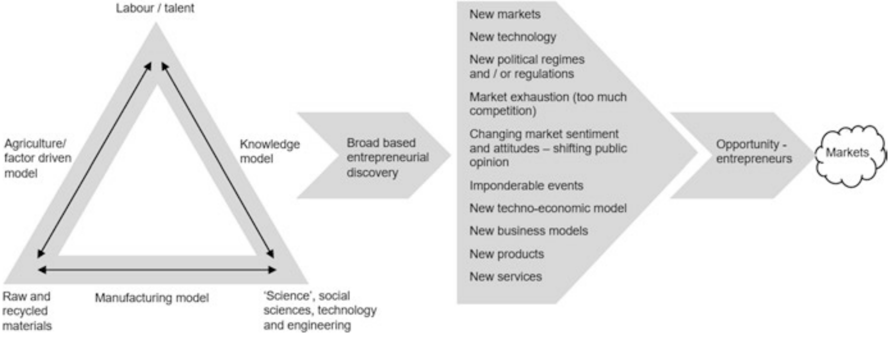


Fig. 1 Relationship between talent, science and materials. (Own elaboration after Parry [4])

Innovation platforms	Social change	Megatrends
• Resource efficiency • Bio-economy: synthetic biology • Digitization and dematerialization: data/sensors/quantum computing/AI • Health services	• Complex societies: urbanization • Web-based empowerment • New business models/ leadership • Maturing environmental concerns • Mobility: transport revolution • Telecoms: geographic dispersion	• Demographic: ageing/longevity • Globalization: who has the power?

Fig. 2 Innovation platforms, social change and megatrends

In the period when the efficiency economic model was at its peak of influence, much of scientific research was undertaken to support defence, energy, and food security, whilst also meeting the need for general cultural development and social advancement.

Although differing across cultures and political regimes during this period, the major science outputs to address these needs have been developed through the work of universities, national research institutes, academies of science, and large companies in the industrial sector of business. To a large extent, these activities were funded by the public purse.

With respect to universities, their historic role has been to produce generic economic and social benefits by educating cohorts of graduates, generating scientific knowledge and creating instrumentation infrastructures, such as test beds and other knowledge-related resources, to support industry [9].

If we now view the future as one embedded in a fourth industrial revolution in which humankind's capacity for analytical and heuristic and thinking is likely to be progressively substituted by computing power with access to large amount of data (in much the same way that previous industrial revolutions substituted human muscle power with other forms of energy), which is having a transformational influence on many older industries, means that knowledge and its use for altering societies and the environment is likely to become the bedrock of future prosperity. Universities need to make sure they remain close to the forefront of these changes.

The advent of low-cost computing in the 1970s dropped the capital cost of entry into the knowledge economy for opportunity-entrepreneurs [10] who began to take advantage of this new technology by creating start-up science-based micro and small and medium enterprises (M&SMEs) to address the new market opportunities [11]. This also enabled improved levels of business sophistication by contributing to higher efficiency in the production of goods and services. Some of the early movers in this process, such as Microsoft (founded in 1975) and Apple (founded in 1976), and later arrivals such as Google (1998) and the founding of Facebook (2004), have become dominant market leaders with an international reach and an important influence in this new industrial model and have created a number of new and innovation ecosystems such as those created by Goggle and Alibaba, that span beyond clusters and innovation platforms.

From the perspective of universities, this early trend was partly enabled and encouraged in the USA when the Patent and Trade Mark Act of 1980 (known as the Bayh-Dole Act) was passed by the USA Congress. It gave rights to universities, small businesses, and not-for-profit organizations to exploit government-funded research patents [12].

This change to ownership of title to intellectual property (IP) created a small surge in the formation of science-based opportunity-entrepreneur-led M&SMEs [13] It also stimulated the proliferation of angel investors and venture capital funds as they recognized the opportunity of access to large volumes of potentially valuable technologies which, in the hands of opportunity-entrepreneurs, could create wealth.

Larger corporations also started to understand the need to move away from running secretive research laboratories and embrace open innovation. This involved collaborating with smaller companies and universities to help them solve their commercial problems as well as create new markets. This increased the importance and value of science-based M&SMEs in the economy as these young firms proved to be willing to carry the risk of developing radical innovation for the more risk-averse large companies. Historically, the latter avoided pursuing radical change because its impact is unknowable, and they have a need to protect their existing investments.

One of the long-term outcomes of the formation of knowledge-hungry M&SMEs has been to create a market for appropriate business accommodation. This needs to offer the right services and access to technology and talent that can help them turn invention and discovery into innovation and successful enterprises, particularly if the accommodation comes with the ‘value proposition’ of sharing the risk of development of the company.

At the same time, some governments have been implementing policies aimed at increasing the proportion of GDP spend on R&D towards 3%, in line with the Lisbon Strategy, and putting in place policies aimed at increasing the social and economic impacts of R&D outputs. Not many countries have achieved this target, but it is now becoming commonplace that governments are paying more attention to creating policies and strategies that support innovation based on their current levels of expenditure and to do this they are privileging entrepreneurship.

It is also evident that the intended innovation, which is being pushed by this move to increase R&D expenditure, is a ‘sticky’ activity in which geography matters [14]. The consequence is that innovation investments and outputs are still concentrated in particular global centers, allowing leading actors to congregate, mingle and compete. This has prompted the need to increase the reach of innovation into more localized areas and the necessary policies to do this have to work on building

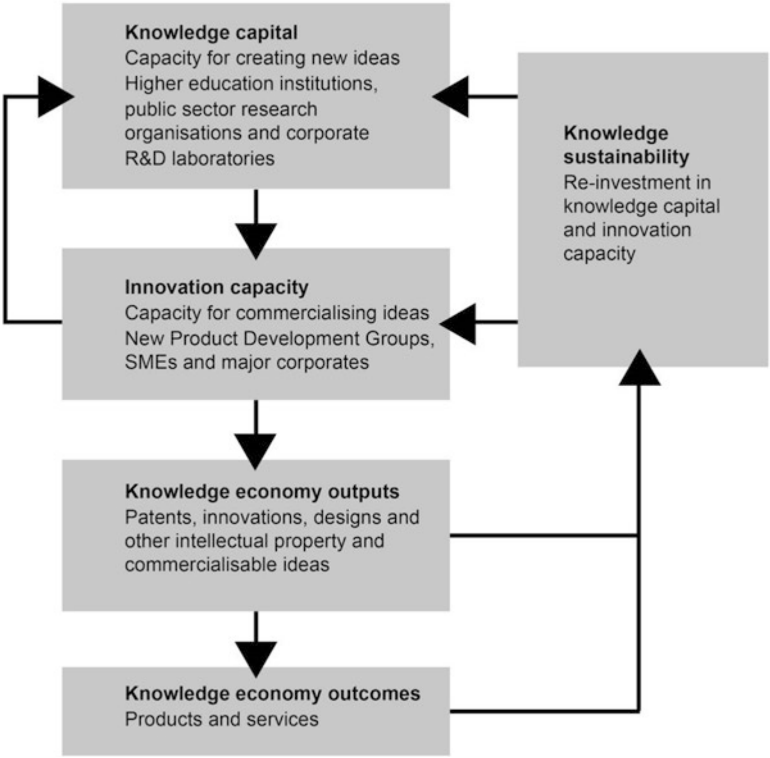


Fig. 3 The relationships that hold the potential to support innovation systems. (*Source*: After SEEDA Robert Huggins Associates [18])

a ‘sticky’ business ecosystem to support, develop and retain talent and technology that underpins this innovation process.

One of the most comprehensively adopted strategies to capture the value from R&D expenditure has been to plan, implement and continually refine national innovation strategies [15] (NIS) and regional innovation systems [16] (RIS) (Fig. 3) and their refinement defined as smart specialization [17] in which regions are being encouraged to build on their existing economic activities by selective investment, particularly by government, to build up these strengths.

The elements on which these innovation systems largely rely are a combination of higher education institutions, public sector research organizations, corporate R&D, M&SMEs, and major corporations. To be most effective, all these institutions need to have the necessary absorptive capacity to build on the intellectual and knowledge capital to try to deliver knowledge economy outputs which find markets.

In turn, finding markets requires what has now been described as entrepreneurial discovery. This requires all of the organizations in these networks to systematically scan technological, political and regulatory, social, and demographic changes to discover opportunities to produce new goods and services. To be most effective this

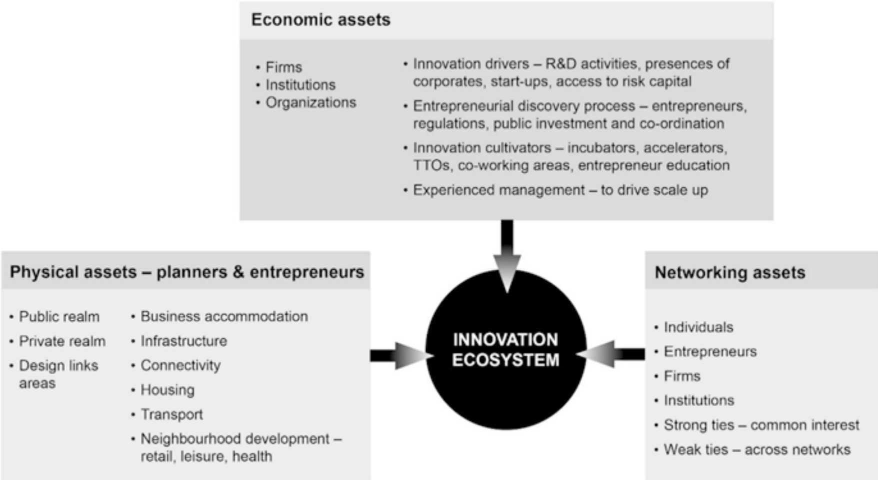


Fig. 4 Characterization of the elements that comprise an innovation district. (After Brooking Institute [20])

discovery process needs to be applied by business, individuals, government and academia if they want to continue to develop and retain a competitive advantage [19]. It is widely acknowledged that when the ultimate goal is to achieve the commercial imperative of successfully taking a new product or service to market there is an important role for entrepreneurial businesses because few would dispute that entrepreneurs, not governments, are most effective at delivering commercial success. However, it is also very clearly understood that to make this process more likely to succeed needs government support through creating the right macroeconomic conditions to fund early stage research and create a supportive regulatory environment for business and investors.

At a city level, where much of the thinking about the future of STPs is being directed, the concept of innovation districts [20] (Fig. 4) are being developed and refined. These districts, that combine assets, are now being planned to assemble the elements that give these locations a creative edge by encouraging innovative companies to adopt open collaborative networks and to integrate this into as many sectors in the economy as possible, making these accessible for creating a work-life balance [21].

The increasing levels of investment by governments in these NIS and developing RIS is driving international competition, precipitating the need for regions to develop specializations on which they can build their own competitive advantage and prompting a number of countries to refine their innovation systems. Commonly, this process involves science and innovation audits on which to base plans on how to invest in regional specializations and develop their capacity for ‘entrepreneurial discovery’.

All these systems, whether city or campus based, are intended to create an effective, functional interconnected framework that comprises institutions, human capital and a research infrastructure where market and business sophistication can develop to deliver knowledge and technology creative outputs that have economic impact. Universities sit at the heart of this ecosystem.

The recognition of the importance of adding innovation to the mix of economic activities in an area has prompted the development of indices for both innovation [22] and business sophistication [23], with some evidence to suggest a positive mutually supportive relationship between the pillars that create the sub-indices of the main indices [24]. This adds weight to the value of investing to increase ranking on both the Global Innovation and Business Sophistication indices.

The economic impact of universities – using international data from the 1960s to 2018 – is that a 10% increase in the number of universities in a region is robustly associated with 0.4% increase in regional GDP. Also, the growth of universities in terms of their size generates start-up activities in nearby areas including in the innovative high-tech sectors [25] which leads to the idea that if this process is facilitated by an STP, it aids the reported GDP beneficial spillover growth via formal and informal interactions between university research and business and the innovative activities of staff, students and graduates [26].

The necessary foundations for creating a national innovation strategy include creating key framework conditions such as the rule of law, effective government, a culture of trust and risk taking, effective protection of IP and enabling competitive markets. This sets the groundwork for an effective tax, trade and regulatory environment which offers open trade opportunities, competitive tax policies and stable and predictable regulations. To build on this, the main suggested key factor inputs include a skilled workforce, physical and digital infrastructure and investment in knowledge creation [27].

These elements are continually being refined by most governments. For example, the UK government has merged its innovation agency (Innovate UK) with its research councils to create UK Research and Innovation (UKRI). It has committed to increase its investment in R&D to 2.4% of GDP but is concerned to increase the social and economic impact of this spend. To this effect there has been a strengthening of the national R&D infrastructure with investment in initiatives such as the Catapult Program [28]. There is also a requirement for public sector funded research to prove social and economic impact on the demand side. Universities are also now subject to Knowledge Exchange Frameworks (KEF) that measure their impact on society. A report [29] has further detailed these impacts to include community-based activities, such as offering public lectures; commercialization activities including licensed research, patenting, creating spin out companies and offering consultancy; problem-solving, ranging from informal advice, consultancy, and contract research; and offering people- based activities, such as enterprise education, conferences and CPD courses [30].

In the UK there is also a raft of policies to support business engagement with innovation by covering tax relief for investment in R&D [31] even where companies are loss-making. In this circumstance, they receive cash-back on this expense, and support for commercializing intellectual property such as the patent box [32] arrangement. Also in the UK there is a new formal interface between universities and industry, which had been the Council for Industry and Higher Education (CIEH) but was disbanded in 2013, has been replaced by the National Centre for Universities and Business (NCUB) when it became clear that universities needed to link with the wider business community, not just industrial companies. In addition, in 2010 the UK government introduced new business-led local enterprise partnerships to replace government-led regional development agencies to encourage business-led innovation activities in which universities are regarded as important stakeholders.

A report [33] – 'Transforming Arab Economies' – also acknowledges the importance of focusing growth based on the knowledge economy and recognized how this could be achieved by creating policies aimed at developing open and entrepreneurial economies, supporting innovation, selectively developing sectors that are a source of new jobs, developing vision and leadership to support an innovation-based drive in the economy, and working on a regional integration process to speed up evolution.

In the case of China, which is facing an innovation imperative to meet the need for its GDP growth by 2025, its government is looking to achieve this with innovation strategies that run to 2025 based on: science from which to develop new inventions and breakthroughs; engineering problems that need to be solved using know-how and ideas and technologies from supply chains; a sharper focus on customers; and a drive to improve efficiency associated with quality, know-how, cost and volume [34].

2 The History of Science and Technology Parks (STPs)

The Valley of Heart's Delight, which is now known as Silicon Valley, has its origins in the late 1800s where pioneers in the early telegraph and radio technologies created a hub of invention and innovation. The momentum continued thanks to defense spending by the US navy when it invested in Moffett Field base in the early 1930s, creating a foundation for the aeronautic industry in that area. The demand for electronics for commercial and defense applications in the 1940s, '50s and '60s, helped by the entrepreneurial approach of the leaders of Stanford University, encouraged the development of this sector and attracted an increasingly skilled workforce that eventually helped to create its particular business culture by 1969 [35] Opportunity-entrepreneurs were able to identify markets for the technology that was being developed in the area and secure finance to support its commercialization.

The Research Park Triangle was established in 1959 by three founding universities – North Carolina State, Duke and the University of North Carolina [36] – with the help of regional government. This helped cement the relationship between government, business and universities, necessary for driving economic development.

In the UK, the first recognizable steps in the development of an STP was when the Cambridge Science Park was promoted by Trinity College Cambridge with the publication of the Mott Report. This provided evidence, given by the Nobel Laureate Sir Nevill Mott to UK Parliament's Select Committee on Science and Technology [37], that the most important ingredient making possible technology transfer and innovation at Cambridge had been the scientific and technological excellence of the University.

This evidence stated that:

> The University [Cambridge] already contains probably the largest concentration of physical, technological, biological, medical and agricultural research laboratories in any university in this country [UK]. If the Government research laboratories in Cambridge and its immediate neighborhood are added to these, the whole complex may be regarded as the largest non-industrial concentration in the country. The investment in scientific staff, equipment and supporting facilities is therefore exceptionally high. The University investment in the application of science and technology to industrial problems is correspondingly high.

The trend that was made explicit in Cambridge and evidenced from the rise of Silicon Valley, Boston's technology corridor on Route 128 through the influence of MIT and Harvard and the three universities that are part of the Research Park Triangle, prompted a number of countries to look to the business culture they created to improve the returns and impact of science coming out of their own universities, public research institutes, and their national business base.

The imperative of national innovation strategies and science outputs gaining traction in commercial markets has prompted many governments to encourage their universities to widen their role and develop strategies to support community and economic development while continuing to meet their traditional roles of teaching and research. This change is happening in nearly all cultures, under nearly all political regimes and irrespective of the relationships between government and their universities. What is emerging is the concept of the entrepreneurial university.

In the UK, this need was made explicit in 1997 when universities were formally required to develop a third mission – of supporting community development. Funds were provided by the government through what is now termed Higher Education Innovation Funds (HEIF). These are still granted to universities in the UK in order to meet the need for securing their commitment to economic development. However, the level of independence of UK universities from government has meant that the option for universities to establish an STP is a matter of choice of their governing councils and executive boards, and many have taken this step.

In China, the movement to create science parks has become highly sophisticated. The TusPark (Tsinghua University Science Park) franchise first came on the scene between 1994 and 1998, created by TUS Holdings. Their engagement in national innovation continues with the development of their facilities to numerous locations in China and on the international stage. Examples of TusPark projects in the UK include their Eagle Labs initiative in collaboration with Barclays Bank, and partnering with the Cambridge Science Park with a number of investments in buildings on that site.

The trend continues: in 2015, Indonesia's Third National Medium-Term Development Plan (Indonesian Government, 2015) was promulgated with the intention of creating a significant number of science and technology parks, and in 2016 this was followed by a national movement to create 1000 digital start-ups. The initial phase of this has been to support the development of science parks in 10 cities.

3 Why STPs?

The key elements of what STPs now do are:

- Support the formation of new technology companies through a range of risk sharing support services, using either their own IP and know-how or supporting opportunity-entrepreneur led start-ups from a wider business community;
- Assist in the growth of existing companies that may have migrated to a park or were incubated on site, which includes some that are specialist parts of large companies.

These changes are part of wider cultural change emerging in universities that has become increasingly adopted in academic systems, regardless of academic and national traditions [38], prompting the idea of the entrepreneurial university and with that the spread of the role of creating STPs.

There are no firm data on the number of operational STPs around the globe, although a personal estimate suggests there are more than 2000 sites that would qualify. The concept has entered the vocabulary of many languages, they have become recognized as part of the business culture of the knowledge-economy that they foster, and they continue to evolve as instruments of economic development. There is also no consistency in the measure of innovation and business sophistication of the locations in which they operate. Some operate in knowledge heartland areas where all the components of RIS and the linkages exist and work well; in economy developing areas where all elements exist but some linkages do not work well; and economic priority areas where both some elements and linkages are missing (Fig. 3). But the evidence from managers that interact with the many tenant companies on these sites provides qualitative evidence that supports the view that these sites share the risk of developing M&SMEs and there are many links and relationships that exist between hosts and tenants that are important from the perspective of commercial benefit, the transfer of knowledge and skills, reputational gains, and economic development. Data collected by the UKSPA in 2018 [39] reveals that among the total employment in the 5600 tenant companies on its member locations, there are an estimated 88,000 (FTE) jobs and other Research and Technology Organizations (RTOs) based on these sites provide an estimated 26,000 employees.

4 Definitions

The interest in planning, developing, and documenting best practices for the management of STPs prompted the formation of a number of national and international associations.

In 1984, the formation of the UK Science Park Association (UKSPA) by the Surrey Research Park and seven other UK university parks marked the launch of the first science park association. The International Science Park Association (IASP) was established in France in 1985, but is now located in Malaga, Spain. The American Association (AURP) formed in 1986, and today national associations are common across Europe, South America and the Asia Pacific Region.

At a city planning level, the World Technopolis Association (WTA) of which the Surrey Research Park was also a founder member, was established by the Korean government and Chungnam National University in the 1990s and has attracted UNESCO as a partner. The WTA specializes in supporting city planning in developing economies with respect to capturing the principles behind STPs in city zones.

The principles set out in the definitions of STPs of these various associations require STPs to include to varying degrees of commitment, a number of requirements to qualify as STPs, although there is no formal registration process for certification. Primarily, an STP must be associated with a host organization with which it has formal links. However, as their reputation as instruments of economic development has grown, the types of host to which they affiliate has extended to include formal and operational links with research institutes, academies of science, and corporate research centres. Nearly all STPs are founded on the principle of incubation and scaling of innovation-led, potentially high-growth, knowledge-based business start-ups and, if there is sufficient space, provide locations where larger businesses can co-locate to develop specific and close interactions with the host for their mutual benefit. On some STPs this involves integrating large corporates into the site when they acquire successful start-ups.

To qualify as an STP they need to have on-site specialized management professionals whose role is to work the STP’s physical, economic and network assets to develop a culture of innovation and the competitiveness for businesses. These teams also provide support for tacit and codified knowledge transfer and translation and the flow of knowledge and technology amongst other regional players. These include other universities, R&D institutions, companies and markets to facilitate the creation and growth of innovation-based companies, with the view to driving technology-led economic development. Since the original STPs were developed, along with the kind of business ecosystem they aspire to create, IASP has refined its definition of STPs by adding to this the idea of Areas of Innovation (AOI). This addition reflects their ambition to create places that are designed and curated to attract entrepreneurial-minded people, skilled talent, knowledge-intensive businesses and investments, by developing and combining a set of infrastructural, institutional, scientific, technological, educational and social assets, together with value added services, thus enhancing sustainable economic development and prosperity with and for the community.

The value of defining the characteristics that set STPs apart from traditional business and industrial estates is that this can be used as a foundation to support and justify – to government and other funding bodies, land use planners, potential hosts and other stakeholders – in that they differ from traditional commercial employment land developments. In some countries, the government uses the definition to set these sites apart from commercial property to provide tenants with tax advantages and other favorable terms for occupation, which includes attracting inward investment.

The STP brand also signals to the business community that they offer support for start-ups, through a managed environment and facilities for co-location [40] that can support their growth by creating environments that give access to talent and technology, and the host includes risk sharing to support science-based start-ups and their early stages of development.

The opportunities for risk sharing include the use of the internet for ‘commercial ideation’, access to funding and investors, access to markets and with the development of STPs moving to locations where they can experiment with the innovation process. Other benefits include support for business development from pre-revenue incubation through stages of scaling-up; remaining at a single location where there is the opportunity to grow and retain continuity with staff, networks and customers; leveraging their location in terms of image and reputation; and access to a pool of talent and technology. All of these benefits are intended to give tenants a competitive advantage.

5 Stakeholders

The fundamental principle behind the adopted definitions of STPs is that they combine the shared intention of the three main stakeholders of government, universities, and tenant companies for creating a place for knowledge exchange, but each does this for a different purpose. STPs are also politically agnostic so can be developed in a diverse range of political, cultural, and business environments. They can be molded to suit countries where universities are independent and able to set their own curriculum and direction, as well as in those countries where universities are state owned and subject to greater direction of their functions. STPs are also sufficiently versatile in terms of size to be established in regions that are as diverse as economic priority areas, developing knowledge economies, and well-connected knowledge heartlands. This is because there is a reliance on entrepreneurship which, although more difficult in some countries than others, is still an individual matter and brings into play the role of the private sector and does not entirely rely on the public purse.

The capacity to work in these different environments and be molded and shaped to match the political, cultural and economic regime in which they are being developed has widened their appeal and is part of the reason why they are now being used to support economic development by nearly all political regimes where there are suitable host organizations.

6 Stakeholder Value Propositions

The objectives and value proposition commonly stated by universities and other hosts for STPs cover physical assets, culture changes, and knowledge transfer. These include:

- Creating new or re-purposing existing property assets to provide some independent income. Also, if land values are high enough these assets can be used as collateral for borrowing.
- Influencing an internal academic culture that helps demonstrate value in entrepreneurial discovery.
- Creating the opportunity for academics, research staff and students to transfer knowledge and technology into the commercial domain through spin-outs or spin-off companies or from the commercial domain into teaching and research activities.
- Attracting inward investment to a region which includes specialist parts of large companies.
- Reducing access costs to 'local learning clusters' through close proximity of the companies on an STP to the host and other firms involved in similar and complementary technologies.
- Offering a good institutional set-up for intellectual innovation for business by developing programs for artificial revelation [41] that can lead to commercialization.
- Creating employment opportunities for graduates, as well as help to create a specialism that can be prioritized to help to create a science cluster or develop a regional smart specialization.
- Licensing IP opportunities to tenants, taking an equity stake in a successful spin-out business, or selling services to tenant companies.
- Raising the profile of the host organization as agents of change in a region which can help support recruitment and retention of staff, students and postgraduates which helps to encourage the development of networks that link universities to the business network.
- Creating multilateral exchanges to support tenants, such as creating an active angel club – this helps to build more effective network assets by the management team that can help to use the economic assets more effectively.
- Linking with government innovation agencies to help start-ups to secure translation funding – these kinds of relationships help to supplement the economic assets that a park can draw on when supporting tenants.
- Engaging with a university business school that runs enterprise-related courses on campus for students, postgraduates and businesses – this helps to build economic and network assets.
- Employing 'Entrepreneurs in Residence' to help with coaching and mentor groups to fill a managerial gap in start-up and growing companies [42] – these individuals have strong network connections.
- Developing a Knowledge-to-Market Accelerator that can help identify, and potentially co-finance, joint projects to increase commercialization of technologies that sit at the heart of a region's technology strength, with the view to building collaboration between institutions and the wider business community to seed and develop innovations.
- Linking innovation 'hotspots' to assist a strategic and planned approach to the provision of innovation centers and support for new and early-stage businesses

across a region. An example is being piloted by the Surrey Research Park-based SETsquared Partnership and Innovate UK, and funded by the Department for Business, Environment and Industrial Strategy (BEIS). This offers university researchers with commercially promising ideas up to £50 k to 'get out of the lab' and validate their ideas in the marketplace.

Common value propositions for national, regional or local government and other public agencies include:

- Encouraging and facilitating economic development. This can be achieved through an increase in the number, size or productivity of companies in a region. Common strategies include either giving land or granting planning permission for a project to enable development and in some cases giving a soft loan or grant to a host to build a facility that otherwise would not be possible because of the prevailing economic conditions.
- Supporting human capital retention. It is clear that the human capital in any area represents a significant resource. However, some areas find it hard to retain their most able young people. The opportunities for creating commercial enterprises provided by parks can help to establish an environment that will contribute to the retention of young people in a region.
- Acting as a center for coordination of stakeholders in the development of a project by bringing these together and curating the disparate value propositions of participants.

Common value propositions that attract firms to STPs include:

- Helping with the recruitment and retention of well-qualified manpower. This has implications for universities as they need to develop courses and teaching methods that ensure that graduates emerge from degree programs not just ready, but able to work. One aspect of this is to change the emphasis of a university education from pure scholarship to include the option of scholarship with entrepreneurship.
- Gaining access to emerging technology that can provide a commercial advantage.
- Presenting a high-quality image to their customers and creating a reputation for value for money.
- Enjoying the benefit from the risk sharing offered by occupation of the STP.
- Gaining access to the right kind of physical space and services at the right time in the development of companies. Companies can grow in one location which helps them to retain staff and continuity with their customer base.

The importance of the value propositions made by universities to STPs is further emphasized by the results of an IASP survey [43] of its membership which reported 68% of the sample parks are located within 5 km of a campus and, of the sample, more than 40% are located adjacent to a campus. This survey also emphasized the relative value of universities against other economic and network assets.

Table 1 Importance of Institutions in influencing the ongoing development of STPs/AOIs

Importance of Institutions in influencing the ongoing development of STPs/AOIs				
	Not at all important %	Slightly important %	Moderately important %	Very important %
Universities/HEIs	0	11.1	21.4	67.5
Banks/other financial institutions	11.1	29.9	43.6	15.4
Venture/seed capital firms	9.4	21.4	35.9	33.3
Legal services firms	17.1	32.5	35.9	14.5
Government	0.9	7.7	20.5	70.9
Other (e.g. external investors)	11.1	26.5	41	21.4

Table 2 Survey of tenant companies and University of Surrey records showing details of links between tenant companies and the University 2014 to 2017 with values for connections

	Large companies	SMEs	Micro companies	Total £ are,000
No of companies	8	90	76	174
Interaction	1	1	0	£185
Research	677	756	1330	£2763
Consultancy	0	35	23	£58
Studentships	155	80	27	£262
PTY placements	7	20	4	£31
Total value of links				**£3114**

The data from this survey (Table 1) also reveal the strength of the links between universities and business, with less than 5% of these sites having no links with a host, and the importance of government as a stakeholder.

Further evidence of the value of a university host comes from a survey of the tenants on the Surrey Research Park over the period 2014 to 2017 which showed that 53% of the 174 companies on the site had an interaction with the University during this period (Table 2). Other details show the size of companies and the value of the links in monetary terms.

The importance of this complementarity for universities is that it helps to bring social and economic value to the process of discovery that can help to build their national and international rankings by signaling they are business-facing entrepreneurial universities that help to meet both the cultural and material needs of society.

7 Growing Differentiation in the Sector

Since the first formal science parks were launched, the type of developments, facilities, and services they offer has burgeoned.

Early STPs were commonly campus based and those termed as research parks were usually restricted to supporting M&SMEs involved in the research, development and design associated with the application of science, social science, technology and engineering in order to create commercially viable products and services. But they also accepted that these firms would go through cycles of research and commercialization at different stages of development, so not all of the activities were 'pure research'.

Science parks, in addition to the activities on research parks, also permitted facilities that were involved in limited high-value low-volume manufacturing. However, the early projects, whether branded research or science parks, almost universally provided incubation facilities and services for science-based start-ups. With increasing sophistication of these incubation services there has been an increasing investment in both business acceleration and co-working spaces on offer on STPs as well as an increasing number of privately operated accelerators in technology hotspots.

The focus of incubation is on assisting entrepreneurs to build successful companies using a supportive growth environment. Incubation provides innovative approaches to establishing accelerated growth for start-ups by offering tactical support programs. Accelerators increase the intensity of this support, which is based on the intention to create investments in the companies and involves more prescriptive programs that are linked to the development of their business plans and models. These companies then compete at the end of the program for access to finance if the business plans prove to be investable. Co-working spaces provide shared work spaces, usually offered through a membership process where like-minded, but commonly lone or independent entrepreneurs can gather and work either on their own or collectively. They have access to discussion groups on business matters and shared physical services, but support by the managers is minimal. A good example of a co-working space for the computer games sector is the 'Rocketdesk' project which is sponsored and operates from Surrey Research Park.

At the smallest end of the spectrum there are estimated, through experience, to be in excess of 8000 incubator and accelerators that are working, although many are not associated with a university but rather operated by either entrepreneurs, e.g. Idealab, WAYRA which is run by Telefonica, or by governments such as the South Korean government's launch of the K-Start-up Grand Challenge in 2018 [44], in order to capture and take equity in new ideas with commercial potential and in the latter case to create employment in SMEs.

In practical terms, these small incubator and accelerator projects, some of which are solely aimed at student enterprise, have a limited catchment area and it is rare to see this more local market extending for further than a 50 km radius from the host park.

Incubators, which commonly are associated with a university campus, but are often based on government land, rarely take an equity stake in tenant companies unless they emerge from within the university and the host university has an interest in the company, where the interest flows from university policy on intellectual property rights (IPR).

The value of the concept of STPs also prompted many governments to orchestrate through both city authorities and regional development agencies a nexus of business and academic links to encourage technology specialization in regions to help to develop a competitive advantage.

In terms of size, STPs range from those which are essentially small isolated city centre incubators to those based on large tracts of urban or suburban land which not only offer incubation space, but also provide accommodation for companies at very different stages of maturity, and in some cases, they are based on complete zones of cities or completely new cities.

8 Paths for Development

Over the last 50 years the value propositions of STPs and AOIs has led to a number of development pathways that have evolved from the original model where most were being established by universities (Fig. 5).

Today this model is being extended with increasing numbers of universities creating campus-based incubators to support both staff and student enterprises, as well as attract to their sites innovative independent companies that want to use the supportive and collaborative environment to develop.

Current examples of campus-based incubators include Universitas Gadjah Mada's (UGM) campus in Yogyakarta Indonesia, the Surrey SETsquared business incubator in Surrey Research Park in the UK, The Hub at Imperial College London, and the Tus-Holdings TusPark projects across China and in 80 cities around the world, including two in the UK at Cambridge and Newcastle.

The changes in corporate research policies from operating closed centres to a more open campus has resulted in a number of parks being established in redundant buildings that are surplus to requirements and offered to the market for occupation

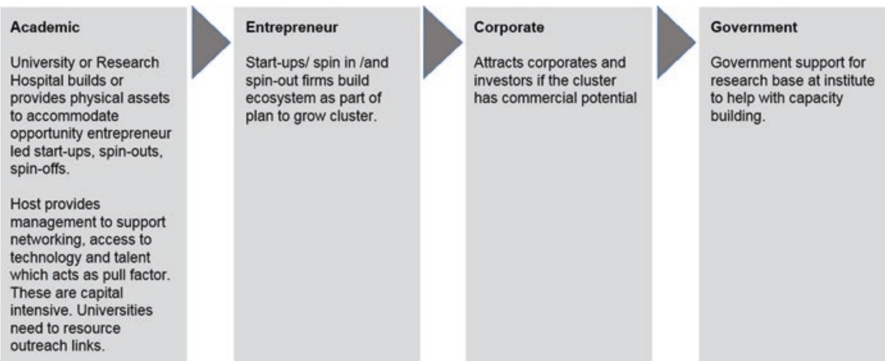


Fig. 5 Academic-led cluster – examples include Surrey Research Park (Guildford, UK); Heriot-Watt University Research Park (Edinburgh, UK); Cambridge Science Park (Cambridge, UK); Karolinska Institute (Stockholm, Sweden); Oxford Science Park (UK)

by technology companies. This strategy enables the integration of open innovation strategies into large corporate research plans and the release of space from under-used corporate space, as the needs for space for science has been driven down by automation.

Examples include the conversion of redundant or underutilized corporate research facilities, or redundant government research institutes in both rural and city locations. Examples of corporate sites that have been closed include the Kent Science Park which is based on a redundant Shell company's agri-science R&D center; the Nottingham and Edinburgh-based Scottish BioCity projects are based on redundant pharmaceutical R&D centers in these cities; the Eindhoven Science Park that has been developed as an open access park on what was the closed R&D center run by Philips; the Adastral Park based on the UK's British Telecom R&D site in Martlesham; and the Horiba MIRA Park in the UK which is was a world-leading motor industries research centre opened in 1946 to support innovative vehicle engineering solutions (Fig. 6).

The same principle has been adopted in the case of parks being established on what were government-funded research facilities (Fig. 7).

It is also clear that economies of cities and regions are being profoundly influenced by the three major historical processes of technological revolution, the now global economy, and the emergence of an informational form of economic production. Recognition of these changes by national, regional and civic authorities is clearly influencing strategic and land use planning. As a result – and at a scale that is orders of magnitude larger than the effort needed to create a science park – these locations are emerging as places that are focusing on creating wealth from the commercialization of science and technology but being prioritized through policy and planning decisions.

Often branded as 'technopoles', these city-based locations offer significant civic investment in science and technology, education, infrastructure and business in order to foster innovation and commercialize the output from the science base. Where this is successful, clusters can emerge in which science and technology-

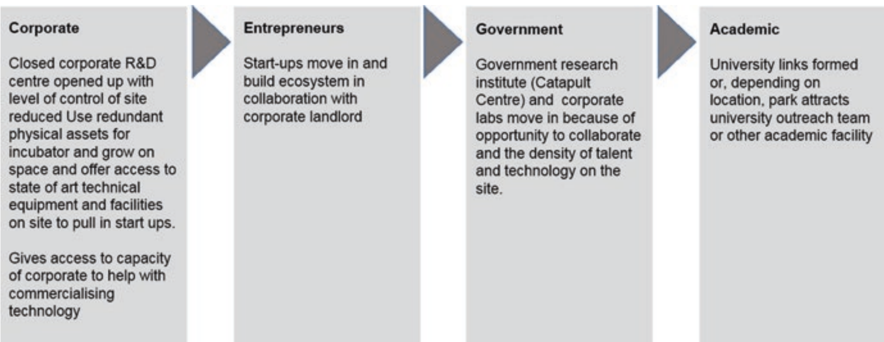


Fig. 6 Corporate-led park – examples include Eindhoven Science Park in the Netherlands, and the Colworth, Adastral, and Horiba MIRA science parks in the UK

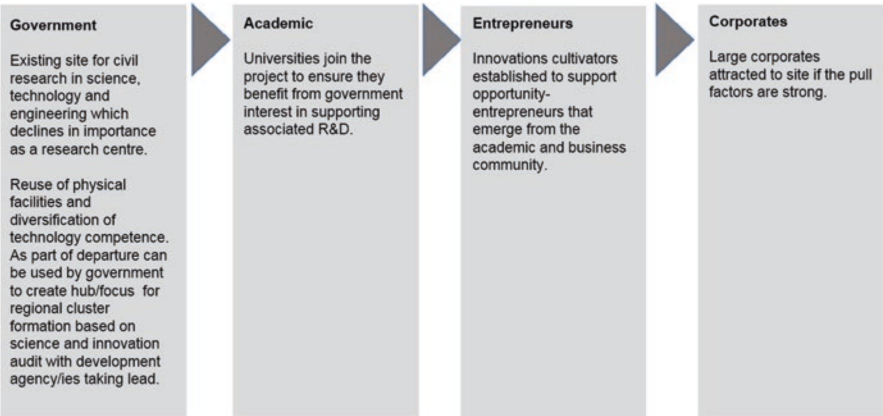


Fig. 7 Government-led parks: include Harwell Oxfordshire and the Norwich Science Park

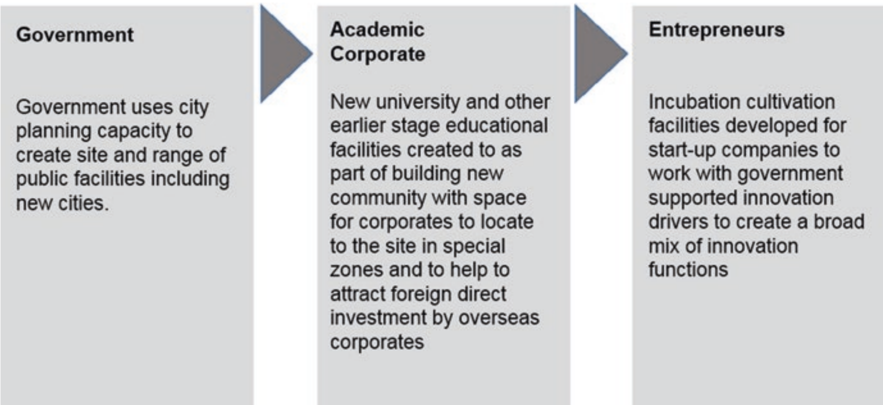


Fig. 8 Government-led new town/city: examples include Cyberjaya Sepang (Malaysia); Innopolis Daejeon (South Korea); Zhongguancun Science Park (Beijing, China); 22@Barcelona innovation district (Barcelona, Spain); Novosibirsk (Russia); Zewail City of Science and Technology (Egypt)

based companies can prosper, and where specialist business advisors and other elements of the supply chain become established, thus leading to a virtuous circle of growth which results in the creation of a highly productive region (Fig. 8).

There is also evidence of technology hotspots in cities that are thriving where the initial movers in these projects have been entrepreneurs themselves. Typical examples include Tech City (London), Silicon Alley (New York) and significantly Silicon Valley where the hotspot has emerged following the clustering of entrepreneurs in, what is commonly, a low-cost area of a city (Fig. 9).

This analysis shows the plasticity of the concept and its potential for adaptation to meet local economic conditions that can be curated to create a place-based ecosystem, effective in delivering the value propositions for each of the stakeholders.

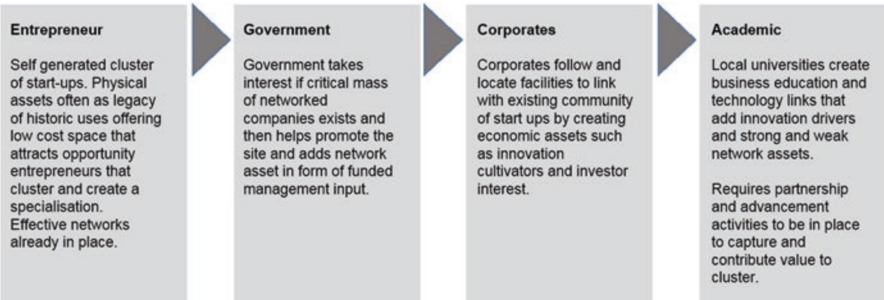


Fig. 9 Some locations have been developed from the aggregation of entrepreneur-led clusters of start-ups. Examples of these clusters include Tech City (London), Silicon Allee (Berlin), and Silicon Valley (San Francisco, California)

Most universities tend to be willing stakeholders in these projects, even when they are not investors, because of the range of value propositions that participation offers. Universities with no formal links with a STP may, for example, run informal business education for those companies in the project. Such arrangements are in place with Universitat de Barcelona (UB), Universitat Autònoma de Barcelona (UAB) and Universitat Pompeu Fabra (UPF) that are involved in the civic-sponsored project 22@ in Barcelona that has been under planning and development since 2001.

9 Governance

International experience has shown that the financial returns on real estate developed as STPs are rarely sufficient to enable these to be completely self-funding based on rental income alone. To overcome this challenge, the majority of STP projects need cooperation between a number of stakeholders in order to execute their development and operation.

The challenges for stakeholders include the acquisition and ownership of land and buildings and then the longer-term operation of the site. Options for their development range from single ownership that covers the design, build, finance and operation through joint ventures to cooperatives.

The integration of stakeholders needs effective governance systems in order to try to match stakeholder value propositions, objectives and performance.

Typical governance structures for university led STPS flows from the University Board (Fig. 10).

In most cases where science parks are operated under this structure, the host's senior management board delegate management responsibility to an overseeing science park board or executive. In the majority of cases this overseeing board puts in place a park management team which then organizes the major tasks that make for a smooth-running delivery of service for tenants.

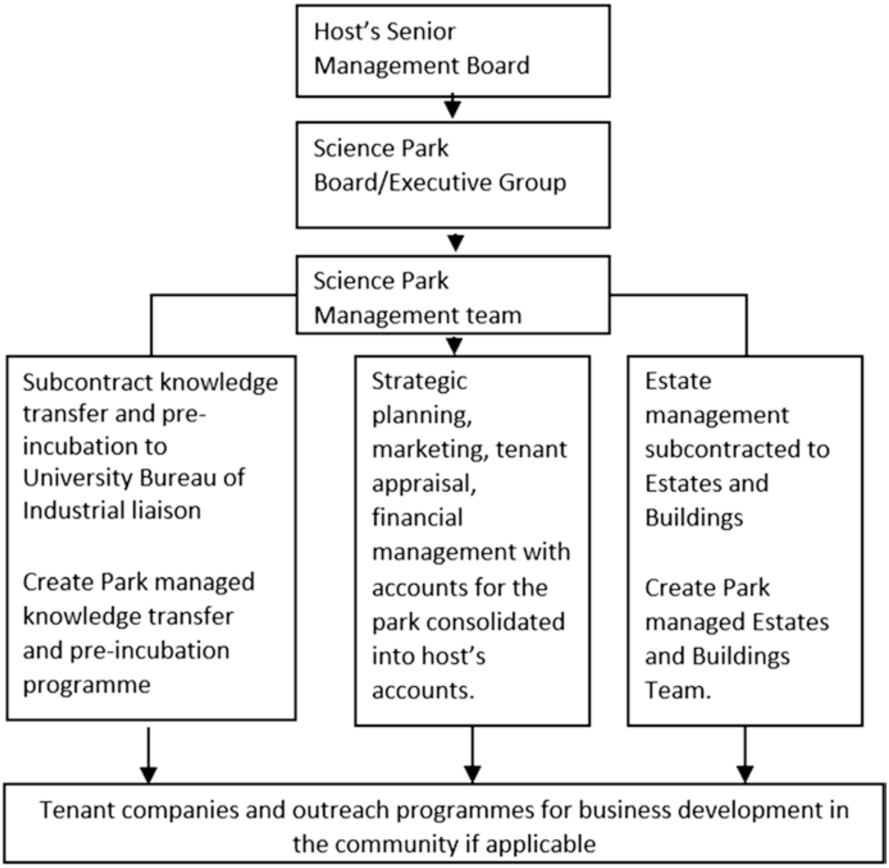


Fig. 10 Organizational chart for single ownership or host-owned STP, after Rowe D 2006 [45]

In many cases, knowledge exchange services are extended through an outreach program to include wider community-based businesses that can then benefit from this shift towards universities becoming more entrepreneurial.

A second joint venture arrangement is similar, but this provides for the stakeholders to also take a place in overseeing the project (Fig. 11) and allows for shared ownership, which enables government engagement that goes beyond any necessary initial planning permission being granted for a site.

The balance of influence between the different shareholders in this kind of structure can vary considerably, but this provides significant flexibility for future restructuring of ownership. It is also important that there is a shareholder agreement that sets out the basic tenets for the STP.

The least cohesive option is for sites that are being developed through a cooperative option involving a university with a development agency or local authority and potentially others, including private sector developers.

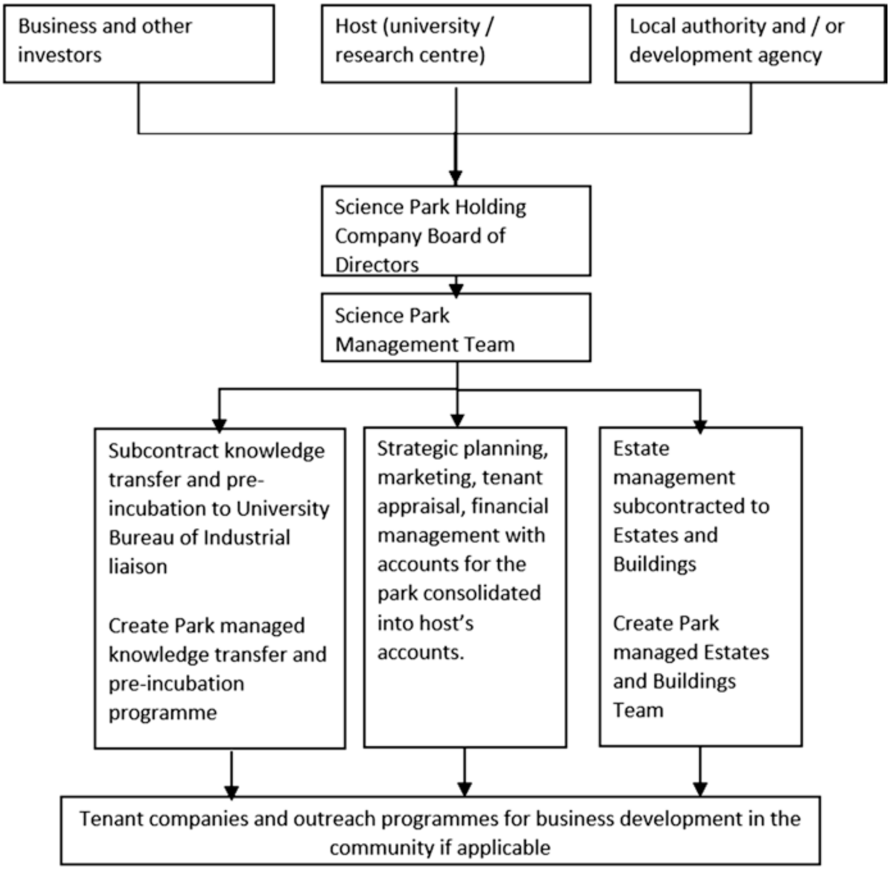


Fig. 11 Organizational chart for shared ownership of STP, after Rowe D 2006 [45]

The cooperative model (Fig. 12) for managing science parks has proved to be a popular structure because in most cases it does not involve a new legal entity or any transfer of assets so it can be established relatively quickly.

In most instances where this structure is in place, a development agency or local authority takes the lead in establishing the physical premises, providing much of the on-site property management, dealing with the financial management and in some cases providing the business development functions to assist tenant companies as well.

In these ventures, a host's principal input is frequently made through their industrial liaison officer that may operate from an office on the park to help in establishing the links between the tenant companies and the host.

In cooperative arrangements, the financial commitment by the host organization and by the agency that provides the business support – whether that is a development agency, a government business support agency or a university's business school – is low. In contrast, the risk for the local authority or government body is

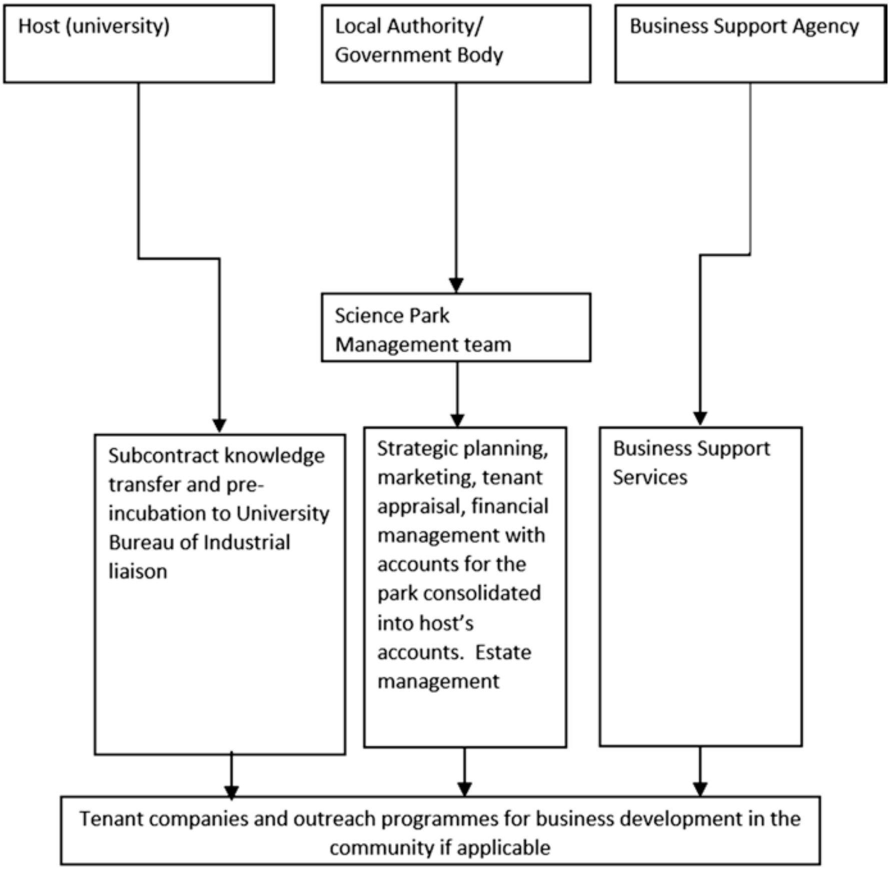


Fig. 12 Organizational chart for co-operative STP, after Rowe D 2006 [45]

high. The cooperative arrangement allows a number of third-party organizations to be involved in supporting the process.

Where parks are based on a cooperative arrangement it is not uncommon to have a partnership agreement in place with a service level agreement to ensure that the co-opted parties are obliged to provide services and maintain standards of delivery.

10 Management Team

In all three options it is necessary to have an effective management team in place. The structure and services these teams provide varies depending on the ownership, size, funding and services that a site offers.

The skills and services needed to support spin-outs from universities and those that emerge from the non-university business community that need incubation include business coaching, mentoring and business education that provide insights to these companies about the SME development journey. They should also guide company owners into gaining insights into the technical developments occurring in the open market as part of an outward-looking market focus. The other aspect of incubation includes creating opportunities for student placements and projects with SMEs, and, if relevant, linking the companies to university researchers and research facilities. If this is successful this can help to develop a regional economy, begin to build an ‘enterprise ecosystem’, and serve established industries with access to new innovations and acquisitions.

In business ecosystems where incubation programs run investments funds and offer funding to incubatees it is common to have a technology investment advisor that can guide funds for any investment decisions in tenants on the STP.

To make for a smooth operation of an STP these projects need operations and development services to cover the development and functioning of a site as a multi-tenanted operation that delivers accommodation and varying levels of services to tenants.

Experience suggests that a commercial director that has responsibility for ensuring the funding is in place to create a sustainable operation adds value to the team by creating a realistic business environment.

To gain the best market penetration and profile of the STP, particularly with stakeholders, it is important to have a marketing and communications function that can raise the profile of the STP with stakeholders. To ensure this is achieved with a commercial focus, an STP also needs a well-organized finance operation.

The extent of the teams that service this portfolio of roles would be expected to vary depending on the experience of team members, the size of the operation, and the level of funding. Experience suggests that where there is government support these projects commonly have larger teams in place to try to drive the objective of economic development and may come with political patronage, while a university-owned, funded and managed project is likely to have a slimmer staff complement.

11 Origin of Companies

One of the challenges that comes with creating an STP is attracting tenants. Experience of many years has shown that government as a stakeholder often operates under the misapprehension that all these companies will be spin-outs from the academic community. This is an unrealistic idea because universities need to continue with their teaching and research and not be completely diverted by the need to focus on spin-outs. Broad experience from across the STP movement is that through a slow process of building up momentum of an STP there needs to be a mix of spin-out companies from the host and companies that are drawn to the site from the surrounding business community. This means all STPs need to work with both new opportunity-entrepreneur-led businesses that are recruited from the region as well as existing businesses that see the value of the risk sharing that STPs offer, which can help them to scale.

To create the dynamic mix of tenants on science parks, STP managers and their management board need to set entry criteria that creates a community of companies that includes both opportunity-entrepreneur-led businesses from the existing business community and those from within the host institution.

Setting entry criteria or the details of the selection process for occupiers is usually a matter for an STP's board or management team; however, experience of many of the organizations that plan, develop and operate these sites is that tenants are recruited from the following groups and they are commonly self-selecting because of the commercial advantages business owners expect to gain from location on an STP [46].

The collective experience of operating parks is that a number of start-ups spin-off from other innovative M&SMEs that are either existing tenants on an operational STP as well as from the immediate region. Common causes for the formation of these new companies come from internal politics or disagreements amongst the micro-companies of fewer than ten members. Some spin-offs come from companies with over 30 staff where entrepreneurs feel frustrated by lack of personal progression and have sufficient entrepreneurial flair to leave and develop an independent business.

Some universities not only offer short-term employment contracts but allow staff to create private companies which result in entrepreneurial staff creating businesses when their contracts end or if they have an idea they want to commercialize. The frequency of these companies moving to parks depends heavily on the policy arrangements of the host university has on the IP title to research outputs and the host university's terms of employment.

The increasing prevalence of staff and student enterprise units on university campuses is now also helping to stimulate entrepreneurship. The number of these young companies tends to be relatively low, but over time many parks have experienced a gradual increase in the number of companies that follow this route as confidence builds and a 'start-up' culture starts to gain traction. In addition, many spin-outs emerge from local larger mature companies where graduates learn a business, have worked with customers and then ask themselves questions about the potential for innovation that they believe they can deliver through their own business. In these instances, market experience is important.

A number of tenants on parks are specialist teams or spin-outs from large companies that want to link to a host institution or create a separate company to develop an innovative idea. The number of these types of tenants can be influenced by the stakeholder's view to supporting foreign direct investment in the park where overseas companies see the benefit of a particular location for a specialist team.

In all cases, the proportion of non-university companies that come forward with an interest in moving to a STP depends on the prevailing social, business and technology conditions in the location. Highest numbers are seen in STPs in economic heartlands where the majority of tenants, including start-ups, emerge from the existing business community. The catchment for these companies is from within an easy commute of the STP. A number of STPs have attracted companies that have been formed following the break-up or privatization of government research facilities that forces technology out into the commercial market. Where this is supported by venture capital or a ‘disbandment fund’ this adds momentum to company formation. A further number of companies are started by serial entrepreneurs who are inclined to drive ideas to market because they see a market for a new technology, such as blockchain, and have the interest and inclination to pursue their idea.

At a government level, some governments are now offering challenge programs where they articulate a problem to which they seek a commercial solution. Where companies are successful in bidding for these challenge funds, this can lead to the development of a start-up or an existing business looking to locate on a park depending on the terms and conditions of the award contract from the challenge fund.

Today, with the expansion of higher education there are now many more places for study in universities. Many universities are adding entrepreneurship into educational programs in order to increase their focus on teaching and encouraging enterprise and entrepreneurship by students and staff. This drive is also being helped by technology transfer offices widening their remit to include the identification and commercializing proprietary intellectual property (IP). In many countries there is now a requirement for academics to demonstrate social and economic impact of their research as part of the social contract for receiving government research funding. The increase in the number of graduates trying to create businesses may well be driven by the diminishing number of government and corporate jobs coming onto the employment market. In addition, entrepreneurship has become an attractive option for graduates, particularly because of the opportunities afforded by the internet to test markets and gain access to business tools and raising finance. In some cases, this route is being aided with access to challenge funds and the influence of high-profile entrepreneurs and whether or not there are facilities and associated accelerator programs available locally.

Some incubators are also running hackathons to try to create teams of entrepreneurs to address commercial opportunities. These need to be managed and are more appropriate for some technologies than others, but they can help to create a positive business culture towards entrepreneurship.

There are also some companies that are formed by highly internationalized well-educated young professionals that have been part of a diaspora. They use their market knowledge to bring technologies or ideas back to their country and build a local or regional business which is commonly founded on a technology that is new to the country or region technology, rather than new to the world, but of no less value in terms of economic development as this all contributes to entrepreneur-led capacity building.

12 Incubation

Over the last 20 years, programs and projects for developing spin-outs and start-ups have become increasingly sophisticated as they build experience of providing service and support for spin-outs from the host university and providing an opportunity for a university to link into the wider business community by engaging with opportunity-entrepreneurs and non-university SMEs. Interaction between businesses from both these origins helps those running incubators to gain insights into both SME development journeys and technical developments occurring in the open market. In addition, where appropriate, incubators create opportunities for student placements and market research and business model projects for SMEs. They also provide broad links between SMEs and university researchers and research facilities.

Experience from Surrey Research Park is that some 40% of the main body of tenant companies come from the early stage services offered by the multi-occupancy Surrey Technology Centre and its formal SETsquared incubator. These facilities (Table 3) are an important part of the infrastructure that helps to create the regional enterprise ecosystem as well as develop smart new-tech SMEs that provide access to innovation and subsequent acquisitions that brings inward investment to the region. These programs also provide the opportunity to create income streams for business advisors.

Experience has also identified that the space provided by an incubator needs to match the type of companies that it wants to attract. Young entrepreneurs are most interested in desk space in an attractive environment with the types of extra facilities noted in Table 3. More tech-intense businesses generally are looking for private working areas with the potential for dry or wet laboratories. Start-ups being developed by more mature business people tend to look for a range of professional services, a functional environment, and generally are a low-noise environment. If incubation space can be integrated into a larger innovation center where reception, security, café and facilities management services provide for larger numbers of small early stage businesses not in the formal incubation process, this helps offset the costs of the operation of the formal incubation programs.

Table 3 Typical university incubators offer the facilities

Features	Services and support
Space suitable for individual working	Confidentiality, noise, safety, storage, at a minimum: desk, phone and internet facility
Networking potential, peer to peer learning	Communal spaces, Café
Location	Convenient transport links
Building and reception facilities	Post handling, visitor processing, call handling, professional meeting and presentation spaces
Affordable and flexible	Day rate through to annual lease, short notice period, itemized billing for services

The value proposition of incubation (Fig. 13) centers on driving technology up the value chain from an idea that has come out of creative thinking associated with technical advances with the potential to gain commercial traction in a perceived market. However, to eventually become an investable proposition the early stage incubation process requires the idea to be tested against competition and demand in order to prove value if it is to attract funds that are necessary to build and operate the exploitation platform and turn this into a fully operational self-funding company.

The empirical evidence [47] from incubation on a science park is that the processes in building a company develop along four strands of activities or journeys (Fig. 14). This portrays the process as linear, but entrepreneurs can start each of these journeys at a different point which commonly depends on personal experience, market knowledge, and business know-how. However, the end point is to have a minimum viable but warrantable product that makes a commercial return.

These journeys need funding and the options for this which will vary over the period of the commercialization process (Fig. 15). However, it is important for STPs to be aware of the Ease of Business Index so that when STPs are being planned there is an awareness of the extent of the support or hindrance to the entrepreneurial process posed by restrictive regulation and how this can be addressed in terms of development. However, in contrast to restrictions for business that limits their freedom to become more entrepreneurial, a number of governments are introducing benchmarking to try to drive increases in efficiency and effectiveness of public funding for knowledge exchange [48].

The funding options for effective incubation requires clear coordination between the government that provides the initial funding options and the private sector funders that follow on from and help companies drive through the TRL stages of 4–7. Part of this coordination is the recognition of the risks for private capital in this process and the need to ameliorate this risk with effective tax-related instruments to ensure that investment in knowledge transfer continues to attract funding while competing against other asset classes.

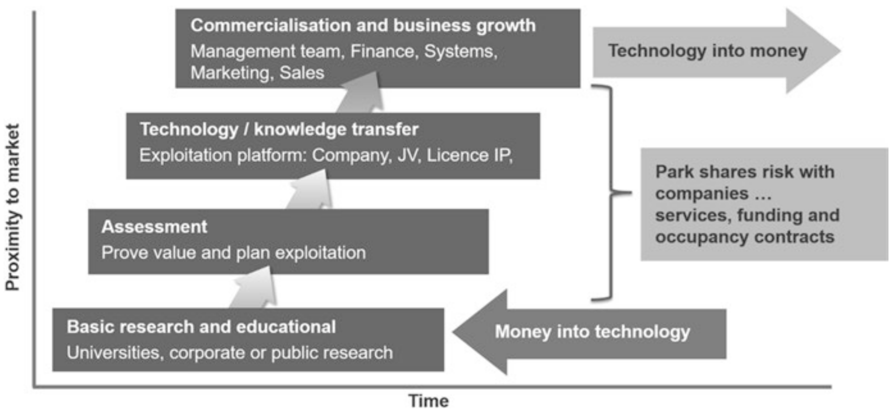
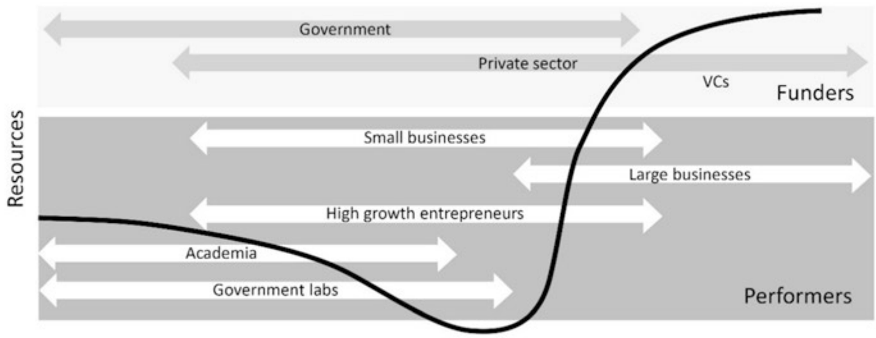


Fig. 13 Steps in driving technology up the value chain. (Parry M – own elaboration)

Fig. 14 Journeys of company development. (Parry M – own elaboration)



TRL	1	2	3	4	5	6	7	8	9
	Discovery and research		Innovation					Commercialization	
	Basic principles recorded	Concept / application formed	Experimental proof of concept	Concept or process validated in laboratory	System or component validated in relevant environment	System, model, demonstrator in relevant environment	System prototyping demonstrator in operational environment	System completed. Qualified test and demo in operational environment	Actual system mission proven in successful mission operations

Fig. 15 Funding innovation across the Technology Readiness Levels (TRL). (*Source*: After Coyle [49])

13 Conclusions

STPs are of their time, they match the need for greater links between knowledge generation and the market in the form of innovation which relies on entrepreneurial discovery for delivery of commercial products, not just on government investment. STPs provide increasing levels of support for companies in places that offer co-location at medium density as well as both tactical and intense support in incubators and accelerators that are usually in high-density occupancy locations occupied by independent companies. This support is provided through management regimes commonly coordinated by governance structures representing the interests of the most common stakeholders in STPs of government, universities and science companies. The origins of these companies flow from various sources which include spinouts from their host, the local business community in the catchment area the STP serves, and inward investors such as large companies or companies that acquire M&SMEs.

Part of the power of STPs comes from their ability to create areas that build tacit knowledge that link talent, technology and place and drive innovation. Part comes from the markets that global demographics and technology markets present. Part comes from their versatility as to work wherever there is a host university that is willing to widen their vision and take on the third mission.

It is clear that all STPs are, in reality, 'work in progress' because they are dealing with the wicked problem of economic development and supporting the development of the fourth industrial revolution.

References

1. Metcalfe JS (2006) Entrepreneurship: an evolutionary perspective. In: Casson M, Yeung B, Basu A, Wadsons N (eds) The Oxford handbook of entrepreneurship. Oxford University Press, Oxford, p 66
2. European Commission Brussels, 2.2.2010 SEC (2010) 114 final Lisbon strategy evaluation document. http://ec.europa.eu/archives/growthandjobs_2009/pdf/lisbon_strategy_evaluation_en.pdf
3. United Nations 17 Sustainable Development Goals (September 2018). https://www.un.org/sustainabledevelopment/sustainable-development-goals/
4. Parry M (1992) Science parks: the driving forces behind the concept and their physical planning and development. In: Conference proceedings. Korean Science and Engineering Foundation
5. World Population Prospects (2017 Revision) United Nations Population Estimates
6. Dobbs R, Madgavkar A, Barton D, Labaye E, Manyika J, Roxburgh C, Lund S, Madhav S (January 2012) The world at work: jobs, pay, and skills for 3.5 billion people. McKinsey Global Institute, p 4. https://www.mckinsey.com/~/media/McKinsey/Featured%20Insights/Employment%20and%20Growth/The%20world%20at%20work/MGI%20Global_labor_Full_Report_June_2012.ashx
7. Carlson B (August 6, 2012 Global Post) In China, College Education comes at a Price. In: Alpert D (ed) The age of oversupply, Penguin
8. Roser M, Ortiz-Ospina E (2019) Global rise in education. Published on line at OurWorldInData.org. https://ourworldindata.org/global-rise-of-education
9. Perkmann M, Walsh K (2007) University–industry relationships and open innovation: towards a research agenda. Int J Manag Rev 9:259–280
10. Eckhardt JT, Shane SA (2003) Opportunities and entrepreneurship. J Manag 9(3):333–349
11. European Commission – what is an SME? http://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_en
12. Council on Governmental Relations (October 1999) The Bayh-Dole Act. A guide to the law and implementing regulations. https://www.umventures.org/sites/umventures.com/files/COGR_Bayh_Dole.pdf
13. Gallagher C, Stewart H (1986) Jobs and business cycles in the UK. Appl Econ 18(8):875–900
14. Segal N, Quince R, Wicksteed B (1985) The Cambridge phenomenon: the growth of high technology industry in a University Town. Segal Quince Wicksteed Ltd, Cambridge

15. Atkinson RD, Ezell S (2015) Principles of national innovation success. https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2015-chapter4.pdf
16. OECD (1997) National innovation systems. http://www.oecd.org/science/inno/2101733.pdf
17. Foray D (2015) Smart specialisation. Opportunities and challenges for regional innovation policy. Routledge Taylor/Francis Group, London/New York
18. Huggins R (2001) Global index of regional knowledge economies: benchmarking south. Report prepared by Robert Huggins Associates, SEEDA, Guildford
19. After Foray D (2015) Smart specialisation. Opportunities and challenges for regional innovation policy. Routledge Taylor/Francis Group, London/New York
20. Katz B, Jones A (2014) The rise of innovation districts: a new geography of innovation in America. Brookings Metropolitan Policy Program, Brookings Institute. https://www.brookings.edu/search/?s=The+Rise+of+Innovation+Districts%3A+A+New+Geography+of+Innovation+in+America
21. Cofrancisco K (2014) Brookings. A new geography of innovation. Available at https://www.brookings.edu/news-releases/a-new-geography-of-innovation/
22. Cornell University, INSEAD, WIPO (2018) The global innovation index 2018: energizing the world with innovation. Ithaca, Fontainebleau, and Geneva
23. World Bank Business Sophistication Index. https://govdata360.worldbank.org/search?key=Business+sophistication+Index
24. Mostafa Razavi S, Abdollahi B, Ghasemi R, Shafie H (2012) Relationship between "Innovation" and "Business Sophistication": a secondary analysis of countries global competitiveness. Eur J Sci Res 79:29–39
25. Valero A, Van Reenen J (2018) The economic impact of universities: evidence from across the globe. Economics of education review (available online, forthcoming in press) reported in Paper 1S06 Azmat G, Murphy R, Valero A, Wyness G September 2018, Universities and industrial strategies in the UK: review of evidence and implications for policy. Centre for Economic Performance, The London School of Economic and Political Science. http://cep.lse.ac.uk/pubs/download/is06.pdf
26. Azmat G, Murphy R, Valero A, Wyness G (September 2018) Universities and industrial strategies in the UK: review of evidence and implications for policy. Centre for Economic Performance, The London School of Economic and Political Science, p 22. http://cep.lse.ac.uk/pubs/download/is06.pdf
27. Ezell SJ, Atkinson RD, Wein MA (2013) Trade: threat to the global innovation economy. ITIR. Available at http://www2.itif.org/2013-localization-barriers-to-trade.pdf
28. Catapult Program: available at https://catapult.org.uk/
29. HEFCE (2016) University Knowledge Exchange (KE) Framework: good practice in technology transfer. https://dera.ioe.ac.uk/27123/1/2016_ketech.pdf
30. HEFCE (2012) Strengthening the Contribution of English higher education institutions to the Innovation system: knowledge exchange and HEIF fundind, Higher Education Business and Community Interaction (HE-BCI) survey. http://www.hefce.ac.uk/kess/hebci/
31. UK Government (2018) Research and Development (R&D) tax relief. https://www.gov.uk/guidance/corporation-tax-research-and-development-rd-relief
32. UK Government (2007) https://www.gov.uk/guidance/corporation-tax-the-patent-box
33. World Bank (2013) Transforming Arab economies: travelling the knowledge and innovation road. https://www.cmimarseille.org/sites/default/files/newsite/library/files/en//KE_ArabEconomies_Overview_EN_0.pdf
34. Mckinsey October (2015) The China effect on global innovation. https://www.mckinsey.com/~/media/McKinsey/Featured%20Insights/Innovation/Gauging%20the%20strength%20of%20Chinese%20innovation/MGI%20China%20Effect_Executive%20summary_October_2015.ashx
35. Berlin L (2017) Troublemakers: how a generation of Silicon Valley upstarts invented the future. Simon and Schuster

36. Cirillo C M (2013) Birth of an idea: the creation of Research Triangle Park and its sustained economic impact on the Research Triangle Area. https://sites.duke.edu/urbaneconomics/?p=899
37. www.parliament.uk in February (1999) Memorandum submitted to UK Government Select Committee by Cambridge University. https://publications.parliament.uk/pa/cm199899/cmselect/cmsctech/17/9020102.htm
38. Etzkowitz H, Webster A, Gebhardt C, Terra BRC (2000) The future of university and the university of the future: evolution of ivory tower entrepreneurial paradigm. Res Policy 29:313–330
39. Perse Comm UKSPA Chief Executive (2018)
40. Madaleno M, Nathan M, Overman H, Waights S (2018) Incubators, accelerators and regional economic development, CEP discussion paper no 1575, September
41. OECD (2015) The future of productivity. OECD Publishing, Paris. https://doi.org/10.1787/9789264248533-en
42. Parry M (2016) Science and Technology Parks, Areas of Innovation, government, universities, civil society and business – where are they going in the innovation race and what should S&TPs be doing to help anchor innovation in a region? In: Proceedings of IASP annual conference, Moscow
43. IASP (2018) Importance of institutions in influencing the ongoing development of STPs/AOIs. Malaga
44. K-Startup (2019) https://www.k-startupgc.org/
45. Rowe D (2016) Interface with the university or centre of technology. In: Parry M (ed) The planning, development and operation of science parks, UKSPA, pp 57–69. http://www.ukspa.org.uk/our-association/ukspa-publications-list
46. Parry M (2007) Understanding, fostering and managing creativity. In: Proceedings of IASP annual conference, Barcelona
47. Parry M (2011) Technology, market and company journeys: how can we help them succeed? In: Proceedings of IASP annual conference, Copenhagen
48. Research England, Knowledge exchange framework (KEF) (2019) https://re.ukri.org/knowledge-exchange/knowledge-exchange-framework/
49. Coyle PE (2011) The missing middle. https://ndiastorage.blob.core.usgovcloudapi.net/ndia/2011/SET/CoyleNDIA.pdf

An Overview of Innovation and Entrepreneurship to Address Climate Change

John R. Hillman and Elias Baydoun

Abstract Opportunities for innovation and entrepreneurship to address the existential challenge of climate change are reviewed, focusing on two themes. (a) The processes and strategies to mitigate the effects of projected climate changes arising from global anthropogenic greenhouse-gas emissions, and (b) the future security of food, water, and energy specifically in the Arab Middle East. It is appreciated that implementation of these changes will be dependent on peaceful and politically stable conditions. Also, the Region is connected to neighbouring countries and shares the atmosphere with the rest of the world so there is a need for concerted multilateral action. All forward projections are subject to numerous uncertainties including the advent of conceptually new forms of disruptive technology and the adaptive capacity of Arab nations. Although the timing and quantification of risks are unclear, a prudent approach is essential to safeguard financial stability of international markets and national economies. Background information is presented on greenhouse gases, fossil fuels, and renewable energy. Climate-change predictions at the general level and specifically for the Arab region are outlined, along with mitigation and adaption strategies and climate engineering. Specific processes and strategies for the Arab Middle East are discussed with detailed proposals for agriculture and food security, water security, energy security, industrial biotechnology, social development, carbon storage and trading, and global biodiversity. The United Nations Sustainable Development Goals are considered in relation to climate change, followed by examination of the terms sustainable and sustainability. Finally, international climate-change negotiations and agreements are briefly reviewed.

Keywords Climate change · Innovation · Entrepreneurship · Arab world · Greenhouse gases · Fossil fuels · Renewables · Climate-change predictions · Mitigation · Adaptation · Climate engineering · Specific proposals · Biodiversity · SDGs · Sustainability · IPCC

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1 Introduction

Earth's chemistry, physics, and biology have been and are being modified on a vast scale by humans. Landscapes, seas, and oceans everywhere are being modified; river flows have been redirected and/or reduced; man-made pollution contaminates the atmosphere, seas, land, humans, livestock, and the natural fauna and flora; natural habitats are being destroyed, and global natural resources are being consumed at an ever-increasing rate in line with human population growth and changing demands. Earth's biodiversity, biogeography, climate, geomorphology, and stratigraphy bear marked evidence of human activity. We are said to be living in the "Anthropocene" epoch [1, 2], a term said to be used by Soviet scientists in the 1960s referring to the present phase of the current Quaternary period but also used since the 1960s and 1970s by the ecologist Eugene F. Stoermer [3] and the atmospheric chemist Paul J. Crutzen [4] (both Nobel Laureates) as a new geological epoch when humans began to have significant impacts on the Earth's ecosystem. There is no agreed date as to the beginning of this epoch because unlike the other geological supereons, eons, eras, periods, and epochs it is not based on stratigraphy. Nor is there agreement on the potentially catastrophic nature of its trajectory. Currently, we are deemed to be in the Phanerozoic eon, Cenozoic era, Quaternary period, and Holocene era. The fundamental question is when did humans become a significant feature on the planet? Was it the advent of agriculture about 10,000 years ago? Or when agriculture began to change sediments 5000 years ago? Or the start of the Industrial Revolution when the atmosphere started to be modified by humans? Or the creation of large dams and extensive use of water, or the creation of significant levels of wastes and pollutants?

Major industries intrinsically affected by climate change include (a) insurance; (b) banking; (c) investments and especially disinvestments from fossil-fuel stocks, drilling, and mining operations, leaving "stranded assets"; (d) energy (especially from oil, gas and coal); (e) mining generally; (f) other civil engineering industries; (g) health; (h) agriculture; and (i) transport. Advances in science, engineering, and technology are pivotal to successful delivery of mitigation and adaptation to climate change. Projected climate-change predictions may accentuate the differential economic and social conditions between the northern temperate developed countries and the rest.

Scientists, engineers, and technologists must address mitigation and adaptation strategies to climate change with the utmost urgency, helping shape policies that ultimately enable the decoupling of economic growth from the consumption of finite natural resources. The thrust of this chapter is concerned with this imperative – to understand, set hypotheses, design experiments, analyse, generate new ideas and concepts, invent products and processes, provide solutions and explanations, and give hope for the future. Climate change offers unparalleled opportunities for innovators and entrepreneurs. No region on Earth deserves and needs greater attention paid to climate change than the Arab Middle East.

2 Background Reports

This year (2019) was the year when the levels of carbon dioxide in the atmosphere exceeded 415 ppm [5]. According to the National Centers for Environmental Information, under the auspices of the National Oceanic and Atmospheric Administration in the USA [6], the July 2019 global land and ocean surface temperature departure from average was the highest for July since global records began in 1880 at 0.95 °C above the twentieth century average.

The United Nations Framework Convention on Climate Change (UNFCCC) is the international intergovernmental forum for negotiating the global responses to climate change (see Sect. 13). Central to addressing the challenges of climate change are the pivotal reports and meetings of the International Panel on Climate Change (IPCC) [7]. The main activity of the IPCC is the preparation of reports assessing the state of knowledge of climate change used inter alia in international negotiations. These reports include assessment reports, special reports, and methodology reports. It is important to stress that to deliver this important work programme, the IPCC holds meetings of its government representatives, convening as plenary sessions of the Panel or IPCC Working Groups to approve, adopt, and accept reports. Plenary Sessions of the IPCC also determine the IPCC work programme, and other business including its budget and outlines of reports. The IPCC Bureau meets regularly to provide guidance to the Panel on scientific and technical aspects of its work. Comprehensive Assessment Reports are prepared about the state of scientific, technical and socio-economic knowledge on climate change, its impacts and future risks, and options for reducing the rate at which climate change is taking place. Special Reports are also prepared on topics agreed to by its member governments, as well as Methodology Reports that provide guidelines for the preparation of GHG inventories.

IPCC assessments and special reports are prepared by three Working Groups, each looking at a different aspect of the science related to climate change: Working Group I (The Physical Science Basis), Working Group II (Impacts, Adaptation and Vulnerability), and Working Group III (Mitigation of Climate Change). The IPCC also has a Task Force on National Greenhouse Gas Inventories, whose main objective is to develop and refine a methodology for the calculation and reporting of national GHG emissions and removals. The Working Groups and Task Force handle the preparation of reports, selecting and managing the experts. The activities of each Working Group and the Task Force are supported by their Technical Support Units.

In the recent IPCC Special Report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global GHG emissions [8], the following 19 highly important points were made.

- Human activities are estimated to have caused approximately 1.0 °C of global warming above pre-industrial levels. Global warming is likely to reach 1.5 °C between 2030 and 2052 if it continues to increase at the current rate.
- Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further

long-term changes in the climate system, such as sea level rise, with associated impacts, but these emissions alone are unlikely to cause global warming of 1.5 °C

- Climate-related risks for natural and human systems are higher for global warming of 1.5 °C than at present, but lower than at 2 °C. These risks depend on the magnitude and rate of warming, geographic location, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options
- Climate models project robust differences in regional climate characteristics between present-day and global warming of 1.5 °C, and between 1.5 °C and 2 °C. These differences include increases in: mean temperature in most land and ocean regions, hot extremes in most inhabited regions, heavy precipitation in several regions and the probability of drought and precipitation deficits in some regions
- By 2100, global mean sea level rise is projected to be around 0.1 m lower with global warming of 1.5 °C compared to 2 °C. Sea level will continue to rise well beyond 2100, and the magnitude and rate of this rise depend on future emission pathways. A slower rate of sea level rise enables greater opportunities for adaptation in the human and ecological systems of small islands, low-lying coastal areas and deltas.
- On land, impacts on biodiversity and ecosystems, including species loss and extinction, are projected to be lower at 1.5 °C of global warming compared to 2 °C. Limiting global warming to 1.5 °C compared to 2 °C is projected to lower the impacts on terrestrial, freshwater, and coastal ecosystems and to retain more of their services to humans.
- Limiting global warming to 1.5 °C compared to 2 °C is projected to reduce increases in ocean temperature as well as associated increases in ocean acidity and decreases in ocean oxygen levels. Consequently, limiting global warming to 1.5 °C is projected to reduce risks to marine biodiversity, fisheries, and ecosystems, and their functions and services to humans, as illustrated by recent changes to Arctic sea ice and warm-water coral-reef ecosystems.
- Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming of 1.5 °C and increase further with 2 °C.
- Most adaptation needs will be lower for global warming of 1.5 °C compared to 2 °C. There is a wide range of adaptation options that can reduce the risks of climate change. There are limits to adaptation and adaptive capacity for some human and natural systems at global warming of 1.5 °C, with associated losses.
- In model pathways with no or limited overshoot of 1.5 °C, global net anthropogenic CO_2 emissions decline by about 45% from 2010 levels by 2030 (40–60% interquartile range), reaching net zero around 2050 (2045–2055 interquartile range). For limiting global warming to below 2 °C, CO_2 emissions are projected to decline by about 25% by 2030 in most pathways (10–30% interquartile range) and reach net zero around 2070 (2065–2080 interquartile range). Non-CO_2

emissions in pathways that limit global warming to 1.5 °C show deep reductions that are similar to those in pathways limiting warming to 2 °C.

- Pathways limiting global warming to 1.5 °C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban, and infrastructure (including transport and buildings), and industrial systems. These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed, and imply deep emissions reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options.
- All pathways that limit global warming to 1.5 °C with limited or no overshoot project the use of carbon-dioxide removal (CDR) on the order of 100–1000 Gt CO_2 over the twenty-first century. CDR would be used to compensate for residual emissions and, in most cases, achieve net negative emissions to return global warming to 1.5 °C following a peak. CDR deployment of several hundreds of Gt CO_2 is subject to multiple feasibility and sustainability constraints. Significant near-term emissions reductions and measures to lower energy and land demand can limit CDR deployment to a few hundred Gt CO_2 without reliance on bioenergy with carbon capture and storage (BECCS).
- Estimates of the global emissions outcome of current nationally stated mitigation ambitions (NDCs; see 13 International Climate-Change Negotiations and Agreements) as submitted under the Paris Agreement would lead to global greenhouse gas emissions in 2030 of 52–58 Gt CO_2 eq year^{-1}. Pathways reflecting these ambitions would not limit global warming to 1.5 °C, even if supplemented by challenging increases in the scale and ambition of emissions reductions after 2030. Avoiding overshoot and reliance on future large-scale deployment of carbon-dioxide removal (CDR) can only be achieved if global CO2 emissions start to decline well before 2030.
- Climate-change impacts on sustainable development, eradication of poverty, and reducing inequalities would be reduced if global warming were limited to 1.5 °C rather than 2 °C, if mitigation and adaptation synergies are maximized while trade-offs are minimized.
- Adaptation options specific to national contexts, if carefully selected together with enabling conditions, will have benefits for sustainable development and poverty reduction with global warming of 1.5 °C, although trade-offs are possible.
- Mitigation options consistent with 1.5 °C pathways are associated with multiple synergies and trade-offs across the Sustainable Development Goals (SDGs). While the total number of possible synergies exceeds the number of trade-offs, their net effect will depend on the pace and magnitude of changes, the composition of the mitigation portfolio and the management of the transition.
- Limiting the risks from global warming of 1.5 °C in the context of sustainable development and poverty eradication implies system transitions that can be enabled by an increase of adaptation and mitigation investments, policy instruments, the acceleration of technological innovation, and behaviour changes.
- Sustainable development supports, and often enables, the fundamental societal and systems transitions and transformations that help limit global warming to

1.5 °C. Such changes facilitate the pursuit of climate-resilient development pathways that achieve ambitious mitigation and adaptation in conjunction with poverty eradication and efforts to reduce inequalities.
- Strengthening the capacities for climate action of national and sub-national authorities, civil society, the private sector, indigenous peoples, and local communities can support the implementation of ambitious actions implied by limiting global warming to 1.5 °C. International cooperation can provide an enabling environment for this to be achieved in all countries and for all people, in the context of sustainable development. International cooperation is a critical enabler for developing countries and vulnerable regions.

Thus, its key finding [9] is that meeting a 1.5 °C target is possible but would require deep emissions reductions and rapid, far-reaching and unprecedented changes in all aspects of society. Furthermore, the report finds that limiting global warming to 1.5 °C compared with 2 °C would reduce challenging impacts on ecosystems, human health, and well-being and that a 2 °C temperature increase would exacerbate extreme weather, rising sea levels and diminishing Arctic sea ice, coral bleaching, and loss of ecosystems, among other impacts.

An IPCC special report was released in 2019 on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [10]. The 20 headline details [11] are as follows:

- Land provides the principal basis for human livelihoods and well-being including the supply of food, freshwater, and multiple other ecosystem services, as well as biodiversity. Human use directly affects more than 70% (likely 69–76%) of the global, ice-free land surface. Land also plays an important role in the climate system.
- Since the pre-industrial period, the land-surface air temperature has risen nearly twice as much as the global average temperature. Climate change, including increases in frequency and intensity of extremes, has adversely impacted food security and terrestrial ecosystems as well as contributed to desertification and land degradation in many regions.
- Agriculture, Forestry and Other Land Use (AFOLU) activities accounted for around 13% of CO_2, 44% of methane (CH_4), and 82% of nitrous oxide (N_2O) emissions from human activities globally during 2007–2016, representing 23% (12.0 +/− 3.0 Gt CO_2 e year^{-1}) of total net anthropogenic emissions of GHGs. The natural response of land to human-induced environmental change caused a net sink of around 11.2 Gt CO_2 year^{-1} during 2007–2016 (equivalent to 29% of total CO_2 emissions); the persistence of the sink is uncertain due to climate change. If emissions associated with pre- and post-production activities in the global food system are included, the emissions are estimated to be 21–37% of total net anthropogenic GHG emissions.
- Changes in land conditions, either from land-use or climate change, affect global and regional climate. At the regional scale, changing land conditions can reduce or accentuate warming and affect the intensity, frequency, and duration of

extreme events. The magnitude and direction of these changes vary with location and season.

- Climate change creates additional stresses on land, exacerbating existing risks to livelihoods, biodiversity, human and ecosystem health, infrastructure, and food systems. Increasing impacts on land are projected under all future GHG emission scenarios. Some regions will face higher risks, while some regions will face risks previously not anticipated. Cascading risks with impacts on multiple systems and sectors also vary across regions.
- The level of risk posed by climate change depends both on the level of warming and on how population, consumption, production, technological development, and land management patterns evolve. Pathways with higher demand for food, feed, and water, more resource-intensive consumption and production, and more limited technological improvements in agriculture yields result in higher risks from water scarcity in drylands, land degradation, and food insecurity.
- Many land-related responses that contribute to climate-change adaptation and mitigation can also combat desertification and land degradation and enhance food security. The potential for land-related responses and the relative emphasis on adaptation and mitigation is context specific, including the adaptive capacities of communities and regions. While land-related response options can make important contributions to adaptation and mitigation, there are some barriers to adaptation and limits to their contribution to global mitigation.
- Most of the response options assessed contribute positively to sustainable development and other societal goals. Many response options can be applied without competing for land and have the potential to provide multiple co-benefits. A further set of response options has the potential to reduce demand for land, thereby enhancing the potential for other response options to deliver across each of climate change adaptation and mitigation, combating desertification and land degradation, and enhancing food security.
- Although most response options can be applied without competing for available land, some can increase demand for land conversion. At the deployment scale of several Gt CO_2 year^{-1}, this increased demand for land conversion could lead to adverse side effects for adaptation, desertification, land degradation, and food security. If applied on a limited share of total land and integrated into sustainably managed landscapes, there will be fewer adverse side effects and some positive co-benefits can be realised.
- Many activities for combating desertification can contribute to climate-change adaptation with mitigation co-benefits, as well as to halting biodiversity loss with sustainable development co-benefits to society. Avoiding, reducing, and reversing desertification would enhance soil fertility, increase carbon storage in soils and biomass, while benefitting agricultural productivity and food security. Preventing desertification is preferable to attempting to restore degraded land due to the potential for residual risks and maladaptive outcomes.
- Sustainable land management, including sustainable forest management, can prevent and reduce land degradation, maintain land productivity, and sometimes reverse the adverse impacts of climate change on land degradation. It can also

contribute to mitigation and adaptation. Reducing and reversing land degradation, at scales from individual farms to entire watersheds, can provide cost-effective, immediate, and long-term benefits to communities and support several Sustainable Development Goals (SDGs) (see 11 Sustainable Development Goals) with co-benefits for adaptation and mitigation. Even with implementation of sustainable land management, limits to adaptation can be exceeded in some situations.

- Response options throughout the food system, from production to consumption, including food loss and waste, can be deployed and scaled up to advance adaptation and mitigation. The total technical mitigation potential from crop and livestock activities, and agroforestry is estimated as 2.3–9.6 Gt CO_2 e.year^{-1} by 2050. The total technical mitigation potential of dietary changes is estimated as 0.7–8 Gt CO_2 e.year^{-1} by 2050.
- Future land use depends, in part, on the desired climate outcome and the portfolio of response options deployed. All assessed modelled pathways that limit warming to 1.5 °C or well below 2 °C require land-based mitigation and land-use change, with most including different combinations of reforestation, afforestation, reduced deforestation, and bioenergy. A small number of modelled pathways achieve 1.5 °C with reduced land conversion and thus reduced consequences for desertification, land degradation, and food security.
- Appropriate design of policies, institutions, and governance systems at all scales can contribute to land-related adaptation and mitigation while facilitating the pursuit of climate-adaptive development pathways. Mutually supportive climate and land policies have the potential to save resources, amplify social resilience, support ecological restoration, and foster engagement and collaboration between multiple stakeholders.
- Policies that operate across the food system, including those that reduce food loss and waste and influence dietary choices, enable more sustainable land-use management, enhanced food-security and low-emissions trajectories. Such policies can contribute to climate-change adaptation and mitigation, reduce land degradation, desertification, and poverty as well as improve public health. The adoption of sustainable land management and poverty eradication can be enabled by improving access to markets, securing land tenure, factoring environmental costs into food, making payments for ecosystem services, and enhancing local and community collective action.
- Acknowledging co-benefits and trade-offs when designing land and food policies can overcome barriers to implementation. Strengthened multilevel, hybrid, and cross-sectorial governance, as well as policies developed and adopted in an iterative, coherent, adaptive, and flexible manner can maximise co-benefits and minimise trade-offs, given that land-management decisions are made from farm level to national scales, and both climate and land policies often range across multiple sectors, departments, and agencies.
- The effectiveness of decision-making and governance is enhanced by the involvement of local stakeholders (particularly those most vulnerable to climate change including indigenous peoples and local communities, women, and the poor and

marginalised) in the selection, evaluation, implementation, and monitoring of policy instruments for land-based climate-change adaptation and mitigation. Integration across sectors and scales increases the chance of maximising co-benefits and minimising trade-offs.

- Actions can be taken in the near-term, based on existing knowledge, to address desertification, land degradation, and food security while supporting longer-term responses that enable adaptation and mitigation to climate change. These include actions to build individual and institutional capacity, accelerate knowledge transfer, enhance technology transfer and deployment, enable financial mechanisms, implement early-warning systems, undertake risk management, and address gaps in implementation and upscaling.
- Near-term action to address climate change adaptation and mitigation, desertification, land degradation, and food security can bring social, ecological, economic, and development co-benefits. Co-benefits can contribute to poverty eradication and more resilient livelihoods for those who are vulnerable.
- Rapid reductions in anthropogenic GHG emissions across all sectors following ambitious mitigation pathways reduce negative impacts of climate change on land ecosystems and food systems. Delaying climate mitigation and adaptation responses across sectors would lead to increasingly negative impacts on land and reduce the prospect of sustainable development.

IPCC analyses and stark predictions and options should be supplemented with reference to two other relevant reports. Firstly, the World Energy Outlook (WEO) report series, the flagship publications of the International Energy Agency [12], are widely regarded as the gold standard of international energy analysis. They provide strategic insights on what current policy and investment decisions mean for long-term trends. The World Energy Outlook 2018 [13] details global energy trends and what possible impact they will have on supply and demand, carbon emissions, air pollution, and energy access. Major transformations are underway in the global energy sector, from expanding electrification and renewables, disturbances in oil production, and globalization of natural gas markets. Across all regions and fuels, policy choices made by governments and large companies will determine the shape of the energy system of the future.

The 2018 report notes that while the geography of energy consumption continues its historic shift to Asia, there are mixed signals on the pace and direction of change. Oil markets are entering a period of renewed uncertainty and volatility, including a possible supply gap in the early 2020s. Demand for natural gas is on the rise, erasing talk of a glut as China emerges as a giant consumer. Solar photovoltaic technology is progressing rapidly, but other low-carbon technologies and especially efficiency policies are lagging. Governments will have a critical influence in the direction of future energy systems. Under current and planned policies, energy demand is set to grow by more than 25% to 2040, requiring more than $2 trillion a year of investment in new energy supplies.

Contrary to the wishes of many, oil consumption is set to grow in coming decades, due to rising demands for petrochemicals, trucking, and aviation, as well as energy systems. Meeting this growth in the near term means that approvals of conventional oil projects need to double from their current low levels. Without such a pick-up in investment, US shale production would have to add more than ten million barrels a day from today to 2025, the equivalent of adding another Russia to global supply in 7 years. In power markets, renewables have become the technology of choice, making up almost two-thirds of global capacity additions to 2040, thanks to falling costs and supportive government policies. This is transforming the global power mix, with the share of renewables in generation rising to over 40% by 2040, from 25% today, even though coal remains the largest source and gas remains the second largest. This expansion in renewables brings major environmental benefits but also a new set of challenges. With higher variability in supplies, power systems will need to make flexibility the cornerstone of future electricity markets in order to keep the lights on. The issue is of growing urgency as countries around the world are quickly ramping up their share of solar photovoltaic systems and wind, and will require market reforms, grid investments, as well as improving demand-response technologies, such as smart meters and battery-based storage technologies.

Electricity markets are also undergoing a unique transformation with much higher demand brought by the digital economy, electric vehicles, and other technological change. Increased electrification would lead to a peak in oil demand by 2030, and reduce harmful local air pollutant. But it would have a negligible impact on carbon emissions without stronger efforts to increase the share of renewables and low-carbon sources of power. Most emissions linked to energy infrastructure are already essentially locked-in. In particular, coal-fired power plants, which account for one-third of energy-related CO_2 emissions today, represent more than a third of cumulative locked-in emissions to 2040. The vast majority of these are related to projects in Asia, where average coal plants are just 11-years-old on average with decades left to operate compared with 40 years on average age in the USA and Europe.

The World Energy Outlook 2019 report will be released in Paris on 13 November 2019.

The scenario-based BP Energy Outlook 2019 Edition [14] considers different aspects of the energy transition and the key issues and uncertainties. In all the scenarios considered, world gross domestic product (GDP) more than doubles by 2040, driven by increasing prosperity in fast-growing developing economies. In the evolving-transition scenario this improvement in living standards causes energy demand to increase by around a third over the Outlook, driven by India, China, and the rest of Asia which together account for two-thirds of the increase. Despite this increase in energy demand, around two-thirds of the world's population in 2040 still live in countries where average energy consumption per head is relatively low, highlighting the need for 'more energy'. Energy consumed within industry and buildings accounts for around three-quarters of the increase in energy demand. Growth in transport demand slows sharply relative to the past, as gains in vehicle efficiency accelerate. The share of passenger-vehicle kilometres powered by electricity increases to around 25% by 2040, supported by the growing importance of fully autonomous cars and shared-mobility services. The world continues to electrify, with around three-quarters of the increase in primary energy absorbed by the power sector. Renewable energy is the fastest growing source of energy, contributing half of the growth in global energy supplies and becoming the largest source of power by 2040. Demand for oil and other liquid fuels grows for the first part of the Outlook before gradually plateauing. The increase in liquids production is initially dominated by US tight (shale) oil, but production from member countries of the Organization of the Petroleum Exporting Countries (OPEC) subsequently increases as US tight oil declines. Natural gas grows robustly, supported by broad-based demand and the increasing availability of gas, aided by the continuing expansion of liquefied natural gas supplies. Global coal consumption is broadly flat, with falls in consumption in China and member countries of the Organisation for Economic Co-operation and Development (OECD), offset by increases in India and the rest of Asia. In the evolving-transition scenario, carbon emissions continue to rise, signalling the need for a comprehensive set of policy measures to achieve 'less carbon'. The Outlook considers a range of alternative scenarios, including the need for 'more energy', 'less carbon' and the possible impact of an escalation in trade disputes.

One of us (JRH) has been writing and speaking about global climate change, especially in respect to agriculture, since 1987. The Scottish Crop Research Institute he directed during 1986–2005 (now the James Hutton Institute) released several relevant reports [e.g. 15, 16] and presentations were made to the Edinburgh Science Festival.

In the unlikely event GHG emissions were to cease abruptly, the lingering effects of existing GHGs will continue to influence the climate for decades and centuries (and possibly millennia) to come. Addressing this imperative is having challenging economic and societal implications for all nations and peoples, especially in the developing world. In essence, the 'climate-change challenge' should be termed 'energy-generation challenge' as countries attempt to 'decarbonise' their economies. Energy is used *inter alia* for heating, cooling, lighting, cooking, transport, manufacturing, harvesting, processing, constructing, maintaining, cleaning, protecting, healthcare, leisure, communicating, and computing (especially with the development of cloud computing etc.). In other words, non-primitive lifestyles are dependent on energy. It seems likely that many developing economies (and some developed economies) intend to gain wealth by burning fossil fuels. Addressing climate change is a thus a particularly rich area of invention, discovery, novel concepts, processes, and entrepreneurial behaviour; there are opportunities for wealth creation while many conventional methods of wealth creation will be disrupted at best or fall into disuse at worst. Some colder parts of the world might be seen as benefiting from global warming but weather perturbations such as dramatic changes in precipitation and winds as well as severe effects in the rest of the world may alter opinions.

3 Greenhouse Gases

GHGs are radiatively active gases in the atmosphere that absorb and emit radiation within the thermal infrared range, giving rise to the so-called "greenhouse effect" [e.g. 17]. Put simply, the radiation emitted from these gases warms the planetary surface, which then emits energy at the lower frequency of infrared thermal radiation.

The 11 most abundant GHGs are water vapour, carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, sulfur hexafluoride, hydrofluorocarbons, Perfluorocarbons, carbon tetrafluoride, and nitrogen trifluoride.

Estimates of the relative contributions by these GHGs to the greenhouse effect are normally given as a range because some of these gases absorb and emit radiation at the same frequency as others, so the total greenhouse effect is not simply the sum of the influence of each GHG. In a given range, the higher figure is for each gas alone, and the lower figure accounts for the overlap with other GHGs. Accordingly, the four most important GHGs are:

- Water vapour (36–72%)
- Carbon dioxide (9–26%)
- Methane (4–9%)
- Ozone (3–7%)

As emissions continue to be released and international efforts are made to reduce the use of fluorocarbons, then the relative balance and interactivity of these gases may well alter. Their longevity in the atmosphere is yet another factor used in climate modelling.

The three major constituents of the atmosphere (nitrogen, oxygen, and argon) are not GHGs. This is because molecules containing two atoms of the same element (diatomic), as well as monoatomic molecules have no net charge in their dipole moment when they vibrate and are therefore virtually unaffected by infrared radiant energy.

Clouds have a major influence on the greenhouse effect [18]. Water droplets in them absorb and emit infrared radiation and therefore have an effect on the radiative properties of the GHGs. The quantity of water depends on the prevailing temperature, so increasing oceanic temperatures enhance the capacity of the atmosphere to hold more water leading to periods of more intense rainfall as well as ramping up GHG warming. The warming effect is counterbalanced to some extent by clouds reflecting many components of the electromagnetic spectrum. Various aerosols (colloids of solid particles or liquid droplets in air) in the atmosphere make climate modelling more complex. Naturally occurring aerosols include fog and forest exudates. Anthropogenic aerosols include haze, dust and dust storms, particulate air pollutants such as those from vehicle exhausts, and smoke. Some aerosols have a cooling effect by reflecting solar radiation whereas sooty (black carbon) aerosols, which arise from incomplete combustion of fossil fuels, biofuels, and biomass – including forest fires, are the most potent of all climate-warming aerosols, absorbing all wavelengths of light and re-emitting this energy as infrared radiation. Moreover, incomplete combustion leads to the release of diverse health-damaging particulates not only from flue stacks and engine exhausts but from burning all form of carbon, thus clean combustion is an imperative for all carbon-based fuels.

Earth’s atmosphere is protected by the magnetosphere [19], the global magnetic field that prevents atmospheric ions from being stripped from the planet by the solar wind – the flow of electrically conducting plasma comprising electrons, protons, and alpha particles with an embedded interplanetary field arising from the outer part of the sun. The solar wind varies in speed, temperature, and density over time and is deflected by the magnetosphere. At this juncture, it is not known how modification of the Earth’s atmospheric composition affects the protective capacity of the magnetosphere.

4 Fossil Fuels

Conventional fossil fuels [20, 21] are derived from deposits of dead organisms (mainly phytoplankton and zooplankton in the case of oil, and terrestrial plants in the case of coal deposits, methane, and type II kerogen – a source of natural gas) buried beneath sedimentary rocks and subject to intense heat and pressure over thousands of years. The deposits contain high proportions of carbon and include (a) various kinds of oil including tight oil (shale oil) contained in petroleum-bearing rock formations of low permeability, often shale or tight sandstone, and released by hydraulic fracturing (“fracking”) – the term “petroleum” covers both naturally occurring unprocessed oil as well as petroleum products; (b) various forms of coal – still the largest source of energy for electricity generation globally; and (c) methane and methane clathrates (methane hydrate) in the shallow lithosphere in Polar regions and in deep-ocean sediments. Methane leaks into the atmosphere not only from these methane deposits with climate warming, but also from coalmines, leaking gas pipes, oil and gas wells, and fracking activity. Natural gas, the fastest growing fossil fuel, comprises mainly methane but also higher alkanes as well as carbon dioxide, nitrogen, and sometimes hydrogen sulphide. Gasoline (petrol) is a petroleum-derived liquid used with additives as a fuel for combustion in internal-combustion engines. Increasingly, it may be used in conjunction with aliphatic alcohols (principally methanol, ethanol, propanol, and butanol) derived from fermentation of biological materials (bioalcohol). Diesel fuel may come from distillates of petroleum oil (petrodiesel), or from vegetable or animal fats (biodiesel), or from natural gas or other hydrocarbons.

Combustion [22] is defined as the high-temperature exothermic redox (electron transfer between chemical species) chemical reaction between a fuel and an oxidant, in this case in considering climate change, atmospheric oxygen. Heat, light (flames), and sound are produced, and combustion is rarely complete so unburnt and partially oxidised products and particulates are released. As the atmosphere contains diatomic nitrogen, several types of nitrogen oxide (NOX) are also produced.

Oxygen is highly reactive, forming oxides with most elements, and is too reactive to remain as a free element in the atmosphere without being replenished by photosynthesis. Dioxygen, the common allotrope of elemental oxygen, is fundamental to life because it is used in cellular respiration. Ozone (trioxygen) is a very reactive allotrope of oxygen and forms the high-altitude ozone layer forming a protective radiation shield for the biosphere against incoming UVB radiation; in contrast, it is one of the damaging pollutants emitted by fossil-fuel-propelled vehicles.

No fossil fuel is regarded as a renewable source of energy because of the length of time needed for its formation. The extraction of coal [23–25], its combustion to generate energy, and its many by-products are associated in particular with severe environmental and health effects, such as groundwater and water-table disruption, contaminated land, subsidence, long-term underground fires, unsightly quarries and storage areas, with the production of health-threatening fly ash, bottom ash, and flue-gas desulphurisation sludge containing mercury, the radioactive elements uranium and thorium, arsenic, other heavy metals, and selenium. Coke is a high-carbon fuel usually derived from certain grades of coal and is used as a reducing agent in smelting iron ore in blast furnaces, and also for preparing producer gas (carbon monoxide and nitrogen) and water gas (carbon monoxide and hydrogen). Petroleum coke is the solid residue remaining from petroleum refinement by "cracking". Lignite (brown coal) is formed as deposits of naturally compressed peat and is regarded as the lowest grade of coal due to its relatively low energy availability, high moisture content, and ability to pollute. Surely it is totally unacceptable for developed economies to use lignite combustion as a significant source of their energy supplies? Peat is partially decayed vegetation unique to the so-called peatlands, one of the world's most efficient carbon sinks, and is regarded as the first step in the geological formation of lignite and coal. According to the 2019 Global Coal Plant Tracker [26] and numerous published reports to the EU and UK, although there has been a cancellation of planned projects, there are still at least 1083 gigawatts of new coal-fired capacity since 2006 plus additional as-yet-unquantified coal-fired and lignite-fired capacity in the pipeline. Peat, a major carbon repository, is used as a fuel but is not regarded as a renewable source of energy because its extraction exceeds its regeneration, and has higher carbon-dioxide and water-vapour emission intensity than coal and natural gas. It is also used as horticultural compost. Carbon-capture and storage (CCS) technologies [27], also known as "clean coal" technologies but incorporate the combustion of all fossil fuels, are being investigated in many power stations. They are based on removing carbon dioxide from flue gases and injecting it into deep underground storage such as expired oil wells or deep saline aquifer formations and attempting to avoid catastrophic leakage. Other approaches include its sequestration into the igneous rock peridotite to form stable carbonates-like limestone or marble mineral. To date, estimates of the energy required to run CCS schemes range from 25% to 40% of the total power generated, meaning that government subsidies and policy interventions are essential to continue with the current technologies. Direct extraction of carbon dioxide from the atmosphere is energy intensive.

In view of the fact that the combustion of fossil fuels produces well in excess of 20 billion tonnes of carbon dioxide per year, but natural processes can only absorb considerably less than half this amount, there is a relentless increase in atmospheric carbon dioxide levels every year. Carbon dioxide is a well-known GHG, enhancing radiative forcing leading to global warming and therefore massive adverse effects, hence the desire to switch to renewable-energy schemes to reduce carbon dioxide pollution, a process creating enormous political and social pressures but providing opportunities for innovation and new businesses.

Fossil-fuel deposits are unequally distributed around the world and its exports have generated enormous unearned wealth and power for those in control, sometimes distorting economies and any benefits failing to reach throughout their societies.

5 Renewable Energy-Generating Systems – Renewables

The seven renewable or sustainable energy-generating, low-entropy systems already in operation or being developed [28–30] are (1) onshore and offshore wind systems using various windmill designs; these have received massive investments in many countries. Offshore systems deliver significantly higher power output over a given area than equivalent on-shore systems but the construction costs are much greater. Given the erratic intermittent nature of wind speeds, the main challenges for wide adoption relate to appropriate siting, energy-storage and demand-management systems, as well as connections to national grids. Objections also arise from impacts on visual amenity, disruption to radar signals, bird strikes, noise, and dependence on subsidies. (2) Solar systems involving (a) thermal panels to heat water or some inert material, (b) solar thermal sun-tracking mirrors which focus on containers holding water and using the resultant steam to drive turbines, (c) photovoltaic panels; and (d) carbon fixation by photosynthesis of higher plants and microorganisms to produce crops for food and vegetative biomass that may be directed combusted to produce energy and particulates – in some parts of the world demand for wood exceeds supply – or processed to yield biofuels and biocomposites. Wood can be used for construction, furniture etc. and is therefore a longer-term carbon repository. The fact that enhanced levels of carbon dioxide in the atmosphere stimulate the amount of photosynthesis of both aquatic and terrestrial plants, and thus improve crop and forest productivity, is undoubtedly one of the few positive effects of mankind's inexorable production of GHGs. R. Sachs of MIT created a company called 1366 Technologies [31], so called after the number of Watts of solar power that strike an average square metre of the Earth's surface; this is an illustration of the prodigious amounts of solar energy for industrial use that are potentially available in the tropics, semi-tropics, and virtually every part of the Arab Region. Technological developments in the efficiency of thermal panels, solar-thermal panels, and photovoltaic panels, coupled to new manufacturing methods and grid connections at both local and national level should lead to widespread adoption of solar-energy systems throughout the Arab Middle East. (3) Hydroelectricity conventionally is dependent not only on an adequate rainfall catchment area and/or river supplies but also on suitable dams to act as water-storage areas and to provide altitude (thus potential energy) for appropriate gravitational power to produce a reliable stream of water (kinetic energy) at the turbine generators. Dams, however, can have marked ecological effects upstream and downstream, such as preventing fish migration, preventing silt deposition downstream, displacing people from the dammed zone, as well as suffering evaporative losses and affecting navigation. Dam failure can be catastrophic. In contrast, if well-managed, dammed water reservoirs can regularise water supplies downstream, provide recreational use, and can be a reliable, good value-for-money source of power over many decades. Recent developments include freestanding, self-aligning turbines that do not require expensive dam structures, and some have vertical shafts raising the generators above water level. In addition, surplus energy from other types of power generation can be used to pump water to higher-altitude reservoirs to provide an energy-storage system. Osmotic-power systems in Norway and reverse-electrodialysis systems in The Netherlands have been proposed as viable energy-generating concepts. (4) Wave power is generated on open waters by wind, itself a manifestation of solar radiation on earth. Wind speed and its duration determine the direction, height, wavelength, and periodicity of the waves. The main challenge is to extract the energy in waves, which is estimated to range from less than 1 kW/m of coastline to over 40 kW/m in many areas exposed to oceans in the higher latitudes. Wave machines are still in their infancy with improvements needed to their weight-to-power ratio and longevity in harsh marine environments; rarely are energy-harvestable waves created in large bodies of fresh water. (5) Tides are the result of complex gravitational influences between the sun, Earth, and moon, coupled to interference by the continental landmasses and shelves that create obstructions in the seas and oceans and give rise to two high tides and two low tides every day. Tidal energy is derived from a combination of lunar gravitational effects and the rotational energy of the Earth. This regular appearance of tidal power, as opposed to the unpredictability of tsunamis, is enormous, given the fact that a stated volume of water is around a thousand times denser than an equivalent volume of air. Various schemes involving barrages, tidal lagoons and pools used to capture the to-and-fro flows between high and low tides, tidal streams in narrow straits, and different types of turbines are beginning to be developed, recognising again the challenges of functioning in corrosive and fouling-prone marine environments. (6) Geothermal energy arises from a combination of radioactive decay and heat leaking from the earth's core through the mantle. The core's heat is reinforced by tidal friction in the magma caused by gravitational influences of the sun and moon. On a typical continent, heat flow from the centre through the mantle has been estimated to be about 10 mW m^{-2} whereas heat flow at the surface is around 50 mW m^{-2}, indicating that radioactive decay adds substantially to the final heat flow. Geothermal energy was confined to areas near tectonic plate boundaries ('hot spots') but now geothermal power schemes are becoming more widespread as deep-drilling technologies improve. (7) Nuclear power is usually excluded in classifications of renewable-energy systems although it is a low-carbon energy source. It is currently based on nuclear fission of the nuclei of the heavy element uranium. More speculatively, nuclear-fusion systems produce power based on fusion of the nuclei of light elements such as hydrogen. Crucially, nuclear power from either fission or fusion processes yields nuclear energy available per atom approximately one million times greater than chemical energy per atom of typical fuels. The sustainability of nuclear-fission reactors to generate energy is dependent on eight factors: the type of reactor, the source of uranium, suitable sites for the reactors, safety, clean-up costs, accidents, misconceptions, and political opposition. Development of small-scale, safe nuclear reactors could revolutionise the generation of zero-carbon energy without building massive conventional nuclear-power stations.

All these renewable-energy systems are described as essentially low-carbon systems, but detailed life-cycle and value-for-money analyses need to be carried out for each scheme, incorporating supplementary infrastructural costs and impacts (such as power grids such as DC grids), construction and maintenance costs, and their impacts on the environment, their reliability over decades, and their ability to provide reliable sources of energy, and whether additional back-up systems are required. Emotion and political pressures often outweigh rational and pragmatic analyses of the economic and technological considerations of renewable-energy systems.

Of interest to much of the Arab Middle East is the Renewable Energy and Energy Efficiency Partnership (REEEP) [32], formed in 2002 at the UN Conference on Sustainable Development; it aims to advance clean energy in developing countries.

6 Major Climate-Change Predictions: General

From IPCC reports noted above and other reports, such as those of the US Environmental Protection Agency [33] in 2017 (now withdrawn through political pressure), the major predictions include:

- Increased global average temperature
- Influences on the patterns and amounts of precipitation, winds, and storm events, with accentuated regional variation
- Reduced ice and snow cover as well as reduction in the area of permafrost
- Sea level rise, imperilling coastal and estuarine low-lying flat areas and islands, as a result of global-warming-induced thermal expansion of the oceans and the melting of sea-borne and terrestrial snow and ice. Warming of the seas and oceans affects marine animal migration patterns, reef bleaching, and the direction and intensity of oceanic currents. At the same time, carbonic-acid-induced increase in the acidity of the oceans affects the calcium metabolism of plankton, molluscs and shellfish, teleost skeletons, and reef-building corals. Freshwater flows from melting of snow and ice such as from glaciers also affect oceanic currents and the jet streams in the upper atmosphere.
- Increased frequency, intensity, and/or duration of extreme weather events

- Shift in ecosystem/habitat characteristics, affecting the diversity and quantity of the natural flora and fauna as well as the capacity to conduct agriculture
- Increased threats to human health through direct physiological effects of temperature, increased frequency of disease vectors and pandemics, restricted availability of water for proper sanitation, hunger, thirst, skin disorders, and respiratory problems
- Adverse impacts on food security regardless of the fertilisation effect of carbon dioxide on photosynthesis, management of and demand for water resources, infrastructure, human migration patterns, and the potential for conflict
- There is already evidence of evolutionary changes in the natural flora and fauna as a result of changing climate

The scope and intensity of these predictions are dependent on seven factors:

- Continuation of the rate of increase in the concentration of GHGs in the atmosphere
- Complex interactions and feedbacks in the global climate system but significant changes in the relative concentrations of GHGs in the atmosphere would be expected to lead to weather perturbations
- Other natural climate-affecting events, including volcanism-induced cooling, solar activity, and ocean circulation patterns
- Uncertainty in and predictive accuracy of climate modelling in the medium to long term
- Implementation of mitigation and adaptation policies
- Global population growth with its relentless demand on (a) natural resources including potable water, (b) pressure on arable land, (c) loss of vegetation cover, and (d) energy from fossil fuels. Another impact is the production of respiratory and waste-product GHGs by the ever expanding human "biomass" as well as all other viable and decaying heterotrophs
- Invention of new technologies able to deal appropriately with GHGs, extreme weather events, and energy generation

7 Climate-Change Predictions: Arab Middle East

Large parts of the Arab Region already suffer from periods of extreme temperatures and shortages of fresh water, so relatively harsher conditions pose special problems for policymakers to make a raft of infrastructural investments as well as convince their populations of the need to make substantial changes in their modus vivendi. Regardless of ongoing conflicts, the Region will continue to suffer heightened geopolitical risks and uncertainties unless and until worthwhile mitigation and adaptation strategies are implemented.

Without these strategies, specific projections and impacts for large parts of the Region include [34–36]:

- Temperature increases in excess of 4 °C, affecting daily human activity, agriculture and forestry, demands for air conditioning in buildings, the natural flora and fauna, and changing pest and disease patterns
- Changes in precipitation patterns, with modified distributions, prolonged drought periods, and extreme desiccation. There may be intense rainfall in some places, leading to flash floods
- Reduced river flows and diminished aquifer recharging
- Sea level rise, adversely affecting human activity in low-lying areas, forcing salination of groundwaters and driving seawater further upstream in rivers
- Greater frequency of hurricanes and dust storms
- Increased aridity will profoundly affect food, water, and energy security

From the foregoing, it is clear that a series of short- and longer-term mitigation and adaptation strategies needs to be implemented by governments, international agencies, and businesses.

8 Mitigation and Adaptation Strategies

Defined as the action of reducing the severity, seriousness, or painfulness of something [37], mitigation is an appropriate strategy to deal with the impacts of climate change. The five key actions [38, 39] are as follows. (a) To substitute energy from fossil fuels with low-carbon renewable sources of energy so as to reduce the emission of anthropogenic GHGs. (b) To greatly improve the efficiency of energy usage. This means better, more efficient buildings and cleaner modes of transport. (c) To increase the number and capacity of carbon sinks. (d) Active participation in international climate-change negotiations. (e) For governments and the business sector to invest in establishing a cohort of experts in mitigation and adaptation strategies. Governments also have the responsibility of ensuring that a combination of education and incentives are essential underpinnings for the transition from a fossil-fuel dependent economy to a less environmentally damaging economy. Healthcare systems will need to deal with increased incidents of skin disorders, heat stress, dehydration, and new or more prevalent pests and diseases. Governments have to weigh up the consequences of enforcing lifestyle changes, imposition of taxes, and the market-distorting effects of subsidies and pernicious taxation.

Carbon sinks [40, 41] include the three natural sinks. (a) Biomass is created by photosynthesis of terrestrial and freshwater plants, and phytoplankton and larger multicellular algae. To date, it has not proved possible to enhance successfully the efficiency of the photosynthetic process so emphasis is given to biomass, especially of forests, agricultural cropping, grasslands, and savannahs. (b) Soils, including peat bogs, currently contain more carbon than all terrestrial vegetation and the atmosphere combined. (c) Oceans not only contain macro-algae and phytoplankton but also absorb carbon dioxide and act as massive heat sinks. Heterotrophic organisms such as humans are generally ignored under the heading of carbon sinks, mainly because of the carbon dioxide released by respiration.

Mitigation measures under active investigation range from (a) incorporation of carbon-rich materials, such as wood, in construction and durable goods; (b) further development of the carbon-capture and -storage technologies beyond fossil-fuel flues; (c) direct injection of carbon dioxide into serpentinite olivine-rich igneous rocks such as dunite and peridotite; (d) injection of carbon dioxide into saline aquifers or deep oceans where solid carbon-dioxide clathrates and hydrates will be formed; (e) sequestration of biomass by burying in silt on the sea floor.

Adaptation aims to reduce the vulnerability of social and biological systems to climate change in an attempt to offset the effects of global warming and its dire consequences. It is an approach that has been criticised as trying to avoid making painful highly expensive policy decisions and fails to deal with a worsening situation. Nonetheless, all countries need adaptation policies because current mitigation policies do not seem to be fully effective in preventing the potential for man-induced climate disasters. Examples of adaptation measures include (a) preparations for raised sea levels by installing barrages as well as planning for roads, railway lines, bridges, airports, and building developments above flood level; (b) deployment of a raft of technologies such as more appropriate cultivars and breeds for food production; (c) weather control by seeding clouds, utilising the urban heat-island effect on downwind rainfall, and the dispersal of stormy weather formations.

The capacity and potential (adaptive capacity) of countries and regions for mitigation and adaptation strategies and policies varies according to social and economic development and varies with time and political changes. Aid programmes are needed but little progress has been made to date. Central to the political decision-making should be assessments of seven criteria: value-for-money and economic efficiency in its widest sense; necessity and urgency; feasibility; equity for all concerned; health and safety consequences; relative roles of the private and public sectors; and democratic support. Pragmatism and reality will invariably override extreme idealism.

9 Climate Engineering

Both mitigation and adaptation could involve climate engineering, also referred to as geoengineering or a form of climate intervention with the intention of combatting the adverse effects of anthropogenic climate change [42]. It refers to large-scale up to planet-scale modification of the earth's climate, and incorporates geological, geochemical, and geophysical engineering. At present, there are two approaches, namely (a) the selective removal followed by storage or conversion of anthropogenic GHGs, especially carbon dioxide; and (b) the management of incoming solar radiation. Both can be regarded as contributions to mitigation and adaptation strategies.

Carbon dioxide can be stripped from the atmosphere directly, a costly process, or by promoting photosynthesis in terrestrial environments, especially by trees, and incorporating biochar made from plant biomass into soils. Combined carbon-capture and -storage technologies could be used to remove carbon dioxide from combusting fossil fuels and biomass and store it as described above. Much interest has focused on oceanic fertilisation of marine phytoplankton, mainly by nitrogen, urea, phosphorus, and iron (usually as iron sulfate). Based on the Redfield stoichiometric ratio giving the relative atomic concentrations of the critical nutrients nitrogen, phosphorus, and iron found in planktonic biomass [43], a figure of 106C:16 N:1P:0.001 Fe indicates that each kilogram of iron can fix 83,000 kg of carbon dioxide. Sulfur, zinc, and copper are other micronutrients whose roles need to be evaluated fully. Volcanic ash, desert-derived dust, and river sediments are also important sources of phytoplankton nutrients.

Solar-radiation management (sunshine reduction) aims to reduce the absorption of ultraviolet, infrared, and much of the visible part of the electromagnetic spectrum in solar radiation reaching the earth. Four technologies are under consideration. (a) Space-based sunshields unfurled to obstruct incoming solar radiation. (b) Upper-atmosphere-based reflective aerosols. (c) Troposphere-based cloud management, for example using sprays of seawater to whiten clouds by salt nucleation and increase their reflectivity. Sulfurous emissions are also suggested. (d) Surface-based albedo management of land and oceans, for example deploying reflective sheeting on roofs and sides of buildings, and over barren ground such as deserts. Foams and light-coloured litter have been proposed for seas and oceans.

Climate engineering faces major political and economic issues [44]. Who controls when to cool the Earth or regulate photosynthetic activity? There is a lack of robust international legal and regulatory frameworks to justify international respect and adoption at present, especially given the potential for severe environmental damage with unintended, unpredictable physical, biological, and social consequences that cut across nations. Proper governance means that work of this nature must be a public good, so a governance and insurance framework must be agreed before any attempts are made. Public participation and open access to all information are prerequisites as are independent impact assessments. Reversibility is crucial. Of course, substantial uncontrollable volcanic activity has a dramatic cooling effect. Climate engineering will not eliminate the need for curbing pollution of all kinds but it is an option or supplementation that needs to be explored.

10 Specific Processes and Strategies Proposed for the Arab Middle East

Food, water, and energy security are closely interlinked, especially in the Arab Middle East [45]. Accordingly, the following processes and strategies interrelate, demonstrating the need for policy coherence across several components of Arab societies. Other than mention of solar reflectivity, large-scale climate engineering does not figure in these processes and strategies until the Arab Middle East becomes a significant active participant in international research and development programmes and there is a genuine all-Arab strategy.

The global prices of food [46] are strongly influenced not only by water availability but also by the cost of oil. At the present time [47], staple crop commodity prices have fallen in recent times commensurate with the steep decline in the prices of oil and oil products. Around 20% of the cost of producing grain is due to direct and indirect oil costs. The world cereal production this year of 2.685 million tonnes represents a 1.2% increase from 2018 but decreased maize production was noted in China as well as East and southern Africa. World cereal utilization in 2019/20220 is forecast to show a marginal increase to exceed 2.708 million tonnes with cereal stocks showing a decrease. As a result of government investment in agriculture, food production has been ramped up in many developing countries in Africa and Asia. Sadly, grain stocks are held in relatively few countries, some of which are noted hitherto for implementing export bans leading to sharp rises in the commodity markets. Establishing reserve stocks in better times offers an insurance policy against food insecurity. There must be deep concerns about the reliable supply of foodstuffs to a projected global population of ten billion even on the basis of current agricultural best practice. Many countries are already facing fundamental food-security problems regardless of projected deleterious climate-change projections. Fresh thinking and constructive initiatives are needed.

In modern agriculture with its dependency on water access and energy inputs, due regard has to be given to the concept of 'negative externalities'. In both production and consumption, negative externalities occur when third parties, including future generations, are adversely affected directly or indirectly without these impacts being adequately reflected in market pricing (the transaction). Examples of negative externalities include anthropogenic pollution of oceans, soil, and atmosphere; soil degradation and erosion; irreversibly depleting aquifers; and utilising fossil fuels. Rarely applied until recently, true-cost economics attempt to take negative and positive externalities into account, and presumably incorporate the data into detailed life-cycle analyses.

For many Arab countries, at this juncture, directly addressing poverty and conflict must take priority over policies that are concerned with issues of longer-term climate-change. Even so, governments must ensure they cultivate the necessary advanced scientific, engineering, technological, and mathematical base in their civil service and in institutions of higher education and research.

Maximising economic growth with wealth creation through innovation – the feature of the global knowledge economy – is a powerful strategy to address climate change. The following research- and development-intensive proposals have major economic and social implications. Although separated into Agriculture and Food Security (Sect. 10.1), Water Security (Sect. 10.2), and Energy Security (Sect. 10.3), many of the proposals have a common purpose. There are separate sections for industrial biotechnology (Sect. 10.4), Social Development (Sect. 10.5), Carbon Storage and Trading (Sect. 10.6), and Global Biodiversity (Sect. 10.7).

10.1 Proposals for Agriculture & Food Security

- Protect existing arable land from encroachment by building developments (housing, factories, roads, airports, leisure facilities etc.). Arable land is a precious and diminishing resource.
- Bring an end to poor agricultural and pastoral practices that cause land degradation, such as over-grazing; stripping away vegetation cover; poor irrigation leading to soil salination; excessive cropping causing a fall in soil carbon and nutrient content; poorly managed intensive monocultivar cropping leading to a build-up in weeds, pests, and diseases as well as nutrient and carbon depletion; illegal and excessive use of old-fashioned pesticides; and pollution from waste dumps. Introduce precision farming and no-till agricultural systems to minimise exposure of soil. Introduce robust biosecurity regulations.
- Facilitate the vertical and horizontal integration of farming and related businesses to allow for adequate capitalisation to ensure improved quality of production, enhanced environmentally friendly efficiency measures, better livestock husbandry, and improved soil quality and, in addition, to give financial resilience to market stresses. This may mean a review of existing land-ownership and land-inheritance regulations, and may involve cooperative arrangements between groups of farmers. The world is urbanising as it seeks a better life away from the poverty of subsistence and low-grade agriculture, and is therefore becoming disconnected from its agricultural hinterland. While the richer developed world devotes excessive efforts to politically motivated anti-big-business "slow food", and the regressive ideals of low-productivity "organic" agriculture with self-imposed non-scientific constraints, as well as a stream of "healthy" food fads lacking scientific basis, burgeoning populations in other countries desperately need the benefits of advanced agricultural and food-production practices
- Deploy the widespread adoption of farming systems utilising the exploitation of agricultural metrics and data capture, encompassing weather, cultivar, soil type and growth media, cultivar and breed performance data, and market-pricing and market-intelligence data in order to encourage best-farming practice, and correspondence with international agricultural standards. This means the introduction of new sensor and data-collation and data-analysis systems for predictive technologies and expert systems to be deployed for pest and disease control and agronomic operations, weather forecasting, and supply-chain management. Grow the right crops and keep the most appropriate livestock breeds in the right places.
- Policy shifts to remove market-distorting subsidies, tariffs, import and export bans, stockpiling unless in times of unrest, restrictions, price controls, interference with trading unless to break cartels and ensure integrity, and excessive bureaucracy. Governments should embark on establishing agricultural and food "roadmaps" to ensure the economically right species are grown in the right place, and supportive processes and infrastructure are created. Technology foresight programmes involving coordination between industries, the research and

development community; government, and civil-society groups would be of benefit in constructing the roadmaps. Grow the most appropriate crops and maintain livestock in the most appropriate places in order to reduce expensive energy- and water-dependent inputs. Import crops heavily dependent on inputs once reliable trading arrangements have been established. In fact, the trading of meat, dairy products, and many types of crops to water-poor regions can be regarded as an efficient way to redistribute water

- Benefit from modern developments in breeding for annual and perennial agricultural and horticultural crops as well as for improved livestock types to obtain better yields, quality, and environmental resilience.
- Crop breeding. Breeding is the single most important factor for arable and horticultural growers for gaining competitive advantage for themselves, for the nation, as well as the main means to adapt the industry to changing physical, social, and economic environments. Improved cultivars are often internationally valuable intellectual property. Essentially long term, crop breeding involves interdigitation with the public sector nationally and internationally for trained personnel, access to germplasm collections and gene banks, statutory-testing arrangements, and access to repositories of important pests and diseases to challenge potential new cultivars. Breeding perennial woody species with long juvenile periods requires special effort using modern propagation and crossing technologies. Conventional plant breeding ("cross two of the best and hope for the best") is expensive and far too protracted to address the urgency of the need to ramp up food supplies and reduce GHG emissions without being supplemented by several of the newer selection and genetic technologies such as gene editing and base editing. Crop-breeding targets include the following nine themes. (a) Enhancing photosynthetic efficiency in C-3 and C-4 plants to capture more solar energy and convert it into useful chemical forms. Even minor improvements to photosynthetic efficiency and plant design would profoundly raise global agricultural productivity and greatly assist in fixing carbon-dioxide emissions. (b) The ability of the main crop species to survive periods of drought and grow in the presence of brackish waters would increase the geographic range of cultivation. (c) Low-temperature tolerance would help extend growing seasons and assist with crop survival in unseasonably low temperatures. (d) An ability to control the timing of flowering and fruit and seed formation is possible with many horticultural species in environmental-control housing but has yet to be extended to extensive field-grown crops although various chemical triggers are promising research targets. (e) Broad-spectrum pest and disease resistance and tolerance characteristics need constantly to be introduced in the genomes of the main crop species, especially in monocultural systems, in order to adapt to the relentless adaptability of pathogens. Sometimes, new biotypes can be identified that need urgent attention of the breeders. (f) Improved water- and nutrient-use efficiency characteristics would lessen the need for inputs. (g) Improving the proportion of harvestable material in the plant would minimise waste. (h) Improved quality of the harvested material, such as chemical composition – for example biofortification, texture, dimensions, machine-harvestability, and durability will remain a key

target. (i) Finally and not least, improved cost-effective yield increases are crucial to provide hope for feeding the global population in the years ahead.

- Livestock breeding has similar aims. These include improved conversion of inputs into usable outputs, pest and disease resistance, yield, lifespan, reproductive capacity, tolerance to environmental perturbations, temperament, quality of the outputs (e.g. meat, milk, eggs, skin for leather), and lowered emissions of GHG often by modifying diets and gut flora and fauna in both ruminants and monogastrics.
- Introduce greater automation in agriculture using energy-efficient machinery. Ground preparation, planting, harvesting, storage, processing, drainage, pollution control, compost and silage making, bioremediation, and land stabilisation can all be automated and warrant the term precision agriculture. An ability to separate the desired agricultural crop from unwanted weed propagules is becoming an established capability of most harvesting machinery. Modern crop breeding and agronomy practices should be carried out in concert with the development of new machinery. Improvements will lead to energy optimisation, water and agrochemical optimisation, improved quality control, less manual work, greater efficiency of operation, and uptake of new intellectual property. By way of illustration, horticultural crops once thought to be resistant to automatic picking (e.g. raspberries, blackcurrants, strawberries, hops, apples) are been bred (with characteristics such as modified bush shape, long fruit-bearing laterals, lack of spines, uniform fruit ripening, fruit with better abscission layers and stronger epidermes) to withstand the rigours of machine harvesting.
- Protected cropping will increase as a result of weather variability and the lack of reliable long-range weather forecasts. Deploy semi-protected and protected cropping to lessen adverse weather effects and reduce depredation by weeds, pests, and diseases. This strategy includes use of windbreaks and mixed perennial and annual crops (crop mixtures and agroforestry). Already, the soft-fruit industry globally has been revolutionised by the introduction of polytunnels offering protection from adverse weather and better working conditions for pickers. Experiments with modifying the spectral transmission of different types of plastic have demonstrated major improvements in controlling insect attacks. Likewise, various types of horticultural fleece are increasingly being used to protect crops such as brassicas from insect attack. There will be more attention paid to windbreaks as well as irrigation, drainage, and cultivation systems to reduce run-off and erosion.
- Periurban and urban agriculture. Urbanisation has prompted numerous initiatives to cultivate horticultural crops and livestock in settlements, towns, and cities wherever planning regulations either permit agriculture or are ignored. Open spaces, rooftops, balconies and window ledges can support local food production and even contribute to the “greening” of the area, and in many instances can improve the visual amenity and enhance biodiversity. New vertical-farming systems can be constructed on urban sites, in tunnels, mines, and factories. Vegetation is an effective “scrubber” of contaminated air. Many of those involved believe that it is just as well to cultivate edible plants rather than ornamentals, and feel reconnected with their rural heritage. Neighbours can be inconvenienced espe-

cially with livestock and there is always the problem of contamination from unsuitable growing media and air pollution. In future, periurban and urban agriculture will undoubtedly become an important source of food. People living in huge urban conurbations are, nevertheless, heavily dependent on efficient supply chains from the rural-based primary-producer network.

- Entirely new crop and possibly livestock species should be investigated. The narrow genetic base of the main global crops means that new species need to be sourced from circa 250,000 naturally occurring angiosperm species, and from which cultivars can be derived. Until now, there has been relatively little attention paid to developing novel wild species but there is great potential in seeking new fibre, starch, lipid, and protein crops although regulatory hurdles abound in introducing new food crops. Even more cultural barriers exist in introducing new forms of livestock.
- Use new generation agrochemicals, less reliant on petrochemicals and with fewer non-target effects, and use in conjunction with biosecurity measures and residue-monitoring assays. New active ingredients and their adjuvants, new methods of application, new monitoring systems, predictive modelling, and integration with agricultural engineering and transgenic technology represent exciting ground-breaking ways of increasing yield performance.
- Adopt modern agronomic practices such as smart irrigation, measures to increase soil-carbon content and water-retention qualities, cultivar mixtures rather than monocultivar crops in monocultural systems, and anti-soil-erosion and anti-desertification schemes. Install water-recovery and water-storage systems, coupled to better drainage and water-purification systems. Encourage a wider adoption of soil-less agriculture (hydroponics and aquaponics). Charcoal incorporation into the soil has many advantages in preventing nutrient leaching, binding toxins and other contaminants, locking up bound carbon dioxide, and increasing the level of organic matter with benefits for fertility. Automated monitoring of the weed-seed bank and soil pathogens should be accompanied by point-source killing of emerging weeds, breaking the dormancy of problem weeds and pest eggs in winter- or drought-killing conditions, and even by plough-mounted sheathed irradiation sources to sterilise badly infested soil. Present-day chemical- and heat-based soil-sterilisation treatments use enormous amounts of energy, are dangerous, and can have long-term undesirable environmental effects; they are also not feasible in large-scale farming systems. Small- to medium-scale cultivation in vitro of photosynthetic microorganisms to create novel food proteins, oils, carbohydrates, and other valuable compounds, will become increasingly important cultivation systems. Such systems can be greatly expanded in urban environments and can operate under extreme conditions using genes from extremophiles.
- Novel foodstuffs. With urbanisation comes demand for convenience foods, usually highly processed and aggressively marketed. A wide range of bacterial, fungal, and protozoan species can supply essential nutrients and growth factors. Processing can create a vast array of interesting tastes, textures, and appearances and these organisms do not require normal agricultural land. Supplementing

food supplies will reduce the trend of converting pristine habitats into arable land and releasing GHG.

- Reduce waste and treat and exploit pre-gut and post-gut wastes for energy (e.g. biodigesters) and removal of heavy metals and veterinary pharmaceuticals. Use composts and modified rhizosphere microbial activity to help displace expensive and energy-dependent fertiliser inputs. Prevent run-off from fields and animal-holding facilities, perhaps by vegetation/tree barriers to extract excessive nutrients and neutralise pollutants
- Establish a network of cold-storage units and clean, pest- and disease-proof storage units to prevent waste of agricultural products by spoilage.
- Habitat reconstruction and land renovation. Protection of the native flora and fauna can be achieved with the combination of ecological dispersal corridors to allow for gene flow and refugia (reserves). Various authors such as Lynas in *The God Species* [48], and Phalan and co-researchers in Cambridge University [49] have noted that nature-friendly agricultural systems are relatively lower-yielding systems than intensive systems and require larger areas to produce the same amount of food. This view is contested by some proponents of organic farming but is not contested by most agriculturalists. Likewise, claims of superior soil maintenance in organic systems fail to recognise that many state-of-the-art agricultural units take care to build up soil organic matter. Intensive farming units separated by pristine habitats and dispersal corridors for flora and fauna represent the ideal solution. Regardless of selecting the type of agricultural practice, restoration of contaminated, eroded, and neglected land is a pressing requirement in most countries. Novel bioremediation technology [50, 51] involving accumulators and metabolisers of toxic compounds, waste recycling, access to germplasm collections of native flora, and advanced analytical chemistry are beginning to be used in conjunction with conventional land-reclamation schemes.
- Biofuels and biodiesel [52, 53]. In theory, "carbon-neutral" biofuels capitalise on a closed system of photosynthetic carbon capture (to form reduced compounds) followed by carbon release when the fuels are combusted (oxidised). Most biofuels are formed by the fermentation of starchy or cellulosic feedstocks, such as ethanol or butanol, or by direct conversion of extracted plant oils to form biodiesel. Patent-protected genetic-modification technologies to enhance carbohydrate and lipid levels in crop plants and create modified microorganisms to generate high-calorific-value end products. Undesirable side effects of governmental drives to foster biofuel production from conventional crops include the diversion of arable land for much-needed food crops into fuel production. Subsidies make this conversion of land use possible even where the energy balance (ratio of the energy yielded by a given quantity of biofuel to the energy needed to create it) is unfavourable.
- Consider long-term storage of carbon in woody perennial species, soil, and natural vegetation
- Remember: the oldest form of carbon trading is the trading of plant and animal products
- Farming the seas and oceans [54]. With the exception of coastal waters, the oceans are not "farmed" sustainably to harvest fish, algae, and other life forms.

There are severe international disagreements over the “ownership” of mineral, oil, and gas reserves under continental shelves and isolated islands. Most countries recognise national ownership of fish and crustacean stocks in coastal waters where an increasing amount of aquaculture is taking place. The days of having a fishing industry largely based on a hunter-gatherer mode of existence is coming to an end as the demand for fish and related life forms and the fishing technology greatly exceeds the reproductive capacity of the desired species. There are massive losses caused to unintended netted species, too. Fish and shellfish farming in the seas and oceans must become the norm if as expected the global population continues to rise in the coming decades. Likewise, the cultivation of marine and freshwater algae for food and industrial feedstocks, and as a source of energy and fertiliser, will come to the fore. Containment facilities will need to be developed, and strategies put in place to breed and propagate, and replace abstracted nutrients.

10.2 Proposals for Water Security

- Monitor rainfall patterns; river-basin flows; water tables; water quality and safety; aquifer capacity plus water inputs and outputs; fossil water reserves; domestic water consumption; and output of desalination plants to inform and underpin advanced management strategies to ensure adequate quantities per person for drinking and sanitation
- Invest in advanced water recovery, below-ground storage, and leak-proof distribution networks plus efficient drainage and water-treatment facilities. Major water pipelines may be needed nationally and internationally
- Have systems on buildings, roads, car and lorry parks, and airports to capture and store water from flash floods and rainfall
- Strengthen coastal defences not only to protect important centres of habitation but also to resist the ingress of saline waters
- Investigate more efficient desalination systems [55, 56] and disposal arrangements for the resultant strong brine that might also be used to extract valuable minerals. Also adopt measures for soil-salinity control [57]
- Seek transnational agreement on the regional allocation of water reserves of all types, and seek to sustain river flows
- Ensure more efficient use of water in industry and agriculture (cultivars with improved water-use efficiency and those able to grow in brackish waters; encourage imports of produce dependent on substantial water usage such as some meat, dairy, and crop products; prevention of evaporation from soils, irrigation schemes, and excessive crop transpiration)
- Educate the public in minimising water usage and introduce more efficient and effective domestic appliances
- Take active measures to prevent water pollution from agriculture, industry, transport, and domestic environments

10.3 Proposals for Energy Security

- Restrict the burning of fossil fuels and introduce schemes to provide energy from renewable sources, but ensure there are emergency alternatives so that continuity of electricity supply is guaranteed. Consider the use of glasshouses to protect parabolic mirror and solar-panel arrays from dust
- Continue to invest in research and development of efficient renewable sources of energy, including energy recovery from wastes. Greatly reduce packaging waste and the import and availability of shoddy goods
- Establish electricity distribution grids, perhaps using direct current rather than alternating current, with grid-storage capacity and demand-management systems. Consider separate grids for uses that do not require constant power supplies
- Link with organisations investigating new forms of energy-storage systems, including batteries, capacitors, massive flywheels, heating and cooling of inert materials, dams with evaporation-prevention measures, and the production of "energy-rich" substances such as biofuels
- Form regional networks to capitalise on major solar-power systems in barren regions connected to national and international grids
- Import energy-intensive goods (such as most metals, glass, cement, paper, many chemicals such as ammonia) from countries with energy surpluses and efficient manufacturing processes offering value for money
- Introduce energy-saving measures across society. Many current systems used in irrigation, lighting, air-conditioning, transport, and power-generation are either energy-intensive or offer poor value for money; they require modification and upgrading.
- In an urbanising world, introduce better planning processes for siting new developments to reduce the need for car usage and complex wasteful utility requirements
- Improved urban planning and intelligent building designs for low-maintenance energy-efficient interconnected buildings with avoidance of unnecessary solar gain through glass and dark surfaces (unless for energy-capture purposes) by using reflective coatings. Demand better insulation and better ventilation and energy-efficient air conditioning, exploiting the temperature stability of the earth and oceans, and the use of energy-storage devices. Install more effective and smarter lighting and domestic appliances optimised not to use power in peak periods. Encourage the construction of subterranean structures and heat pumps so as to maintain even temperatures, not least for present-day computer and server arrays (data centres). Substitute conventional cement/concrete structures with renewable materials. Build more protected walkways and where possible plant deep-rooted trees and shrubs to "scrub" polluted atmospheres and waste water
- Design intelligent integrated transport networks with fewer energy-sapping bottlenecks; build more efficient mass-transport systems, enforcing vehicle (includ-

ing lorries and buses) and aircraft emission restrictions and investigate electric vehicles. Vehicle ownership can therefore be reduced – especially in urban and periurban areas – along with health-threatening exhaust emissions

- Consider emissions-trading schemes using market mechanisms to improve the environment. "Green" bonds could incentivise a switch to low-carbon energy generation and usage; however, there needs to be reliable and accurate assessments of carbon production, reinforced by a legal framework and independent oversight from experts. In the case of vehicles and power generators, simple taxation of fossil fuels (a type of carbon tax and certainly any subsidies should be removed) rather than focusing on the quantity and quality of emissions may be a simpler route in the first instance

10.4 Proposals for Industrial Biotechnology

- Advances in industrial biotechnology [58, 59] are offering new ways to save, purify, and recycle water. Biorenewables are substituting for materials that are sourced either through major environmental disturbance (such as metals) or through fossil fuels (such as most plastics). New types of second- and third-generation fuels are beginning to replace fossil fuels. Related biotechnology such as recombinant antibodies and nucleic-acid-based techniques are producing new forms of diagnostics for disease assessments of food and water. Advances in agricultural biotechnology offer a wide range of crops with desirable characteristics and new food products employing nanotechnology. Integral to the advancement of biotechnology are new types of analytical and physical chemistry, information and communications technology, bioinformatics, and organismal and systems biology.

10.5 Social Developments

Arab governments could also assist to a great extent by encouraging smaller family sizes to lessen the demands of population growth on the environment, improving education, curtailing wasteful lifestyles, and improving their cross-border cooperation (as opposed to overt and covert interference), the success of which is dependent on pledges being met and verifiable. After all, weather and the atmosphere, like gene flow, do not stop at political borders. Governments worldwide must develop evidence-based policies using high-level scientific, engineering, and technological expertise. For nearly all governments, there is an uneasy relationship with research and development (R&D) because (a) new facts, processes, concepts, and products can bring about significant economic and social changes; (b) the outcome of R&D cannot be controlled beforehand worldwide; and (c) legislation almost invariably lags the introduction of new technologies. In respect of climate-change science, technology, and engineering, this mean detailed environmental as well as short-term political analyses of all proposed legislation and major developments will need to be carried out.

10.6 Carbon Storage and Trading

Deep-burial storage of liquefied carbon dioxide from carbon-capture units attached to fossil-fuel-burning energy generation stations (see Sect. 4) is fraught with danger in respect of the potential for catastrophic release from subterranean ground movement and insecure sealing, perhaps further acidifying the oceans and rapidly altering atmospheric composition. Moreover, the carbon-capturing processes are energy-intensive and have yet to prove value for money. Long-term storage of fixed carbon can arise on land from using timber (xylem and cork) and other plant products such as fibres for industrial and construction purposes, delaying therefore carbon recycling possibly for centuries. Careless deforestation without timber replacement dramatically releases GHG besides having other severe environmental knock-on effects. In the seas and oceans, “marine snow” [60] comprising live and dead planktonic cells, secretions, dead animals, and faecal materials sink into deep waters and represent a form of locking away carbon. A small proportion becomes part of sedimentary rock; the remainder can be recycled at various times by upwelling and eddy diffusion. At present, phytoplankton in oceans and seas that cover around 75% of the Earth’s surface incorporate about 45–50 billion tonnes of inorganic carbon into their cells and about 8 billion tonnes of this carbon are transferred to the deep oceans as marine snow [61, 62]. Plants in terrestrial habitats fix about 60 billion tonnes of carbon dioxide a year [63, 64]. Encouragement of oceanic photosynthesis by supplying growth-limiting nutrients, especially iron, combined nitrogen, and potassium as phosphates, is a feasible form of geoengineering. Inadvertent eutrophication already demonstrates the dramatic effects of nutrients on photosynthetic organisms in both fresh and marine coastal waters. Clearly, it is far better to constrain GHG emissions, but photosynthetic capture of carbon dioxide remains the single most effective way to amend the chemical composition of the atmosphere without resorting to other forms of geoengineering.

Carbon trading is a complex topic [65, 66]. Fixing a price on carbon emissions and trading offsets may not be the best way to address the climate-change challenge or assist is securing global food security. Carbon-dioxide emissions are not a commodity per se; the scheme is essentially trading a penalty, a negativity, and is dependent on a combination of auditors and regulators of variable quality who may be prey to preferential political and pressure-group coercion, as well as fraud and speculation. Carbon trading in its present form requires perhaps an unachievable level of international transparency and integrity, and it is currently attracting speculators packaging carbon credits into complex financial products. Independently vetted proper carbon accounting (carbon “footprints”), energy-expenditure analyses, emission-control regulations, and thorough life-cycle analyses need to be implemented as a matter of urgency. Carbon trading is not being built upon strong foundations at present despite enthusiastic involvement of various quasi-public bodies and market traders. It is not too late to reverse direction, however, and trade positively in the form of various kinds of fixed carbon, namely agricultural and maritime commodities, tangible expressions of fixed carbon, diamonds of global food security.

10.7 Global Biodiversity

In terms of global biodiversity [67, 68], the effectiveness of existing measures to establish protected areas will not be able to overcome losses in both terrestrial and marine environments according to Mora and Sale [69]; they recommended new protection strategies and stabilising the human population and its ecological demands. Although adequately supported science, engineering, and technology can provide answers, only a suitable and peaceful political climate can provide an appropriate framework for action. Food security must not be confused with food sovereignty; growing the right crops and livestock in the right places transcends any selfish national interests if precious natural resources are to be deployed sustainably. Time is of the essence; delay in taking action will cause misery for many.

11 Sustainable Development Goals

The year 2015 marked the transition between the end of the eight United Nations Millennium Development Goals (MDGs) and the introduction of the Sustainable Development Goals (SDGs). The MDGs were largely met because of progress in China and India. Ratification of the SDGs took place on 25–27 September 2015 in the UN headquarters in New York and came into force in January 2016 with a deadline for completion in 2030. Compared with the relatively straightforward MDGs, the SDGs are more detailed, comprising 17 SDGs with 170 targets [70]. All are relevant to the Arab Region; to some, it seems as if they were directed at the Arab world.

- Goal 1 is “No Poverty”. Economic growth must be inclusive to provide sustainable jobs and promote equality. This Goal has 7 targets
- Goal 2 is “Zero Hunger”. The food and agriculture sector offers key solutions for development, and is central for poverty and hunger eradication. This Goal has 8 targets
- Goal 3 is “Good health and Well-Being”. Ensuring healthy lives and promoting the well-being for all at all ages is essential to sustainable development. This Goal has 13 targets
- Goal 4 is “Quality Education”. Obtaining a quality education is the foundation to improving people’s lives and sustainable development. This Goal has 10 targets

- Goal 5 is “Gender Equality”. Gender equality is not only a fundamental human right, but a necessary foundation for a peaceful, prosperous and sustainable world. This Goal has 9 targets
- Goal 6 is “Clean Water and Sanitation”. Clean accessible water for all is an essential part of the world we want to live in, This Goal has 8 targets
- Goal 7 is “Affordable and Clean Energy”. Energy is central to every major challenge and opportunity. This Goal has 5 targets.
- Goal 8 is “Decent Work and Economic Growth”. Sustainable economic growth will require societies to create the conditions that allow people to have quality jobs. This Goal has 12 targets
- Goal 9 is “Industry, Innovation, and Infrastructure”. Investments in infrastructure are crucial to achieve sustainable development. This Goal has 8 targets.
- Goal 10 is “Reduced Inequalities”. To reduce inequalities, policies should be universal in principle, paying attention to the needs of the disadvantaged and marginalised populations. This Goal has 10 targets
- Goal 11 is “Sustainable Cities and Communities”. There needs to be a future in which cities provide opportunities for all, with access to basic services, energy, housing, transportation, and more. This Goal has 10 targets
- Goal 12 is “Responsible Consumption and Production”. This Goal has 11 targets
- Goal 13 is “Climate Action”. Climate change is a global challenge that affects everyone, everywhere. This Goal has 6 targets
- Goal 14 is “Life Below Water”. Careful management of this essential global resource is a key feature of a sustainable future. This Goal has 10 targets
- Goal 15 is “Life on Land”. Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss. This Goal has 12 targets
- Goal 16 is “Peace, Justice and Strong Institutions”. Access to justice for all, and building effective accountable institutions at all levels. This Goal has 12 targets
- Goal 17 is “Partnerships”. Revitalise the global partnership for sustainable development. This Goal has 19 targets

These Goals and targets may be regarded as far too numerous, too complex, far too ambitious, and a wholly unrealistic “shopping list” to the point of being utopian, especially in recessionary times. We strongly contest this negative attitude for we believe they are both timely and essential. For developing countries and countries suffering or recovering from conflict, the most worrying aspect is that the funding mechanisms are unclear and not universally agreed. The inability of international organisations to prevent several long-running vicious conflicts and deal with refugees and migrants does not bode too well for the future. Donor fatigue, the downturn in global economic growth, persistent unmet funding promises from certain countries, and political manoeuvrings and interference will undoubtedly make delivery of many of these Goals unattainable for the time being.

Parenthetically, Goal 4 (Quality Education) was an underpinning rationale for publications in the series. (a) ‘Universities in Arab Countries: An Urgent Need for

Change" published in 2018 [71], (b) "Major Challenges Facing Higher Education in the Arab World: Quality Assurance and Relevance" published in 2019 [72], and (c) this current volume "Higher Education in the Arab World: Building a Culture of Innovation and Entrepreneurship". Goal 4 is closely integrated with all the other SDGs.

12 Sustainable and Sustainability

Numerous politicians, academics, and pressure-group activists commonly use the related words "sustainable" (an adjective) and "sustainability" (a noun), often so liberally to the point that they become meaningless or polemic assertions, and there is a creeping orthodoxy based on definition imprecision. The terms are difficult to define because they have overlapping economic, ecological, political, and cultural domains [73, 74]. The terms are also generally deemed to be "politically correct" terms (a "green theology"), and environmental activists castigate any actions and activities that do not conform to current perceptions of what is sustainable, especially by businesses but now leisure activities such as tourism and flying are coming under scrutiny. Some activists fail to recognise that simply imposing economic hardship and a "hair-shirt" mentality is often unacceptable to most people without proper justification and positive encouragement. Clearly, scientists seek clarity as to the meaning of "sustainable" and "sustainability" and evaluate measures to implement changes to meet specific targets – especially if these terms constitute part of the title of conferences and papers! In the context of this chapter, "sustainability" in most dictionaries refers inter alia to an activity that can be maintained at a certain rate or level, or to conserving an ecological balance by avoiding depletion of natural resources. Defining "ecological balance", however, is exceptionally complex when considering concepts of vegetation successions, gene flow, migrations, seed and propagule dispersal and dormancy, natural cataclysmic events, and evolution. Sometimes, there is an implicit and mistaken intention of thinking that the laws of thermodynamics can be overridden (see Conclusions), but nothing is sustainable for all time! Opinions, facts, needs, and social arrangements change through the generations so decision-making on sustainability should seek answers to questions about "sustainable": (a) what precisely is being sustained, (b) over what area (c) for how long, (d) for what purpose, (e) at what cost (for example cost-benefit analyses) and for whom; (f) what are the upsides, trade-offs, conflicts of interest and consequences; (g) will the developing world be condemned to a life of poverty and inequality especially if wealth-creation is adversely affected in donor countries and there are constraints on technology transfer; (h) are there alternative solutions; and (i) how is it measured and by whom? We wonder when "sustainable sustainability" will be introduced into the literature.

13 International Climate-Change Negotiations and Agreements

The United Nations Framework Convention on Climate Change (UNFCCC) occupies primacy of place in international negotiations and agreements on climate change [75]. It entered into force on 21 March 1994. Today, it has near-universal membership. The 197 countries that have ratified the Convention are termed Parties to the Convention. The UNFCCC is a “Rio Convention”, one of three adopted at the “Rio Earth Summit” in 1992. Its sister Rio Conventions are the UN Convention on Biological Diversity and the Convention to Combat Desertification. The three are intrinsically linked. It is in this context that the Joint Liaison Group was set up to boost cooperation among the three Conventions, with the ultimate aim of developing synergies in their activities on issues of mutual concern. It now also incorporates the Ramsar Convention on Wetlands. Preventing “dangerous” human interference with the climate system is the ultimate aim of the UNFCCC. To this end, it recognises the need for scientific evidence, sets an ambitious but specific goal, puts the onus on developed countries to shoulder their responsibilities, directs new funds to climate-change activities in developing countries, and closely monitors progress. Considerable diplomatic skills are needed to accomplish adaptation to climate change.

Closely allied to the negotiations about the SDGs are the outcomes of the UN Climate Change Conferences [76]. These conferences are the foremost global forums for multilateral discussion of climate-change matters. They rotate annually among the five United Nations regional groups, serve as the formal meetings of the Conference of the Parties (COP), the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP) and the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (the CMA).

Attending the Conferences are numerous negotiating groups recognised by the UN. These include (a) the Group of 77 (comprising 134 members!) with various sub-groups; (b) the 28-member European Union; the 12-party Umbrella Group comprising a loose coalition of non-EU developed countries; the 6-member Environmental Integrity Group; OPEC countries; the group of countries from Central Asia, the Caucasus, Albania and Moldova; the Cartagena Dialogue of about 40 countries; the Independent Alliance of Latin America and the Caribbean; and the Like-Minded Developing Countries representing more than 50% of the global population. Interacting with the delegates are numerous activist civil-society groupings and environmental Non-Governmental Organisations, as well as businesses investing in “green” technology, and the global news media. Much hinges on whether the burden of funding essential to accomplish the necessary changes will be acceptable to the richer countries without considerable burden-sharing by other countries. Debate continues on the issue of “loss and damage”, i.e. compensation from the rich to the poor.

In 2015, 196 Parties came together under the Paris Agreement to transform their development trajectories so that they set the world on a course towards sustainable development, aiming at limiting warming to 1.5–2 °C above pre-industrial levels. Through the Paris Agreement, Parties also agreed to a long-term goal for adaptation. The goal aims to increase the ability to adapt to the adverse impacts of climate change, foster climate resilience, and develop low GHG emissions development, in a manner that does not threaten food production. Additionally, they agreed to work towards making finance flows consistent with a pathway towards low GHG emissions and climate-resilient development. Nationally determined contributions (NDCs) are at the heart of the Paris Agreement and achievement of the long-term goal. Each party has to prepare, communicate, and maintain successive nationally determined contributions that it intends to achieve.

NDCs are submitted every 5 years to the UNFCCC secretariat. In order to enhance ambition over time, the Paris Agreement provides that successive NDCs from each country will represent a progression compared with the previous NDC and reflect its highest possible ambition. Starting in 2023 and then every 5 years, governments will take stock of the implementation of the Agreement to assess the collective progress towards achieving the purpose of the Agreement and its long-term goals. The outcome of the global stocktake will inform the preparation of subsequent NDCs, in order to allow for increased ambition and climate action to achieve the purpose of the Paris Agreement and its long-term goals. Quinquennial assessments appear to be the correct frequency to determine if adequate progress has been made.

INDCs should refer inter alia to a quantifiable reference point or base year, time frames for implementation, scope and coverage, planning processes, assumptions, and methodological approaches, and comments on fairness, ambitions, and contributions to the Conference objectives. Early evidence pointed to countries making pledges entrenched in self-interest as opposed to a common goal, an inadequate pace and scale of changes necessary to meet common targets, and the distinct likelihood of a failure to agree on a global price on carbon. Legitimate questions can be asked as to the integrity of official emission data from several countries but new and developing satellites with a wide range of sensors are beginning to monitor pollution events. Big multinational companies including the oil majors as well as major investors have previously called for a global oil price to help spur long-term investments in low-carbon energy. Compounding concerns about international agreements is the discomfiting reality that many governments having previously made pledges on diverse issues then failed to deliver them. A prime example is the failure to deliver aid to conflict zones in the Arab Region and elsewhere. In view of this, how much confidence can be attached to climate-change pledges? Should there be a detailed international “Failed Pledges” register detailing aid (quantity and quality) and/or other international promises made, with timelines and actual amount delivered? Nevertheless, there have been reports to the effect that there is at least a significant intention towards approaching the 2 °C target; unchecked, the current trend of GHG emissions points in our opinion more to a 3 °C rise in global temperature. Many of the proposed emissions reductions are conditional on financial support from richer countries. Several emerging economies steadfastly refuse to implement rigorous carbon-cutting policies until their economies reach parity with richer nations, yet demand financial support meantime, linking the assistance to the alleviation of poverty. Proposals for an International Tribunal of Climate Justice, akin to the UN Court of Justice in the Hague, or International Green Court as a way to enforce agreed climate goals by non-compliant nations have not reached fruition, not least because of friction between donor and recipient countries. Some politicians, economists, and financiers worry that continuing development of the UNFCCC processes will lead to another severe economic recession, in so doing limiting monetary transfers, and will put the global energy market into the hands of a few governments.

On 22 September 2015, the UN launched the "Climate Neutral Now" initiative [77] in order to encourage individuals, businesses, and governments to avoid the worst effects of climate change by means of a three-step process: (a) measure their GHG emissions; (b) reduce them as much as possible; and (c) compensate those that cannot be avoided by using UN-certified emission reductions (CERs). An online portal is in operation. The offset mechanism is an important feature in light of the extent of airline and vehicle travel simply for leisure purposes and some energy- and natural-resource-consuming profligate lifestyles. The offset mechanisms, however, deserve close scrutiny as to their effectiveness and integrity. As regards climate change, aircraft consume fossil fuels and emit GHGs and particulates (e.g. carbon dioxide, water, NOX, sulfur oxides, and soot) into the upper troposphere and lower stratosphere, affecting atmospheric composition, including ozone chemistry in the case of NOX, and triggering the formation of condensation trails and cirrus cloudiness.

14 Conclusions

There is the view that food, water and energy security, and therefore sustainability, cannot be properly addressed until population growth is curtailed and technological advances are applied universally to ensure that the demand for natural resources does not exceed supply, and wide-ranging ecological protection measures are taken. Without external intervention, several countries already have populations whose demands far exceed their wealth-creating ability and/or their natural resources and thus require external assistance to meet food, water and energy security. Poverty is underpinned by the lack of secure food, water, and energy supplies and will continue to drive political instability and conflict.

Although the term "anthropogenic" is usually applied to climate change, humans are now dramatically changing other key components of the planet. All technologies attempt to exploit, control, or modify aspects of the environment. Activities such as agriculture, horticulture, managed forestry, fishing, irrigation, drainage and water-purification schemes, mining, drilling for oil and gas, civil engineering and construction, manufacturing, using manufactured products (such as paints, cosmetics, cleaning agents, leather, paper, agrochemicals, synthetic dyes, etc.), just living, most leisure activities, travel (including cars, lorries, buses, trains, shipping, and aviation), and generating waste products inevitably destroy the natural environment directly and indirectly. Evolutionary processes are being disrupted and other species are in the process of being extinguished. Chemical, light, and sound pollution pervades the natural environment. Of the four Laws of Thermodynamics, the First and Second Laws directly apply. According to the first Law (conservation of energy), whenever energy is moved around or manipulated by technology, environmental consequences must arise to redress the balance. In the Second Law, order can be increased in one system (such as the human economy) only by increasing disorder or entropy (defined in terms of classical and non-equilibrium thermodynamics and statistical mechanics) outside that system (such as the natural environment) so that the total system moves towards thermodynamic equilibrium. The economic policies and theories of year-on-year growth are self-evidently impossible to achieve in the medium to long term without damaging the environment. Even approaching and not achieving the concept of sustainability will only be possible by adopting a combination of more sophisticated environmentally aware technologies, changes in lifestyle, and most importantly sharply reducing the birth rate. Science, technology, and engineering are key to positive outcomes; subsidies and taxation will not fully address the challenge. Fortunately, the raft of transformative technologies is ever expanding, examples of which are listed in Table 2 of a chapter in our previous book in this series [78].

Leaders, decision-makers and their advisors world specifically in the Arab Middle East (from businesses, institutions, local and national governments, and households) must face up to their responsibilities for their people. They should prepare coherent mitigation and adaptation strategies at the same time as addressing both poverty and bringing about peaceful conditions as a prelude to implementing those changes. Only then will the world and the Region be in a realistic position to address profound and justified concerns over the future.

References

1. Carrington D (2016) The Anthropocene epoch: scientists declare dawn of human-influenced age. The Guardian https://www.theguardian.com/environment/2016/aug/29/declare-anthropocene-epoch-experts-urge-geological-congress-human-impact-earth
2. Working Group on the 'Anthropocene' (2019) Subcommision on Quaternary Stratigraphy http://quaternary.stratigraphy.org/working-groups/anthropocene/
3. Stoermer EF (2019) Wikipedia https://en.wikipedia.org/wiki/Eugene_F._Stoermer
4. Crutzen PJ (2019) Wikipedia https://en.wikipedia.org/wiki/Paul_J._Crutzen
5. Daily CO_2 (2019) CO_2.earth https://www.co2.earth/daily-co2
6. Global Climate Report – July 2019 (2019) National Centers For Environmental Information. National Oceanic and Atmospheric Administration https://www.ncdc.noaa.gov/sotc/global/201907
7. The Intergovernmental Panel on Climate Change (2019). https://www.ipcc.ch/
8. IPCC (2018) Global warming of 1.5 °C. An IPCC Special Report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. In: Masson-Delmotte V, Zhai P, Pörtner HO, Roberts D, Skea J, Shukla PR, Pirani A, Moufouma-Okia W, Péan C, Pidcock

R, Connors S, Matthews JBR, Chen Y, Zhou X, Gomis MI, Lonnoy E, Maycock T, Tignor M, Waterfield T (eds). In Press. https://www.ipcc.ch/sr15/
9. Special Report on Global Warming of 1.5 °C (2019) Wikipedia. https://en.wikipedia.org/wiki/Special_Report_on_Global_Warming_of_1.5_%C2%B0C
10. Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems (2019). https://www.ipcc.ch/report/srccl/
11. IPCC (2019) Special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Summary for policymakers. Approved draft. Headline Statements. https://www.ipcc.ch/site/assets/uploads/2019/08/3.-Summary-of-Headline-Statements.pdf
12. International Energy Agency. https://www.iea.org/
13. World Energy Outlook (2018) International Energy Agency. https://www.iea.org/weo2018/
14. BP Energy Outlook (2019) BP p.l.c. https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/energy-outlook/bp-energy-outlook-2019.pdf
15. (a) Crawford JW, Duncan JM, Ellis RP, MacKerron DKL, Marshall B, Woodford JAT, Hillman JR (1989) Global warming, the implications for agriculture and priorities for research. Scottish Crop Research Institute Report (now James Hutton Institute), Invergowrie, Dundee, UK, 77pp; (b) Crawford JW, Duncan JM, Ellis RP, Griffiths BS, Hillman JR, MacKerron DKL, Marshall B, Ritz K, Robinson D, Wheatley RE, Woodford JAT, Young IM (1990) Global warming: implications for agriculture and opportunities for research. Scottish Crop Research Institute Report (now James Hutton Institute), Invergowrie, Dundee, UK, 110pp
16. (a) Hillman JR (2001) Report of the Director. Global perspectives of factors influencing agricultural, biological, and environmental sciences, and their associated industries: 2000–2001. Annual Report of the Scottish Crop Research Institute 2000/2001, pp 13–51; (b) MacKerron DKL, Hillman JR, Duncan JM (2002) Sustainability in agriculture. Annual report of the Scottish Crop Research Institute for 2001/2002. Scottish Crop Research Institute, Dundee, pp 69–82
17. Greenhouse gas (2019) Wikipedia https://en.wikipedia.org/wiki/Greenhouse_gas
18. Clouds and Climate (2019) ESRL Physical Sciences Division. National Oceanic and Atmospheric Administration https://www.esrl.noaa.gov/psd/outreach/education/science/clouds_and_climate.html
19. Earth's magnetosphere (2019) Space Weather Prediction Centre. National Oceanic and Atmospheric Administration https://www.swpc.noaa.gov/phenomena/earths-magnetosphere
20. Kopp OC (2019) Fossil fuel. Encyclopaedia Britannica https://www.britannica.com/science/fossil-fuel
21. Fossil fuel (2019) Wikipedia https://en.wikipedia.org/wiki/Fossil_fuel
22. Combustion (2019) Wikipedia https://en.wikipedia.org/wiki/Combustion
23. Kopp OC (2019) Coal. Encyclopaedia Britannica. https://www.britannica.com/science/coal-fossil-fuel
24. What is coal? (2019) World Coal Association. https://www.worldcoal.org/coal/what-coal
25. Coal (2019) Wikipedia. https://en.wikipedia.org/wiki/Coal
26. Global Coal Plant Tracker (2019) Global Energy Monitor. Endcoal.org https://endcoal.org/global-coal-plant-tracker/
27. What is CCS? (2019) Carbon Capture & Storage Association http://www.ccsassociation.org/what-is-ccs/
28. MacKay DJC (2008) Sustainable energy – without the hot air. UIT Cambridge. ISBN 978-0-9544529-3-3, http://www.withouthotair.com/cft.pdf
29. Renewable Energy (2019) Alternative Energy http://www.altenergy.org/renewables/renewables.html
30. Types of Renewable Energy (2019) Renewable energy world. https://www.renewableenergyworld.com/index/tech.html#gref
31. The Manufacturing Platform for Terawatt Solar (2019) 1366 Technologies. https://1366tech.com/

32. Renewable Energy and Energy Efficiency Partnership (2019). https://www.reeep.org/programme-people
33. Future of Climate Change (2017) United States Environmental Agency. https://19january2017snapshot.epa.gov/climate-change-science/future-climate-change_.html
34. Climate Change in the Middle East & North Africa (2019) The World Bank. https://www.worldbank.org/en/programs/mena-climate-change#5
35. Climate change is making the Arab world more miserable (2018) The Economist. https://www.economist.com/middle-east-and-africa/2018/05/31/climate-change-is-making-the-arab-world-more-miserable
36. Bucchignani E, Mercogliano P, Panitz H-J, Montesarchio M (2018) Climate change projections for the Middle East-North Africa domain with COSMO-CLM at different spatial resolutions. Adv Clim Chang Res 9(1):66–80. https://www.sciencedirect.com/science/article/pii/S1674927817300552
37. Mitigation (2019) Merriam-Webster. https://www.merriam-webster.com/dictionary/mitigation
38. Responding to Climate Change (2019). https://climate.nasa.gov/solutions/adaptation-mitigation/
39. Adaptation and Mitigation (2019) Intergovernmental Panel on Climate Change. https://ar5-syr.ipcc.ch/topic_adaptation.php
40. The role of land carbon sinks in mitigating global climate change (2001) The Royal Society. London, 27pp. https://royalsociety.org/-/media/Royal_Society_Content/policy/publications/2001/9996.pdf
41. Carbon sink (2019) Wikipedia. https://en.wikipedia.org/wiki/Carbon_sink
42. Climate engineering (2019) Wikipedia. https://en.wikipedia.org/wiki/Climate_engineering
43. Redfield AC (1934) On the proportions of organic derivatives in sea water and their relation to the composition of phytoplankton. In: Daniel RJ (ed) James Johnstone memorial volume. University of Liverpool, pp 177–192
44. Hands off Mother Earth (2019) Geoengineering Monitor. http://www.geoengineeringmonitor.org/
45. Badran A, Murad S, Baydoun E, Daghir N (eds) (2017) Water, energy & food sustainability in the Middle East. Springer. ISBN 978-3-319-48919-3. https://doi.org/10.1007/978-3-319-48920-9
46. Rosen M, Ritchie H (2019) Food prices. Our World in Data. https://ourworldindata.org/food-prices
47. World Food Situation. FAO Cereal Supply and Demand Brief (2019) Food and Agricultural Organization of the United Nations. http://www.fao.org/worldfoodsituation/csdb/en/
48. Lynas M (2011) The god species. How the planet can survive the age of humans. HarperCollins, London. ISBN 978-0-00-731342-6
49. Phalan B (2019) Cambridge Global Food Security. https://www.globalfood.cam.ac.uk/images/memberphotos/ben-phalan.jpg/view
50. Bioremediation. Wikipedia. https://en.wikipedia.org/wiki/Bioremediation
51. Bioremediation (2019) ScienceDirect. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/bioremediation
52. Biofuel (2019) Wikipedia. https://en.wikipedia.org/wiki/Biofuel
53. Biofuels (2019) European Commission. https://ec.europa.eu/energy/en/topics/renewable-energy/biofuels
54. Offshore aquaculture (2019) Wikipedia. https://en.wikipedia.org/wiki/Offshore_aquaculture
55. Desalination technology (2019) ScienceDirect. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/desalination-technology
56. Desalination (2019) Wikipedia. https://en.wikipedia.org/wiki/Desalination
57. Soil salinity control (2019) Wikipedia. https://en.wikipedia.org/wiki/Soil_salinity_control
58. What is Industrial Biotechnology? (2019) Biotechnology Innovation Organization. https://www.bio.org/articles/what-industrial-biotechnology
59. Biotech Industry 2019 (2019) ReportLinker. https://www.reportlinker.com/market-report/Biotechnology/6233/Biotech?utm_source=adwords3&utm_medium=cpc&utm_

campaign=Biotechnology&utm_adgroup=Biotech_Industry_Reports&gclid=EAIaIQobChMImeiBssCe5AIVkuF3Ch2kNg0BEAMYASAAEgLzK_D_BwE
60. What is marine snow? (2019) National Ocean Service. National Oceanic and Atmospheric Administration. https://oceanservice.noaa.gov/facts/marinesnow.html
61. Falkowski PG (1994) The role of phytoplankton photosynthesis in global biogeochemical cycles. Photosynth Res 39(3):235–258. https://doi.org/10.1007/BF00014586. https://www.ncbi.nlm.nih.gov/pubmed/24311124
62. Basu S, Mackey KR (2018) Phytoplankton as mediators of the biological carbon pump: their responses to a changing climate. Sustainability (mdpi.com) 10(869):1–18. https://doi.org/10.3390/su10030869
63. Winkler AJ, Myneni RB, Alexandrov GA, Brovkin V (2019) Earth system models underestimate carbon fixation by plants in the higher latitudes. Nat Commun 10:885. https://doi.org/10.1038/s41467-019-08633-z. https://www.ncbi.nlm.nih.gov/pubmed/30792385
64. Kesselmeier J, Ciccioli P, Kuhn U, Stefani P, Biesenthal T, Rottenberger S, Wolf A, Vitullo M, Valentini R, Nobre A, Kabar P, Andreae MO (2002) Volatile organic compound emissions in relation to plant carbon fixation and the terrestrial carbon budget. Glob Biogeochem Cycles. https://doi.org/10.1029/2001GB001813. https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2001GB001813
65. Emissions Trading (2019) United Nations Climate Change. https://unfccc.int/process/the-kyoto-protocol/mechanisms/emissions-trading
66. EU Emission Trading System (EU ETS) (2019) European Commission. https://ec.europa.eu/clima/policies/ets_en
67. Carrington D (2018) What is biodiversity and why does it matter to us? The Guardian, 12 March 2018. https://www.theguardian.com/news/2018/mar/12/what-is-biodiversity-and-why-does-it-matter-to-us
68. Biodiversity (2019) Wikipedia. https://en.wikipedia.org/wiki/Biodiversity
69. Mora C, Sale PF (2011) Ongoing global biodiversity loss and the need to move beyond protected areas: a review of the technical and practical shortcomings of protected areas on land and sea. Mar Ecol Prog Ser 434:251–266. https://www.researchgate.net/publication/269576361_Ongoing_global_biodiversity_loss_and_the_need_to_move_beyond_protected_areas_A_review_of_the_technical_and_practical_shortcomings_of_protected_areas_on_land_and_sea
70. About the Sustainable Development Goals (2019) United Nations. https://www.un.org/sustainabledevelopment/sustainable-development-goals/
71. Badran A, Baydoun E, Hillman JR (eds) (2018) Universities in Arab countries: an urgent need for change. Springer Nature. ISBN 978-3-319-73110-0. https://doi.org/10.1007/978-3-319-73111-7
72. Badran A, Baydoun E, Hillman JR (eds) (2019) Major challenges facing higher education in the Arab World: quality assurance and relevance. Springer Nature. ISBN 978-3-030-03773-4. https://doi.org/10.1007/978-3-030-03774-1
73. Sustainability (2019) Wikipedia https://en.wikipedia.org/wiki/Sustainability
74. Sustainability (2019) Investopedia https://www.investopedia.com/terms/s/sustainability.asp
75. What is the United Nations Framework Convention on Climate Change? (2019) United Nations. https://unfccc.int/process-and-meetings/the-convention/what-is-the-united-nations-framework-convention-on-climate-change
76. What are the United Nations Climate Change Conferences? (2019) United Nations. https://unfccc.int/process/conferences/what-are-united-nations-climate-change-conferences
77. Climate Neutral Now (2019) United Nations. https://unfccc.int/climate-action/climate-neutral-now
78. Hillman JR, Baydoun E (2019) Quality assurance and relevance in academia: a review. In: Badran A, Baydoun E, Hillman JR (eds) Major challenges facing higher education in the Arab World: quality assurance and relevance. Springer, Cham, pp 13–18. https://doi.org/10.1007/978-3-030-03774-1_2

Intellectual Property Rights

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Abstract Intellectual property rights (IPRs) are defined and described, encompassing trademarks, copyright, patents, industrial designs, and geographical indications. The various protections and rights are detailed along with consideration of the relevant international law, specifically the Paris Convention for the Protection of Industrial Property (1883); the Madrid Agreement Concerning the International Registration Marks (1891) and the protocol Relating to that Agreement (1989); the Nice Agreement Concerning the International Classification of Goods and Services for the Purposes of the Registration of Marks (2017); the Berne Convention for the protection of Literary and Artistic Works (1886); WIPO Copyright Treaty (1996); and the Patent Cooperation Treaty (1970). IPRs in the Arab world are discussed followed by the issues of confidentiality, infringements, and remedies. Various improvements to the IPR system are recommended.

Keywords Intellectual property rights · Trademarks · Copyright · Patents · Industrial designs · Geographical indications · Arab world · Assignment · Conventions and treaties · Novelty · Industrial applicability · Inventive concept · Confidentiality · Non-disclosure agreement · Compulsory use · Infringements · Fair use · Provisional application · Remedial actions · Injunctions · Provisional and precautionary measures · Seizure · Damages · Trade secret · Unauthorized use · Unfair competition

1 Introduction

Growth of the modern global economy is dependent on a combination of innovation, entrepreneurship, and high-quality governance in all sectors of society. Establishing successful businesses that exploit inventions, discoveries, concepts, and novel processes invariably involves obtaining ownership of the underpinning intellectual property (IP). Company valuations are increasingly reliant on intangible

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assets such as specialist know-how, research and development investments, and various forms of IP that have yet to be brought to market.

As a major source of innovation and creativity, universities have a duty to facilitate the identification, protection, and exploitation of IP generated by their staff members and students, drawing on external expertise where necessary. Universities in the Arab world have underperformed in this regard and there is an increasing urgency for higher education to focus on IP to justify investments in them and for socio-economic development more generally in their host countries.

This chapter is an account of intellectual property rights (IPRs), describing the main types of IP, the relevant international law, and the main issues of IPRs to be considered by all higher-education institutions.

2 Definition and Various Types of Intellectual Property Rights

Intellectual property rights (IPRs) represent the legal rights that aim to protect the creations of the intellect and mind, e.g. inventions, literary and artistic works, designs, symbols, names, and images used in commerce [1]. They are similar to any proprietary right and can be legally owned, sold, or licensed. Indeed, IPRs allow creators or owners of patents, trademarks, or copyrighted works to benefit from their own work or investment in a creation. They are assets that need to be protected and are important for a long-term financial success. Nonetheless, IPRs have an intangible nature and their ownership should therefore be evidenced and protected. The most prominent types of IPRs are trademarks, patents, and copyrights though many other types also exist, i.e. industrial designs and geographical indications.

2.1 Trademarks

A trademark is a distinctive sign that identifies certain goods or services produced or provided by an individual or a company. Trademarks may be a word or a combination of words, letters, and/or numerals. They may also consist of drawings, logos, designs, or symbols, three-dimensional signs such as the shape and packaging of goods. They can be owned by one or more natural persons /or and can be protected in more than one class according to the Nice Agreement Concerning the International Classification of Goods and Services [2].

They are considered a valuable part of one's business and a marketable asset. In fact, any asset purchase agreement should clearly specify that the purchased assets include the trademarks and the goodwill related to them.

2.2 Copyright

Copyright refers to the protection rights that authors, artists, and other creators have over their literary and artistic works generally referred to as "Works". Works covered by copyright include but are not limited to books, poems, plays, music, paintings, sculpture, musical compositions, paintings, drawings, photographs, films, computer programs, databases, advertisements, maps, and technical drawings.

In general, the Works commonly protected by copyright throughout the world include without limitation: (a) literary works such as novels, poems, plays, reference works, and newspaper articles; (b) films, musical compositions, choreography, and all kind of audio-visual works; (c) artistic works such as paintings, drawings, photographs, and sculptures; (d) architecture, advertisements, maps, and technical drawings; and (e) computer programs and databases.

It is unanimously recognized that facts and ideas are not protected by copyright and can rightfully belong to the public domain. Indeed, it is the particular expression of an idea under the Works that is specifically protected under copyright. Copyrights protect expression and creativity not ideas.

2.3 Patents

A patent is an exclusive right granted for an invention, which is a product or a process that provides, in general, an innovation, a new way of doing something, or offers a new technical solution to a problem. To obtain a patent, technical information about the invention must be disclosed to the public in a patent application. Patents are not discoveries and therefore should fulfill the following three criteria of patentability:

(i) ***Novelty***. The patent should have no precedence in the industrial prior art, i.e., the invention was not disclosed to public anywhere at any time whether by written, oral disclosure or by use or any other method.
(ii) ***Industrial applicability***. The invention should be used in the industrial field including agricultural and technological fields.
(iii) ***Inventive Concept***. The invention should have technical development that is not obvious to any skilled person in the respective field of technology of the invention.

It is, however, to be noted that patentability shall not include:

(i) Discoveries as long as they are employed for industrial and technical applications;
(ii) Ideas, scientific theories, mathematical methods, exercise of pure intellectual property activities, or practice of a specific game;
(iii) Computer programs are protected under copyright. Nevertheless, computer programs may be registered as patents in the case they fulfill the three criteria

of patentability mentioned above specifically, if they evidence a technical innovation that can solve technical problems;

(iv) Plants and animals, and essential biological processes for the production of plants or animals other than microbiological processes;

(v) Diagnostics, therapeutic and surgical methods for the treatment of human or animals;

(vi) In general, any innovation that is contrary to morality and public order.

2.4 Industrial Designs

An industrial design refers to the ornamental or aesthetic aspect of a product. It is what makes an article attractive and appealing, hence it adds to the commercial value of a product and increases its marketability. Industrial designs protect solely the non-functional features of an industrial product and do not protect any technical features of the object to which it is applied. They may consist of three-dimensional features, such as the shape of an article, or two-dimensional features, such as patterns, lines, or color.

Industrial designs are applied to a wide variety of products of industry and handicraft ranging from technical and medical instruments to watches, jewelry and other luxury items, packages and containers, furnishing and housewares, lighting equipment, electronic devices, architectural structures, and textiles to leisure goods.

2.5 Geographical Indications

A geographical indication, also known as appellation of origin, is a sign used on products that have a specific geographical origin and possess qualities or a reputation due to that place of origin, specifically agricultural products, foodstuffs, wine and spirit drinks, handicrafts, and industrial products.

In order to function as a geographical indication, a sign must identify a product as originating in a given place. It is worth mentioning that the characteristics or reputation of the product should be substantially linked to the place of origin since the qualities of such product depend on the geographical place of production, e.g. "*Roquefort*" for cheese produced in that region of France. The use can also highlight qualities of a product that are due to human factors found in the product's place of origin, such as specific manufacturing skills and traditions e.g. *"Switzerland"* for watches.

3 Protections and Rights

3.1 Nature of Protection

3.1.1 Rights Under Trademarks

Trademark protection ensures that the owner of the marks have the exclusive right to use the registered trademark, to sell or license the said trademark to another party in return for payment or without consideration, and therefore to prevent others from using the trademark.

Protection of the trademarks is evidenced through registration. In case of dispute or litigation, registration of the trademark provides evidence that the person/entity, under which the trademark is registered, is the right holder of the trademark. Indeed, rights under trademarks are private rights and protection is enforced through court orders.

It is, however, worth mentioning that proprietary of a trademark can be determined through seniority of use. In case a person alleges the precedence of using a trademark that is not filed, it is always imperative in such circumstances that written evidence is submitted in this respect. It has also been recognized that a longstanding use and notoriety of a trademark, i.e. a trademark that is sufficiently used so that the public identifies the mark with the user, can establish seniority and grant the owner of an unregistered trademark prior rights over the user of the same registered trademark.

3.1.2 Rights under Copyright

Rights granted under copyright are both economic and moral rights. Economic rights are the rights that entitle the owner of the Work (i) to receive financial rewards from the sale or licensing of their works by others, and therefore (ii) to prohibit or authorize the reproduction of the Works in all forms including, printing, publication, recording, broadcasting, and their translation and adaptation. On the other hand, moral rights protect the non-economic interests of the author being the right to claim authorship of a Work and the right to contest any changes to a Work. Moral rights enjoy eternal protection and pass on to others by inheritance.

It is to be noted, however, that the protection of copyright extends only to expressions, and not to ideas, procedures, methods of operation, or concepts as such.

In special cases, *fair use* of the copyright works without the authorization of the author is unanimously recognized, provided that such use does not conflict with a normal exploitation of the Work and does not unreasonably prejudice the legitimate interests of the author.

Such limitations and exceptions to the exclusive right of the author to exploit the Works are defined under the Berne Convention for the Protection of Literary and Artistic Works (1886) [3].

3.1.3 Rights Under Patent

The rights granted under patents are private rights. In other words, patent protection means that the invention cannot be commercially made, used, distributed, imported, or sold by others without the patent owner's consent. In fact, the patent owner has the exclusive right to prevent or stop others from commercially exploiting the patented invention. On the other hand, a patentee may decide at its sole discretion to assign or license the right to use his invention against or without any consideration. In fact, holders of patent rights have the right to decide who may use the patented invention for the period during which it is protected, to permit, license other parties the use of their inventions on mutually agreed terms, or sell their inventions' rights to someone else. In addition to the right to exclusively exploit, sell or license the patent, the patentee has the right to mortgage the patent in guarantee of payment of debts or other financial obligations.

As patents are considered as other IPRs as assets that may be exploited financially, a patentee could sell or license the use of a patent to a company against his/its participation in the shares of the said company.

Patents rights are territorial rights and are only enforceable in the country or region in which a patent has been registered or granted in accordance with the laws of the country of registration.

It is worth mentioning that a holder of a patent right has the obligation to exploit the patent within the time-limit specified by the laws of the relevant country of registration, otherwise the patent shall be subject to compulsory use. In addition to such obligation, a patentee should pay the renewal fees for a patent application for the years following that in which the patent has been granted according to the laws of the relevant country of registration. The non-payment of the renewal fees within the prescribed time-limit shall incur the loss of the patent rights.

3.1.4 Rights Under Industrial Design

A registered industrial design grants its owner the right to prevent third parties from making, selling, or importing articles bearing or embodying a design which is a copy, or substantially a copy, of the protected design, when such acts are undertaken for commercial purposes.

Similar to patents, the owners of an industrial design have the exclusive right to use the design, to make, import, or sell any objects to which the design is applied. They can authorize others to exploit the design in return for payment or without any compensation, and therefore bring a legal action against anyone using the design without authorization.

3.1.5 Rights Under Geographical Indication

A geographical indication guarantees to consumers that a product was produced in a certain place and has certain characteristics that are due to that place of production. A protected geographical indication enables the holder to prevent the use of the indication sign by a third party whose product does not conform to the applicable standards. It grants the holder a right over the sign of the geographical indication but does not hinder the use by others of the same techniques and standards set out for that indication.

3.2 Relevant International Law

As detailed on the website of the World Intellectual Property Organization [4], to benefit from the protection ensured by national laws, the holder of IPRs should register his/her/its rights in each country of interest; i.e. where the intellectual property rights will be exploited according to the national laws of the said country. It is however to be noted that many treaties and international agreements have been signed in this respect between several countries to help inventors and/or holders of other intellectual property rights, benefit from an equal national treatment of protection in each contracting country and/or benefit from an international registration that will have effect in these countries of interest. The most important treaties having been signed in this respect and that need in our opinion to be considered hereinafter, are the following:

3.2.1 Paris Convention for the Protection of Industrial Property (1883)

The Paris Convention [5] applies to all industrial property i.e. patents, trademarks, industrial designs, service marks, trade names, geographical indications, and the repression of unfair competition.

Under the provisions of the Paris Convention the following have been clearly stated:

(a) Regarding the protection of industrial property, each contracting state must grant the same protection to nationals of other contracting states that it grants to its own nationals. Nationals of non-contracting states are also entitled to national treatment under the Paris Convention if they are domiciled or have a real and effective industrial or commercial establishment in a contracting state.
(b) In the case of patents, marks and industrial designs a right of priority has been provided for any applicant filing a first application in one of the contracting states. Such applicant may, within a certain period of 12 (twelve) months for patents; 6 (six) months for industrial designs and marks, apply for protection in any of the other contracting states and these subsequent applications will be

regarded as if they had been filed on the same day as the first application, hence, having priority over applications filed by others during the said period of time for the same invention, mark or industrial design. Therefore, applicants seeking protection in several countries are not required to present all of their applications at the same time but have 6 (six) or 12 (twelve) months to decide in which countries they wish to seek protection, and to organize with due care the steps necessary for securing protection.

(c) Patents granted in different contracting states for the same invention are independent of each other: the granting of a patent in one contracting state does not oblige other contracting states to grant a patent; nor to refuse and terminate a patent on the ground that it has been refused or terminated in any other contracting state.

(d) Trademark*s***.** The conditions for the filing and registration of trademarks are governed by the provisions of the national laws of each contracting state and are independent of its possible registration in any other country, including the country of origin. Therefore, the annulment of the registration of a mark in one contracting state will not affect the validity of the registration in other contracting states. However, each contracting state may refuse registration in case (i) the mark would infringe the acquired rights of third parties; (ii) is lacking distinctive character and is able to create confusion; (iii) is contrary to morality or public order; or (iv) is of such a nature as to be liable to deceive the public.

(e) Industrial Designs. Industrial designs must be protected in each Contracting State, and protection may not be refused on the ground that articles incorporating the design are not manufactured in that State.

(f) Geographical indications**.** Measures must be taken by each contracting state against direct or indirect use of a false indication of the source of goods or the identity of their producer, manufacturer or trader.

(g) Unfair competition. Each contracting State takes the necessary measures against unfair competition.

3.2.2 Madrid Agreement Concerning the International Registration of Marks (1891) and the Protocol Relating to that Agreement (1989)

The Madrid system [6] enables a right holder to protect a mark in a large number of countries by obtaining an international registration that has effect in each of the contracting parties. Instead of filing a separate national application in each country of interest, in several different languages, in accordance with different national or regional procedural rules and regulations and paying several different fees, an international registration may be obtained by simply filing one application with the International Bureau in one language and paying one set of fees.

The effects of an international registration in each designated contracting party are, from the date of the international registration, the same as if the mark had been deposited directly with the office of that contracting party. If no refusal is issued within the applicable time limit, the protection of the mark is, from the date of the international registration.

An international registration is effective for 10 years. It may be renewed for further periods of 10 years upon payment of the prescribed fees.

3.2.3 Nice Agreement Concerning the International Classification of Goods and Services for the Purposes of the Registration of Marks (2017)

The Nice Agreement, concluded at Nice in 1957, revised at Stockholm in 1967 and at Geneva in 1977, and amended in 1979, establishes a classification of goods and services for the purposes of registering trademarks and service marks (the "Nice Classification") [7].

The use of the Nice Classification is mandatory for national registration of marks in countries party to the Nice Agreement, as the competent offices of the contracting states must indicate in official documents, and in any publication they issue in respect of the registration of marks, the numbers of the classes of the Classification (45 classes), to which the goods or services for which the mark is registered belong.

3.2.4 Berne Convention for the Protection of Literary and Artistic Works (1886)

The Berne Convention [3] deals with the protection of copyright. It sets the rules and principles determining the minimum protection to be granted, as well as special provisions available to developing countries that want to make use of them.

The principles that are set under the Berne Convention are the following:

(i) *Principle of national treatment*, i.e. Works must be given the same protection in each of the contracting states;
(ii) *Principle of automatic protection*; i.e. protection must not be conditional upon compliance with any formality;
(iii) *Principle of independence of protection*; i.e. protection is independent of the existence of protection in the country of origin of the work.

The Berne Convention provides for certain economic rights that need the author's authorization:

- right to translate,
- right to make adaptations and arrangements of the Work,
- right to perform in public dramatic, dramatico-musical and musical works,
- right to recite literary works in public,
- right to broadcast,
- right to make reproductions in any manner or form (with the possibility that a contracting state may permit, in certain special cases, reproduction without

authorization, provided that the reproduction does not conflict with the normal exploitation of the Work and does not unreasonably prejudice the legitimate interests of the author; and the possibility that a contracting state may provide, in the case of sound recordings of musical works, for a right to equitable remuneration),
– right to use the Work as a basis for an audiovisual work, and the right to reproduce, distribute, perform in public or communicate to the public that audiovisual work.

Exceptions to the above- mentioned general rule are provided for under the Berne Convention whereby the protected works may be used without the authorization of the author and without any compensation in case the conditions of the "*three-step test" are fulfilled*; i.e. reproduction in certain cases as stated under article 9(2) hereunder of the said Convention, the use of the Works by way of illustration for teaching purposes; the reproduction of newspaper or similar articles and the ephemeral recordings for broadcasting purposes.

Indeed, article 9 of the Berne Convention clearly states the following:

(1) Authors of literary and artistic works protected by this Convention shall have the exclusive right of authorizing the reproduction of these works, in any manner or form.
(2) It shall be a matter for legislation in the countries of the Union to permit the reproduction of such works in certain special cases, provided that such reproduction does not conflict with a normal exploitation of the work and does not unreasonably prejudice the legitimate interests of the author.
(3) Any sound or visual recording shall be considered as a reproduction for the purposes of this Convention.

The Berne Convention also protects the "moral rights*",* i.e., the right to claim authorship of the Work and the right to object to any mutilation, deformation or other modification of, or other derogatory action in relation to the Work.

As to the duration of protection, the general rule is that protection must be granted until the expiration of the 50th year after the author's death. However, in the case of anonymous works, the term of protection expires 50 years after the Work has been lawfully made available to the public, except if there is no doubt as to the author's identity or if the author discloses his or her identity during that period; in the latter case, the general rule applies. In the case of audiovisual works, the minimum term of protection is 50 years after release of the Work to the public, failing which, from the creation of the Work. In the case of works of applied art and photographic works, the minimum term is 25 years from the creation of the Work.

3.2.5 World Intellectual Property Organization (WIPO) Copyright Treaty (1996)

The WIPO Copyright Treaty [8] is a special agreement under the Berne Convention that deals with the protection of copyright in the digital environment. The WIPO Copyright Treaty mentions two subject matters to be protected by copyright: (i) computer programs, whatever the mode or form of their expression; and (ii) databases, in any form, which, by reason of the selection or arrangement of their contents, constitute intellectual creations.

As to the rights granted to authors, apart from the rights recognized by the Berne Convention, the Treaty also grants: (i) the right of distribution; i.e. the right to authorize the making available to the public of the original and copies of a work through sale or other transfer of ownership; (ii) the right of rental of the works; and (iii) a broader right of communication to the public by wire or wireless means.

It is also provided for under the WIPO Copyright Treaty that all limitations established under national law in compliance with the Berne Convention may be extended to the digital environment, i.e. *if the conditions of the "three-step" test are met according to article 9 of the Berne Convention*, in addition to new limitations that may also be set by the contracting states to the digital environment. As to duration, the term of protection must be at least 50 years for any kind of work.

The WIPO Copyright Treaty obliges the contracting parties to provide legal remedies against encryption used by authors in connection with the exercise of their rights, and against the removal or altering of information, such as certain data that identify works or their authors, necessary for the management of their rights e.g., licensing, collecting and distribution of royalties.

3.2.6 Patent Cooperation Treaty (1970)

The Patent Cooperation Treaty [9] is an international treaty that enables inventors to seek patent protection for an invention simultaneously in a large number of countries by filing a single "*international*" patent application instead of filing several separate national or regional patent applications. The granting of patents remains under the control of the national or regional patent offices in what is called the "national phase".

The Patent Cooperation Treaty procedure includes:

– **A filing of an international application** with a national or regional patent office or WIPO, complying with the Patent Cooperation Treaty formality requirements.
– **Conducting an *international search*** by an *international searching authority* to identify the published patent documents to see if the invention is patentable.
– **Disclosing through an *international publication*** the content of the international application.
– **Conducting an optional *supplementary international search*** by a second international searching authority to identify further published documents.
– **Conducting an optional *international preliminary examination*** at the inventor's request by one of the *international searching authority* to carry out an additional patentability analysis.
– ***National Phase*: Thirty** months from the earliest filing date of the initial application, a national application for the grant of the patents should be filed directly

before the national patent offices of the countries in which registration is requested.

The Patents' rights have a *territorial* nature. Therefore, in order to protect an invention in several countries, an inventor shall have the option to either (i) file a patent application in one country-of-interest member of Paris Convention, then file within 12 months as of the filing date of the first patent application, separate patent applications in other Paris Convention countries; the subsequent applications will therefore have the same date of the first application; or (ii) file one application under the Patent Cooperation Treaty, directly or within the above mentioned 12-month period provided for by the Paris Convention, which application shall be effective in all contracting states of the Patent Cooperation Treaty. The procedure under the Patent Cooperation Treaty is therefore simpler, easier, and cost-effective.

4 Intellectual Property Rights in Relation to the Arab World

This section is a summary of the IPRs as protected and regulated in the Arab countries, being for the purposes hereof, Algeria, Bahrain, Iraq, Kingdom of Saudi Arabia, Kuwait, Libya, Lebanon, Morocco, Oman, Sudan, Syria, Tunisia, UAE, and Yemen (the "Arab countries"). The source of information hereunder is Talal Abu-Ghazaleh Intellectual property [10].

4.1 Trademarks

- *Conventions and Treaties:* The Convention having been signed by the Arab countries and under which the IPRs relating to trademarks are regulated, is the "Paris Convention for the Protection of Industrial Property". The International Classification of Goods and Services for the Purposes of the Registration of Marks under the Nice Agreement is also being followed in the Arab countries.
- *Registration procedures*: Registration of a trademark shall be made through one application to be filed by the owner of the trademark. Such application can include goods and/or services in many numbers of classes, with additional fees to cover the additional classes (Algeria, Lebanon) or through a separate application to be filed with respect to each class of goods or services (Kuwait, UAE, Syria).

It is to be noted however that trademarks covering alcoholic goods are not registrable in Saudi Arabia as well as retail and wholesale services. In Kuwait, Libya, and Qatar, the trademark law does not provide for the protection of trademarks for alcoholic drinks under classes 32 and 33 and pork meat in class 29.

Once a trademark application is filed, it shall be examined by the competent authorities as to its registrability. Such examination shall consist in checking if the trademark application violates the public order and morals and/or prior rights.

The use of a trademark is not compulsory for filing applications, maintaining trademark registration in force, and renewal or maintenance of a trademark. Prior use constitutes the main criteria in determining proprietorship of a trademark. In Lebanon, prior use is never considered as a pre-requisite for registration, or a requirement to maintain any registration valid and enforced in the future. However, in Bahrain, Egypt, Kuwait, Libya, Qatar, Morocco, UAE, Saudi Arabia, Sudan, and Yemen, any interested party may request the court to cancel a trademark registration if the owner of the trademark fails to use such trademark in the relevant country for five consecutive years from the date of registration. Said period is three consecutive years for Algeria, Jordan, Iraq, and Oman. In Tunisia, the use of a trademark within a period of 5 years is a must by law. All trademarks registered before the issuance of this law must be used within 5 years from its issuance date. Otherwise, the trademark will be vulnerable to cancellation due to the non-use.

– *Term of protection*: The term of a trademark registration can vary, but is usually10 years for almost all the Arab countries. It can be renewed for indefinite similar periods on payment of additional fees. In Lebanon, a trademark registration is valid for 15 years as of the registration date and is renewable for indefinite similar periods. Filing a late renewal application is possible through a grace period varying from 3 months (Lebanon, UAE, Libya) to 6 months (Algeria, Egypt, Iran, Kuwait, Oman, Saudi Arabia) as of the date of expiration.
– *Assignment of trademark*: In order to be effective against third parties, the change of ownership of a trademark registration through an assignment or merger transaction should be registered with the competent authorities of the country of registration and published in the Official Gazette. In general, the assignment of a trademark is possible with or without the goodwill of the business concern.
– *Sanctions of Unauthorized use:* Imitation of a registered trademark applied on goods of the same class, sale, storing for the purpose of sale, exhibiting for sale of goods bearing a counterfeit mark, or using a mark duly by another party in order to serve the purpose of unauthorized promotion of goods of the same class are all offenses punishable under the laws of the relevant countries.

4.2 Patents

– *Conventions and Treaties:* In addition to the Paris Convention for the Protection of Industrial Property that have been signed by the Arab countries, the Patent Cooperation Treaty is signed and ratified by Algeria, Bahrain, Jordan, Qatar, Morocco, Sudan, Tunisia, UAE, Saudi Arabia, and Syria. As mentioned above, an applicant who has duly filed an application for the registration of a patent, in a country member of the Paris Convention, shall enjoy a right of priority during a period of 12 months for applying in this respect in any of the other contracting states and these subsequent applications will be regarded as if they had been filed on the same day as the first application. However, under the Patent Cooperation Treaty filing one application according to the process described in Sect. 3.2.6 shall be cost-effective and valid in all contracting states.

A Gulf Cooperation Council (GCC) Patent Office is a regional office for the GCC and comprises the United Arab Emirates, Kingdom of Bahrain, Kingdom of Saudi Arabia, Sultanate of Oman, State of Qatar, and State of Kuwait. Certificates of patents granted by the Patent Office secure legal protection of the inventor's rights in the above-mentioned member states.

– *Registration procedures*: For some Arab countries, the nature of the registration system is a deposit system rather than an examination–based system e.g. Lebanon, Egypt, Sudan. In such a system, there is no examination for patent applications. Patent applications are therefore examined as to the formalities and technical requirements. Therefore, an invalidation has to be done through courts and a patent may be later cancelled by a judicial ruling in some cases of the law (e.g. lack of novelty, applicability to industry, sufficiency for a skilled person in the art to apply, etc.). On the other hand, in other countries as the UAE and Jordan, patent applications are subject to substantive examination and are bound to meet the patentability criteria mentioned hereunder for receiving acceptance by the competent authorities. Such criteria are "novelty", "Inventive Concept" and "Industrial applicability".
– -*Novelty*: the patent should have no precedence in the industrial prior art, i.e. the invention was not disclosed to public anywhere at any time whether by written, oral disclosure or by use or any other method.
– *Industrial applicability*: the invention can be used on an industrial level.
– *Inventive Concept*: the invention should have technical development that is not obvious to any skilled person in the respective field of technology of the invention.
– *Term of protection*: in most Arab countries, patents are protected for 20 years from either the grant date of the Patent or from the national filing date of the application. In Libya, a patent is valid for 15 years starting from the date of filing of the application.

The validity of the registered patents is subject, however, to the payment of the prescribed annual fees with a grace period ranging from 3 months (UAE, Saudi Arabia) to 6 months (Lebanon) as of the beginning of each year subsequent to the year of the acceptance date or filing date as the case may be for each relevant country.

Under the Patent Cooperation Treaty (PCT), a patent is valid for 20 years starting from the international filing date of the application. Such validity is subject to the payment of the prescribed annual fees. Annuities are to be paid counting from the international filing date. A 6-month grace period with a fine is allowed for late payment of the annuity. Therefore, according to the UAE Patent Law, annual maintenance fees are due on the anniversary of the international filing date for the national phase of PCT applications and on the anniversary of the national filing date for non-PCT applications.

As patent rights are territorial, such rights shall expire on (i) the lapse of the protection period as prescribed by the relevant law of the Arab country of registration, (ii) upon lawful assignment of the patent rights, (iii) the rendering of a final court decision to this effect, or (iv) the non-payment of a due annuity within the respective time-limits. In fact, *the owner of a patent who has not paid the renewal fees within the prescribed time- limit may incur the loss of his patent proprietary rights.*

– *Assignment of Patent:* the rights to a patent are private rights and belong to the inventor. Therefore, such rights can be assigned with or without consideration as the inventor may solely deem fit.

In the Arab countries, an assignment shall have no effect against third parties, unless it has been entered in the relevant records of the competent authorities of the relevant countries and satisfied the publishing requirements in the Official Gazette. A patentee may decide at its sole discretion to license the right to use his invention against or without any consideration. License agreements must be recorded with the competent authorities to be effective against third parties.

Moreover, licensing a patent does not prevent the patentee from utilizing the patent or from granting a license on the same patent to another person, unless otherwise restricted in the original license agreement. The licensee may not assign the rights and privileges conferred on him, unless his ability to do so is expressly stipulated in the license agreement.

– *Compulsory use of the Patent:* working of patents is an official requirement. If the owner of a patented invention or his successors (i) do not satisfy the stipulated working requirements within 3 years from the issuance of the date of grant (Lebanon), within 4 years as of the date of application (Tunisia); 5 years from the date of registration (Libya, Qatar, Morocco, Sudan, UAE), (ii) refuse to license it under a contract of fair terms, or (iii) the invention ceases for 2 consecutive years (Iraq and Syria), the patent will be subject to compulsory licensing under the provisions of the relevant law.

4.3 Copyright

– *Conventions and Treaties*: The Convention that has been signed by almost all the Arab countries is the Berne Convention for the Protection of Literary and Artistic Works.

According to the Berne Convention, literary and artistic works are protected automatically as soon as they exist without the need for any formalities in the countries party to that convention. Therefore, it is not mandatory to register copyrights in order to benefit from the protection afforded by the law. However, registration of copyright is recommended in such countries in case the ownership of the copyright is disputed. In fact, article 52 of the Lebanese Decision-Law n° 2385/1924 clearly states that "*the registration shall not grant the ownership of a drawing or a design, but it creates a presumption of ownership in favor of the person who makes the registration, however the real ownership shall be acquired through the use of the drawing or design*".

Protection covers all intellectual works of any type i.e. literary, scientific or artistic and is granted to nationals and foreigners. In Saudi Arabia, printed materials or computer programs can be distributed only after receiving the approval of the Ministry of Information for such purposes. Therefore, a local distributor should be appointed and should get the legal authorizations for such purposes.

- *Term of protection*: in Algeria, Jordan, Lebanon, Oman, Saudi Arabia, and Tunisia protection is granted for the lifetime of the author and for a period of 50 years after his death. In Morocco, the new law provides for a term of patrimonial rights amounting to 70 years after the death of the author, while in Tunisia such protection is for 25 years for computer programs and 25 years following the death of the author for Sudan.
- *Infringement of Copyright* through unauthorized reproduction, addition, omission, or modification shall be prosecuted before the competent courts of the respective countries of registration and infringers will be penalized by a fine or imprisonment. The courts can stop the circulation of the infringing works, seize and destroy them and the equipment used, estimate the infringers' proceeds, and call upon experts' assessment.

Reproducing of protectable works by means of photocopying without obtaining the author's permission by public libraries, non-commercial documentation centers, and education, cultural, and scientific institutions is a limitation to copyright under the Berne Convention and is recognized in most of the Arab countries.

A right to allow publication of the work of art is reserved to the competent authorities of some countries e.g. Algeria, Bahrain, Jordan, in case the copyright holder or if his/her heirs has not done so within a period of time (1 year in Bahrain, 6 months in Jordan) against a fair compensation to be provided to the copyright holder or the heirs.

5 Intellectual Property Rights and Confidentiality

As explained above, ideas cannot be protected with any form of IPRs. Indeed, neither patents nor copyrights protect ideas. Therefore, without any protection, ideas are free and can be used and taken without remuneration. On the other hand, ideas are a necessary first step towards an invention or creation as no intellectual property can be created without an idea. For such purposes, it is essential to protect ideas.

Another source of intellectual property that should be protected are trade secrets. A trade secret is generally known as any business information not commonly known, having a technical and economic value, and deserving protection, i.e. business plans, customer lists, formulae, practice, compilation of information, ideas related to research and development cycle, etc. To be more specific, a definition of the "trade secret" is found in the Uniform Trade Secrets Act [11] and may help understand the meaning thereof:

"information, including a formula, pattern, compilation, program device, method, technique, or process, that: (i) derives independent economic value, actual or potential, from not being generally known to, and not being readily ascertainable by proper means by, other persons who can obtain economic value from its disclosure or use, and (ii) is the subject of efforts that are reasonable under the circumstances to maintain its secrecy".

In general, there is no formal government protection granted for trade secrets; each business must take measures to safeguard its own trade secrets. Therefore, any information to be disclosed to a third party concerning a trade secret, whether this information relates to an "invention under completion" or not, should prior to any disclosure, be protected under a confidentiality agreement to be signed by the party receiving the confidential information (the "Recipient").

We should however point out that *preparatory works* are protected under IPRs laws. We mean by preparatory works especially with respect to computer programs, the preparatory works that will lead to the completion of the computer program at a later stage. It is generally understood that copyright protection should apply to preparatory works, insofar as the conditions of formatting, originality, and creativity are met, and provided that the preparatory works will lead to the completion of the computer program. In the light of the foregoing, preparatory works that do satisfy the conditions mentioned above should be protected under copyright and filed in the name of the right holder. On the contrary, preparatory works that do not satisfy the said conditions shall remain mere ideas that should be protected under a confidentiality agreement before disclosure.

In fact, Confidentiality or Non-Disclosure agreements usually known as "NDAs" are agreements by virtue of which the party receiving the information, generally called the "Recipient", undertakes not to divulge the disclosed confidential information. NDAs should comprise many provisions that ensure the protection of the confidential information, e.g. a provision including an exhaustive list of items of the confidential information, i.e. know-how, schema, financial or technical information, verbal representations, customer lists, vendor lists, business practices/strategies, plans, formulas, standards, systems, manuals, etc. It should, however, be stated in the NDA that the items of confidential information are not limited only to the ones listed in the NDA but includes any other information of a confidential nature that may be disclosed by the Disclosing Party to the Recipient during the term of their business/employment relationship.

The term of the confidentiality, i.e. the time period of confidentiality should be also defined. It is important to state that the obligations of confidentiality should survive the termination of any business or employment relationship between the parties. Moreover, the obligations of the Recipient regarding the confidential information are to be determined, typically:

- to use the information only for enumerated purposes;
- to disclose it only to persons with a need to know the information for those purposes;
- to take all reasonable and appropriate measures to keep the information secure;
- to ensure that anyone to whom the information is disclosed further abides by the obligations of confidentiality.

It should be stated in the NDA that any breach of the provisions thereof would cause the Disclosing party irreparable harm, which cannot be adequately compensated by monetary damages. The Disclosing party shall, therefore, be entitled to temporary and permanent injunctive relief from a court of competent jurisdiction, in addition to indemnification for damages incurred by the Disclosing Party, including the recovery of monetary damages.

It is essential that employees, freelancers, and agents having worked on preparatory works or inventions do sign an NDA by virtue of which they declare that the works trade secrets and inventions are the proprietary of the disclosing party, undertake to keep the trade secret business information confidential and refrain from using it directly or indirectly for their benefit or for the benefit of employers, companies, or other entities carrying activities similar or competitive to the activities carried out by the disclosing party.

To summarize the foregoing, trade secrets that may not be protected under copyright in the form of *preparatory works* as mentioned above, and any information relating to a patent under completion not registered yet, should alike any ideas or other trade secrets, be protected under a confidentiality agreement. Such confidentiality agreement should comprise a non-compete undertaking of the Recipient to the benefit of the Disclosing Party.

6 Infringement of Intellectual Property Rights and Remedies

As explained above, IPRs are private rights and, therefore, they are enforceable through courts.

Several types of remedies can be secured under the applicable laws for the protection of right holders in case of violation of their respective rights. The different types of remedies described hereunder are the types of remedies secured under the applicable Lebanese laws and are generally available by most of the Arab countries' laws. Such remedies have a civil, criminal and administrative nature.

Rights holders may have recourse to the civil courts and request the following *Civil sanctions*:

- *Provisional and precautionary measures:* the judge of urgent matters, the president of the competent court of first instance may take a decision in order to protect the rights that are likely to be infringed. In particular, coercive measures to enforce the judge's decisions may be imposed and temporary seizure of the material constituting evidence may be ordered.

- *Injunction*s: rights holders may have recourse to the competent judicial authority in order to seek a decision for the cessation of the infringement and the prevention of its recurrence in the future.
- *Seizure:* the judge of urgent matters, the president of the court of first instance or the public prosecutor may temporarily seize the material constituting evidence of a copyright or a related right infringement and leave it in the custody of the defendant.
- *Civil damages:* any right holder whose copyright or related right has been infringed, may claim adequate compensation from infringers for any moral or material injury as well as the payment of damages arising from such infringement including an account on profits. The right holder may also claim the enforcement of an agreed upon penalty clause or any damages assessed and agreed upon between the contracting parties.
- *Destruction of infringing materials:* the competent court may order the destruction of all unauthorized copies as well as all equipment and devices used to produce infringing copies.

Moreover, rights holders may have recourse to criminal courts and claim the following *Criminal sanctions:*

- *Imprisonment* in addition to a *fine* that may be multiplied in case of recidivism.
- *Damages* may also be granted in some cases, and the court may order the *closure of the premises* and the *destruction of all unauthorized copies* and of all the equipment and the devices used to produce infringing copies.

On the other hand, *Administrative sanctions* consist of the following: the police, customs officers, and employees of the Intellectual Property Protection Office sworn in to that effect having the authority to act ex officio in copyright and related rights infringement cases, may inspect, seize, and take samples of suspect articles wherever they are found and may also, on their own initiative, detain items which they suspect to infringe the provisions of the Copyright Law.

7 Intellectual Property Rights and Recommended Improvements

It is unanimously understood that IPRs laws should be drafted and revised to meet the needs of technological and digital innovation as well as the objectives of transfer and dissemination of technology, in a manner leading to social and economic growth, and to a balance of rights and obligations.

The most important developments in the subject matter have been made through the signature of the TRIPS (*Trade-Related Aspects of Intellectual Property Rights*)

Agreement [12], an international legal agreement entered between all the member nations of the World Trade Organization (the "WTO"). The TRIPS Agreement sets down minimum standards for the regulation of many forms of intellectual property and requires member states to provide strong protection for intellectual property rights. For example, under the TRIPS Agreement:

A. Copyright

- Copyright must be granted automatically without the need for any registration;
- Computer programs must be regarded as "literary works" under copyright law and receive the same terms of protection;
- Copyright term of protection is granted for the life of the author and must extend to at least 50 years;
- National exceptions to copyright such as "*fair use*"are limited under the Berne three-step test. *See supra Sect.* 3.2.4. *Fair use* "is a doctrine in the law of the United States that permits limited use of copyrighted works without having to obtain the prior approval of the copyright holder. *Fair use* is one of the limitations to copyright, intended to find a balance between the private interests of copyright holders and the public interest" [13].

B. Patents

- Patents must be granted for "inventions" in all "fields of technology" provided they meet all patentability requirements. Patents should be enforceable for at least 20 years;
- Exceptions to exclusive rights must be limited, provided that a normal exploitation of the work (art. 13) and normal exploitation of the patent (art 30) are not in conflict;
- No unreasonable prejudice to the legitimate interests of the right holders of computer programs and patents is allowed;
- Legitimate interests of third parties have to be taken into account by patent rights (art 30).

In addition to general standards created by the TRIPS Agreement, many other objectives set under the WIPO treaty and the WIPO Performances and Phonograms Treaty [14] have been reiterated by the TRIPS Agreement and the "TRIPS-Plus Agreement" [15] that followed it, including the creation of *anti-circumvention laws* to protect *digital rights management systems*, i.e. for restricting and controlling the use, modification, and distribution of copyrighted works. Moreover, the TRIPS agreements aim at imposing firm restrictions on compulsory licenses for patents and more aggressive patent enforcement.

In the light of the foregoing and the new developments in the IPRs field, we strongly recommend adapting and updating the IP laws in the Arab countries in the light of the current new context.

For instance, the Lebanese Copyright Law n° 75/1999 lacks any protection for technical measures and rights-management information and should be revised (specifically articles 23, 24, and 25 of the said Copyright Law) to comply with the provisions of the TRIPS Agreement and the Berne Convention and, therefore, enable Lebanon to join the World Trade Organization which is important for Lebanon's economic growth. Moreover, new laws in Lebanon relating to Trademark, Industrial designs, Geographical indication, and unfair competition should be enacted to be aligned with the recent developments in this respect.

Essential Treaties should be also ratified by Arab countries that have still not ratified such treaties, ensuring thereby a better and easier protection of IPRs. We specifically highlight the following treaties:

– The *WIPO Copyright Treaty* that mainly protects computer programs as literary works and databases in the light of the recent innovation in technology and digital environment. The said treaty prohibits circumvention of technological measures for the protection of Works and unauthorized modification of rights management information contained therein. Alike Lebanon, many Arab countries have not yet ratified the said Treaty, e.g. Egypt, Iraq. Sudan, Syria, Tunisia, Yemen.
– The *Patent Cooperation Treaty* has not been also ratified by many Arab countries including Lebanon. The said treaty should be ratified as it ensures an easier and cost-effective way to protect and register patents in the contracting countries of interest. For further details, please see supra Sect. 3.2.6.

As preparatory works are protected under Copyright, the protection of patents before completion through *provisional application* [16] is in our opinion, a must that should be implemented in all countries. In fact, under the United States patent law, a provisional application including the description, drawing…of an invention at an early stage could be filed without the need for any formal patent request. Under US laws, the inventor is granted a twelve-month period to test, develop, seek investors to finance further improvements/development of his invention before turning the provisional application into a final patent application. Another important advantage of the said American system is that a provisional application helps the inventor develop and promote his invention safely, without fearing that the idea or the trade secret attached thereto would be stolen.

8 Conclusions

Finally, it is worth mentioning that each theory and principle sustaining a law of whatsoever nature has both proponents and opponents as the enforcement of such law may create advantages to the benefit of certain parties and disadvantages to the detriment of others. In the field of IPRs, the two main opponents are the intellectual-property *rights holders* and the *public users*. While the first ones may claim the economic and rather the moral rights attached to their IP works, the latter may allege the *fair use* and *fair competition* theories.

We believe that any new IPR laws should be enacted with the spirit of enhancing the economic-growth interests of one's country without infringing morality and public order. Legislators should however bear in mind that such economic growth is fundamentally related to the growth of start-ups and small- and medium-sized enterprises and their capability of attracting investors and venture capitalists, relying mostly on their major and principal asset: "Intellectual Property Rights".

References

1. Intellectual Property. https://en.wikipedia.org/wiki/Intellectual_property#cite_note-104
2. International (Nice) Classification of Goods and Services. https://en.wikipedia.org/wiki/International_(Nice)_Classification_of_Goods_and_Services
3. Berne Convention for the Protection of Literary and Artistic Works. https://www.wipo.int/treaties/en/ip/berne/
4. World Intellectual Property Organization https://www.wipo.int/about-ip/en/
5. Paris Convention for the Protection of Industrial Property https://www.wipo.int/treaties/en/ip/paris/
6. Madrid Agreement Concerning the International Registration of Marks https://www.wipo.int/treaties/en/registration/madrid/ Protocol Relating to the Madrid Agreement Concerning the International Registration of Marks https://www.wipo.int/treaties/en/registration/madrid_protocol/
7. Nice Agreement Concerning the International Classification of Goods and Services for the Purposes of the Registration of Marks. https://www.wipo.int/treaties/en/classification/nice/
8. WIPO Copyright Treaty (WCT). https://www.wipo.int/treaties/en/ip/wct/
9. The Patent Cooperation Treaty(PCT). https://www.wipo.int/treaties/en/registration/pct/
10. Abu- Ghazaleh Intellectual property (AGIP). http://www.agip.com/offices.aspx
11. https://en.wikipedia.org/wiki/Uniform_Trade_Secrets_Act
12. https://www.wto.org/english/docs_e/legal_e/31bis_trips
13. https://en.wikipedia.org/wiki/Fair_use
14. https://www.wipo.int/treaties/en/ip/wppt/
15. https://en.wikipedia.org/wiki/TRIPS_Agreement
16. https://en.wikipedia.org/wiki/Provisional_application

Building the Entrepreneurial Mindset Through Experiential Learning

Jacqueline El-Sayed

Abstract Entrepreneurship is important to any nation's economy. In the U.S., data suggest that start-up businesses are a primary driver, if not the primary driver, of both job growth and new job creation, according to Decker et al. (J Econ Perspect 28(3):3–24, 2014). Successful entrepreneurs have a unique entrepreneurial mindset that allows them to be successful. This mindset includes both knowledge and skills. Entrepreneurial knowledge includes business acumen like finance, product development, and marketing. Entrepreneurial skills include visioning, problem solving, creativity, risk taking, and communication. To be successful, entrepreneurial knowledge and skills must be honed through experience. Using academic reverse-design methods, higher education can create pathways that not only develop entrepreneurial knowledge and skills but also provide intentional experiential-learning opportunities to refine them into a successful mindset. This paper presents the process for building the entrepreneurial mindset in higher-education students through the application of integrated experiential-learning techniques. A case study is provided to illustrate the process.

Keywords Curriculum design · Reverse design · Experiential learning · Entrepreneurship · Entrepreneurial mindset · Benchmark analysis · Learning outcomes · Academic pathways

1 Introduction

Entrepreneurship is important to any nation's economy. In the U.S., data suggest that start-up businesses are a primary driver, if not the primary driver, of both job growth and new job creation [1]. Successful entrepreneurs have a unique entrepreneurial mindset (EM) that allows them to be successful. This mindset includes both

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knowledge and skills. Entrepreneurial knowledge includes business acumen like finance, product development, and marketing. Entrepreneurial skills include visioning, problem solving, creativity, risk taking, and communication. To be successful, entrepreneurial knowledge and skills must be honed through experience. Using academic reverse-design methods, higher education can create pathways that not only develop entrepreneurial knowledge and skills but also provide intentional experiential-learning opportunities to refine them into a successful mindset. This paper will provide an overview of the Experiential Learning Model and Learning Process Design. The components of the Entrepreneurial Mindset and related Learning Outcomes will be discussed. Utilizing these concepts, a process is presented for building the entrepreneurial mindset in higher education students through integrated experiential learning. A case study is provided to illustrate the process.

2 Experiential Learning Model

While traditional learning in higher education has been accomplished through lecture-based classes in which students are the passive recipients of knowledge conveyed by professors, there has been consistent movement toward utilizing active-learning techniques. Passive learning is sometimes referred to as "Sage on the Stage" technique. This is because the focus is on the delivery of the information by an instructor. Active learning is sometimes referred to as "Guide on the Side" technique. This is because the focus is instead on the learning that occurs when the student takes ownership of the construction of their own knowledge and the instructor provides timely interventions, such as guided inquiry, reflective discussions, and flipped classrooms, to support the student's growth. The next higher level of active learning are simulations in the classroom. Traditional laboratory courses are one type of learning through simulation methodology. Another example of simulation methodology are case studies with role playing. The highest level of active learning includes experiential or immersion-learning techniques. Experiential learning is when students learn through observing and dealing with the consequences of their own actions. Immersion learning is experiential learning that is occurs within an immersive experience with a 'sink-or-swim' dynamic. One example is of a student of French language participating in a study-abroad experience in France where the student must communicate to French speakers and therefore receives immediate results of their linguistic competence. Another example is an engineering student who participates in an industry-based cooperative learning experience where they receive immediate feedback on their professionalism and technical mastery. There is evidence that such high-impact instructional practices like experiential learning result in more superior construction of knowledge than traditional passive-learning techniques. An overview and the benefits of experiential learning [2] are provided in Fig. 1.

Experiential- and immersive-learning experiences result in both intentional and unintentional learning for students. This is because some learning can be anticipated

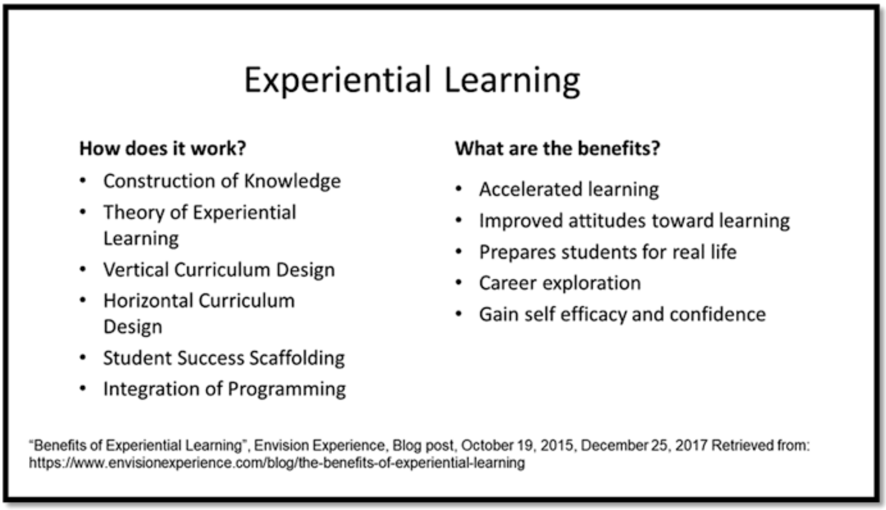

Fig. 1 Overview and benefits of experiential learning [2]

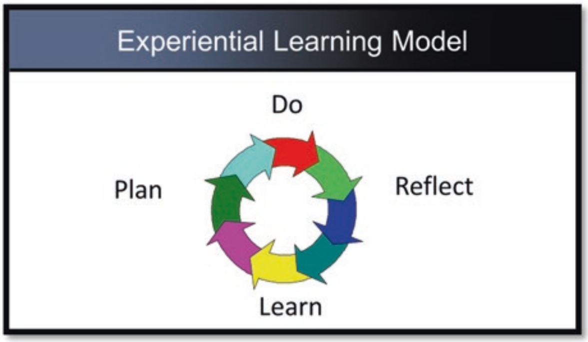

Fig. 2 The experiential-learning model [7]

and controlled while other learning will be spontaneous due to the nature of using real-life situations for learning. That is not to suggest that unintentional learning is unimportant. On the contrary, it may be that the spontaneous, unintentional learning provides a memorable context for students that is extremely powerful and meaningful.

Experiential Learning Theory is usually described as an interactive cycle of the phases: Plan, Do, Reflect, Learn [3]. It is through these four phases that students learn through consequences of their own actions (see Fig. 2). The first phase of "Plan" requires that students plan an action to cause a result. For optimum learning to occur, students must fully understand what they are attempting to accomplish and what is their anticipated outcome. The second phase of "Do" requires that students execute their plan. They must fully understand their observations of the results. The third phase of "Reflect" is perhaps the most critical of the four phases in that students must make connections between their anticipated outcomes and the actual outcomes of their plan. They must identify what worked as they expected and what worked differently from what they expected. In the fourth phase of "Learn", students must then draw conclusions as to why these differences in outcomes occurred. They must deduce how they could change their original plan to eliminate the difference and cause their intended result to occur. In addition to the specific learning directly related to their plan, students should also then begin to make generalizations about larger concepts associated with their discipline or with the organizational dynamics of their experience. Among the generalizations associated with repeated exposure to experiential learning, students often form the framework for the importance of life-long learning [4].

3 Design of the Learning Process

Among the well-developed methods for developing curriculum are the 'Backward or Reverse Design' methodologies [5]. In these methodologies, the desired knowledge and skills are selected up front as "learning outcomes" and then lesson plans are created with the intention to gradually teach the necessary concepts to students. These lesson plans must start with teaching foundational concepts first and subsequently increasingly more-advanced topics are taught until students reach proficiency and attain the desired learning outcomes. In higher education, this method is traditionally segmented into program design, course design, and activity design. Program design includes the macro, overarching design of academic programs such as academic majors and minors or institutional hallmarks. Each program would have designated program-learning outcomes. These often correspond to discipline-specific knowledge or in the case of professional programs, industry-established standards. Each program is composed of many courses. Following the reverse-design thinking, after the program is designed, then the sequence of courses that make up the program must be designed. Each class in the sequence would have course learning outcomes. The courses and the course learning outcomes would build in difficulty. Finally, to develop the knowledge and skills required to attain the course learning outcomes, activities must be designed to help students construct the knowledge at every level while providing for differentiation in instruction for students who learning at different rates or in different ways.

In a similar manner, experiential learning can also be designed utilizing reverse-design practices [6]. Experiential learning is not generally segmented into rigid courses and instead students are immersed in enriched-learning environments [7]. However, these experiential-learning opportunities are richer when they are intentionally designed. In addition, because students learn at different rates and start their learning at different levels, it is important that specific learning outcomes are selected for each experience and that there are assessments in place to gage where students are during the experience so that interventions can be provided to ensure

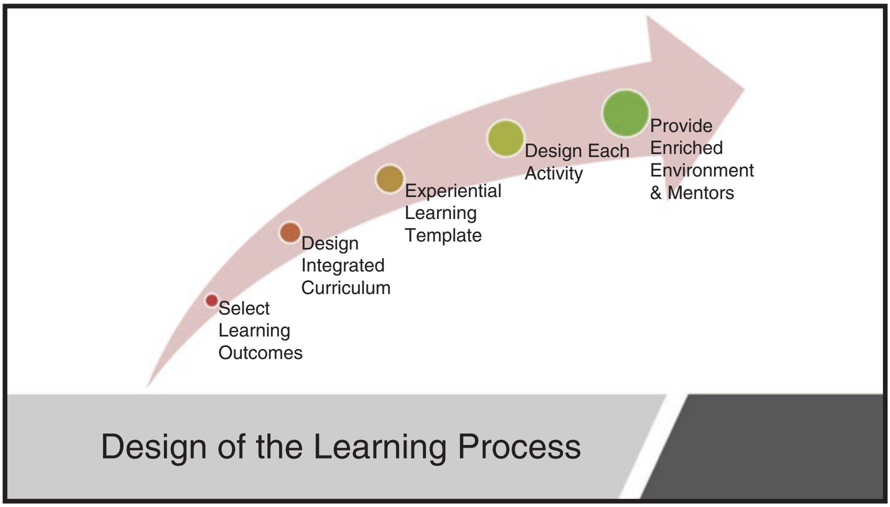

Fig. 3 Design of the learning process [8]

that the appropriate learning takes place. Of course, experiential learning also results in complex unintentional learning outside of the specific learning outcomes, but this is exactly what makes experiential learning so robust and memorable. Students who engage in experiential learning often remember the lessons learned for their life time.

The process for designing experiential learning [8] includes (see Fig. 3):

- Select Learning Outcomes
- Design Integrated Curriculum
- Construct an Experiential Learning Template
- Design Each Activity
- Provide an Enriched Environment and Mentors

Selecting learning outcomes is one of the most critical parts of this process. These learning outcomes should include the basic knowledge that students should acquire and also include the application skills that students should achieve. Since experiential learning often resides within academic programs, it is important at the program level to design how the courses and experiential learning opportunities will integrate within the academic curriculum. It is a best practice to ensure that courses that may come prior to the experiential-learning opportunity provide activities that will provide a base-line to launch student learning and for courses that follow the experiential learning to provide for reflection and integration afterward.

Just as there are best practices for using standard templates to design academic programs, it is also a best practice to develop a standardized template to capture the program design for integrated and laddered experiential-learning opportunities [7]. In this way, the roadmap for experiential learning is clearly outlined and transparent to students, instructors, advisers, and mentors. Once the overarching program is designed then each activity must also be designed. In experiential learning, this is often through providing students with tasks or projects that they must plan out and execute within the immersion environment. It is important for students to do the planning themselves and have a clear understanding of what they are intending to have a happen. Then they execute their plan and observe what works out the way they intended and what does not. As students reflect upon the disparity between their intended results and the actual results, they learn how make better plans in the future. By attempting many plans in different types of enriched environments, students can triangulate and generalize their learning to better understand human behavior and organizational dynamics as well as their own strengths and areas for improvement. Due to this, it is very important to provide students with mentors. Mentors should include both peer mentors, who may be students in the same cohort or a couple of years senior to them but also it is important to match students with an experienced mentor who may be a professional in the field. These professional mentors can provide perspective to help student make connections between their learning experiences and their professional goals.

4 Entrepreneurship Overview

While there are different views as to what characteristics entrepreneurs must embody, there are some that appear to be more universal. These include entrepreneurial knowledge such as business acumen like finance, product development and marketing, as well as entrepreneurial skills such as visioning, problem solving, creativity, risk taking, and communication. In order to seed and grow a new business, entrepreneurs must have an understanding of the market place that their business must navigate. They must understand how this market place will affect the finances of their business. They must understand product development and commercialization as well as the basics of how their product will need to be marketed. In addition, entrepreneurs must be visionary to identify opportunities and develop solutions through problem solving. They must be creative and innovative so that their product or service is unique and different from their competitors. They must be comfortable with taking risks and learning through failure, because there is a high rate of failure on the way to success. Entrepreneurs must also be passionate and have the ability to communicate their passion and ideas to others.

5 Entrepreneurial Mindset Student Learning Outcomes

Generally, these characteristics are seen as a type of mindset. Research and business articles have been published that captures the entrepreneurial mindset [9–11]. One of the more noteworthy examples of such research comes from work done by the Kern Foundation [12]. In 2005, the Kern Foundation founded the KEEN network composed of a selected number of higher-education institutions. The basic vision of the KEEN network was to identify the characteristics of the entrepreneurial mindset, foster the entrepreneurship mindset in students and prepare graduates that

KEEN Student Learning Outcomes			
"3 C's" Categories	Curiosity	Connections	Creating Value
Learning Outcome	demonstrate constant curiosity about our changing world	integrate information from many sources to gain insight	identify unexpected opportunities to create value
Learning Outcome	explore a contrarian view of accepted solutions	assess and manage risk, e.g. interconnected ramifications	persist through and learn from failure, essential when iterating using stakeholder feedback

Fig. 4 Chart of KEEN student learning outcomes [12]

embodied the entrepreneurial mindset. Through much collaboration and research, in 2013 the members identified the framework for an entrepreneurial mindset, an associated complementary skillset, and developed the KEEN Student Learning Outcomes for use in higher education (see Fig. 4).

The KEEN Entrepreneurial Mindset purports that "Individuals with an entrepreneurial mindset • have an insatiable, dispositional curiosity to understand the changing world and its technical, societal, and economical aspects of problems, solutions, and opportunities; • make connections from many sources of information to enable insights and the development of creative solutions; • focus on creating value, broadly defined as value for others—this may be economic value but, importantly, it also includes societal and personal value" [12].

The KEEN Complementary Skillset projects that "Effective individuals connect their mindset with a complementary skillset. An entrepreneurial engineer has complementary skills, such as the ability to design, analyze, create a prototype, validate a model, and work on a team. These, plus additional outcomes listed below, can be compared with the graduate entrepreneurial outcomes defined by the UK QAA (2012): • identify an opportunity • define benefit and value • investigate a market • create a preliminary business model • evaluate feasibility, viability, and desirability • quickly test value proposition • engage stakeholders early • assess policy and regulatory issues • communicate solutions in economic terms • communicate in terms of societal benefits • validate market interest/stakeholder sentiment • develop partnerships • build teams • identify supply chains • identify distribution channels • protect intellectual property" [12].

The characteristics of mindset and skillset were simplified into a visionary phrase titled the "3Cs of entrepreneurial mindset" which include: "Curiosity, connections, and creating value" which were then used as organizing categories for the student learning outcomes. The KEEN Student Learning Outcomes include "Entrepreneurially minded individuals have Curiosity 1. demonstrate constant curiosity about our changing world 2. explore a contrarian view of accepted solutions Connections 3. integrate information from many sources to gain insight 4. assess and manage risk, e.g. interconnected ramifications Creating value 5. identify unexpected opportunities to create value 6. persist through and learn from failure, essential when iterating using stakeholder feedback" [12].

6 Building Entrepreneurial Mindset Through Experiential Learning

Once the Student Learning Outcomes have been selected for any program, the overarching program design must begin. If Entrepreneurial Mindset (EM) is to be an institutional hallmark and all programs, majors and minors must integrate this hallmark into their curriculum, often this type of initiative will be titled "Entrepreneurship Across the Curriculum' or "Entrepreneurship Across the University" (EAU). In program design, it is important to understand that there are many components of each program. There are different curricular components such as general education, education specific to each major, cooperative & experiential education, and the institutional hallmarks such as EAU (see Fig. 5). In addition, there is both vertical and horizontal design and integration. Vertical design includes the sequence of courses that build upon each other, such as prerequisites. Horizontal design includes the integration of courses over a specific timeframe such as the First Year Experience (FYE) that many institutions offer to support high school students to become successful college students as well as Culminating Undergraduate Experiences (CUE) which are designed, often throughout the final year, to transition college students to become successful graduates who are gainfully employed. Frequently another component of academic design is the opportunity for scaffolding learning through services offered through an Academic Success Center (ASC). While each institution may be different and have different learning outcomes, Fig. 5 provides a visual overview of the components that must be included in a strong program design [7].

When tackling the challenge of building the Entrepreneurial Mindset through Experiential Learning, the process described previously will be customized for the

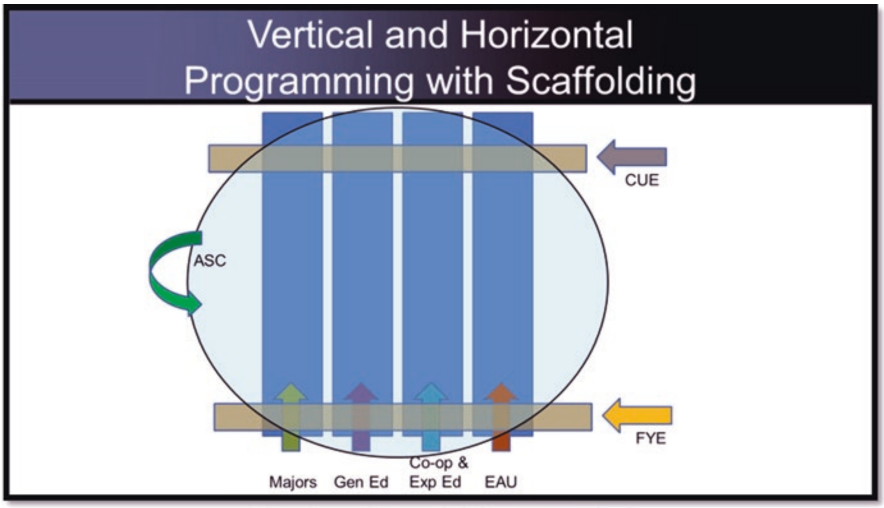

Fig. 5 Vertical and horizontal programming with scaffolding [7]

specific EM Learning Outcomes selected and the specific combination of curriculum, co-curriculum, and experiential education. The program must be designed first, then each of the courses and experiential learning opportunities, and within each course and learning opportunity, the individual activities must be designed. Above this, the assessment processes must be designed to ensure that the students are attaining the desired learning outcomes and also to ensure continuous improvement of the curricula.

7 Case Study: Kettering University

Kettering University is a private, urban STEM-focused university in Flint, Michigan with mandatory experiential learning (www.kettering.edu). Students alternate through classroom and industry-based cooperative education terms. Kettering began as General Motors Institute in 1927 and was then owned and operated by General Motors Corporation. During this time, all students and faculty were employees of General Motors and the program adhered to the employee develop principles and goals of the General Motors Corporation. Student participated in a “legendary” rotational co-op program often called, “The West Point of Industry,” and the institution had points of pride such as “1 in 6 became CEO’s”. In 1998, the institution changed its name to “Kettering University” and was by then a private, not-for-profit organization that had expanded its portfolio of majors and were placing co-op students at hundreds of industries, in addition to those placed at GM [13].

In 2009, a national study was conducted in which the objective was to gather data and benchmark Kettering University’s Cooperative Education program with peer institutions that also had a mandatory cooperative education program [14]. The Peer Benchmarks selected were Drexel University, Georgia Institute of Technology, Northeastern University, University of Cincinnati, University of Waterloo, and Wentworth Institute of Technology. This study provided many recommendations and insights to strengthen the learning environment for experiential learning at Kettering University. The primary first phase recommendations of this student were: (1) Change the administrative structure so that the Cooperative Education Department became one of the academic units under the Provost Office (2) Appoint high level academic leadership to guide and oversee student learning and (3) Design the cooperative education program as an academic program through both vertical and horizontal design (see Fig. 6).

The recommended components for the Academic Program Design included developing learning outcomes, designing experiences through developmental activity design, putting in place processes for students to receive meaningful feedback, relaunching reflective learning, providing online modules to guide student learning during co-op terms, reorganize the culminating experience, and storing student accomplishments in e-portfolios [14].

The recommendations were presented to the President and all Kettering Managers in 2010 and were accepted. Kettering’s Provost launched the implementation of the Co-op Benchmark Analysis Report’s recommendations in 2011, led by the Associate

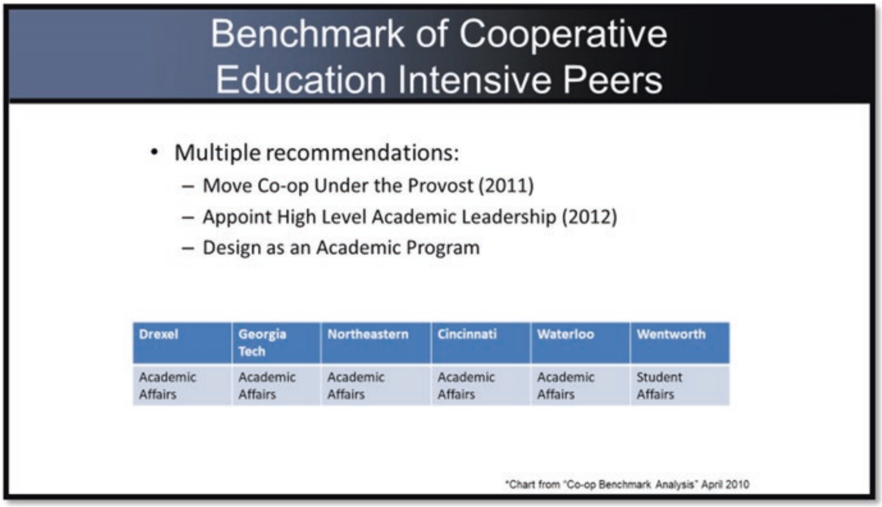

Fig. 6 Recommendations from the Co-op Benchmark analysis report [14]

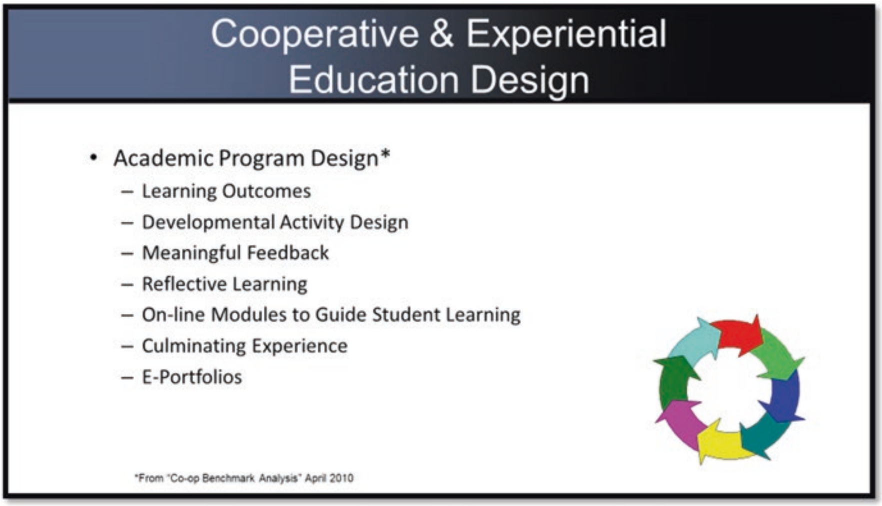

Fig. 7 Co-op Benchmark analysis report: Co-op education academic design [14]

Provost to oversee the academic program design (see Fig. 7). By engaging student, faculty, and staff, program subcomponents were designed, developed, and implemented. For example, the student body assisted in the development of the Work Template found in Fig. 8. Several interdisciplinary Faculty members assisted in the development of the Reflective Learning Plan found in Fig. 9. In addition, experiential-learning opportunities were expanded to include additional customized

Student Developed Work Template

Table 1: Template Co-op Program

Term	Objectives	Tasks
FR 1	Get students familiar with company, technology, product, processes, and people. Make sure they understand the "bigger picture".	Training under a mentor or group of mentors and depending on the company, it can be either real work where the results are used by the company or it can be self-contained work.
FR 2	Similar to above, but emphasis begins to shift away from training. Depending on the company, there may be some sort of rotation.	Work as part of group. Mentor(s) are still available for questions and help, but have less of a direct role.
SO 1	Build trust and skills.	Continue working as part of a group, gaining more responsibility. Focus of mentor(s) should now be on assigning work, not on training.
SO 2	Similar to above, but begin to transition to individual work.	Begin taking added individual responsibility. Work should be good mix of individual and group.
JR 1	Be the equivalent of a full-time employee.	Work mostly individually, take responsibility from projects start-to-finish.
JR 2	Same as above, but also start thesis planning	Same as above.
SR 1-3	Thesis project	Complete the thesis

*Chart by Mike Antonacci

Fig. 8 Student-developed work template [7]

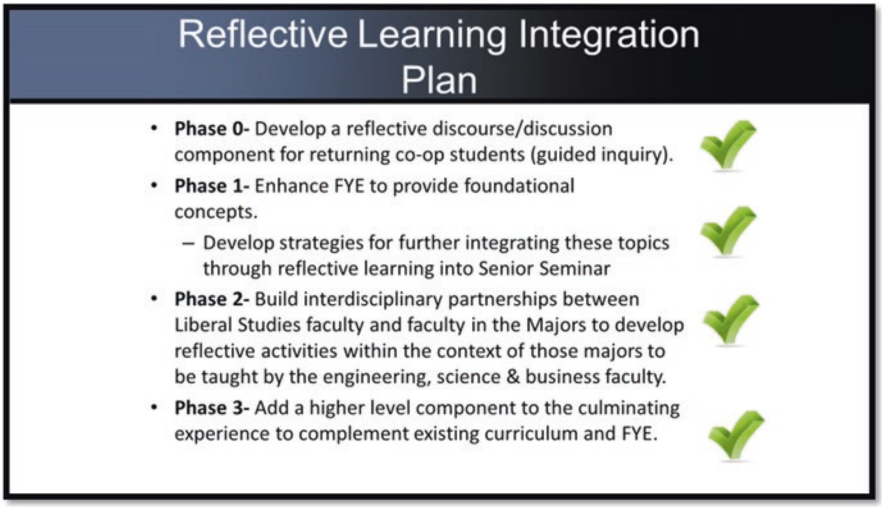

Fig. 9 Faculty reflective learning integration plan [7]

experiential-learning opportunities beyond traditional industrial-based co-op such as Service Learning and Entrepreneurship [7].

The Entrepreneurship track was designed with learning outcomes similar to the KEEN EM learning outcomes and provided students with the opportunity to develop a business plan for their start-up company while working closely with faculty and experienced entrepreneurs as mentors. In addition, for those students who were interested in entrepreneurship but still wanted to participate in traditional co-op, an online "Intrapreneurship" learning module was developed so that students could hone their entrepreneurship skills by seeking out internal opportunities to improve their co-op sponsor's business through identifying process or product changes. Students were given the opportunity to develop their ideas through discussions with mentors and then present their ideas to their employer's senior management team for discussion.

The academic design of Kettering's experiential learning and the expanded tracks that included entrepreneurship was then integrated into all processes and rituals of the academic enterprise [7]. The Cooperative Education Department was renamed as the Cooperative & Experiential Education Department. The individuals who mentored students were retitled from Co-op Managers to Co-op Educators, thus reinforcing the co-educator model of their roles. The Cooperative & Experiential Education Department received an academic banner to be lofted during the processional of Kettering's graduation commencement, raising experiential learning on part with the other academic departments. The new framework for Kettering's expanded experiential learning offerings were integrated into the academic curriculum via approval of the Faculty Senate procedures. New assessment metrics aligned to the new framework were integrated into the accreditation teaching and learning plans via the university-wide Planning and Assessment Council. In addition, the expanded experiential-learning opportunities including the entrepreneurial options were included in the design of the new website. Frequent articles and communications were written to showcase the Kettering student body's innovative work and a number of start-up companies the resulted in job creation for the surrounding Flint, Michigan area.

8 Conclusions

Through the processes presented in this paper and the applications discussed in the case study, several important conclusions were identified. Experiential learning constructs knowledge in a superior manner over classroom learning alone. Experiential learning must be designed as an academic program to be most effective for all students. Integrating experiential learning with classroom learning and student scaffolding resources optimizes student success. Entrepreneurship can be taught though intentional academic design of experiential learning. Entrepreneurial mindset provides the framework for student-learning outcomes utilized in academic design for student development of entrepreneurial knowledge and skills. The development of entrepreneurial knowledge and skills through experiential learning results in competent entrepreneurs with meaningful achievements in fostering start-up companies and job creation.

References

1. Decker R, Haltiwanger J, Jarmi R, Miranda J (2014) The role of entrepreneurship in U.S. job creation and economic dynamism. J Econ Perspect 28(3):3–24. https://doi.org/10.1257/jep.28.3.3
2. Envision Experience (2015) Benefits of experiential learning blog post. https://www.envision-experience.com/blog/the-benefits-of-experiential-learning
3. El-Sayed J (2016) Community building through participatory curricula transformation. Int J Progress Educ 8(2):37–48. Pacific Crest, Lilse, IL. http://www.ijpe.online//2016_2/2016_community.pdf
4. El-Sayed M, El-Sayed J (2014) Achieving life long learning outcomes in professional degree programs. Int J Progress Educ 6(1):37–42. Pacific Crest, Lilse, IL. http://www.ijpe.online/2014/lifelong.pdf
5. Kurt S (2016) Backward design. Educational Technology. https://educationaltechnology.net/backward-design-understanding-by-design/
6. El-Sayed, J (2008) The role of co-op education in achieving engineering educational outcomes. In: Proceedings of the ASEE Annual Conference and Exposition, Pittsburg, PA
7. El-Sayed J (2013) Integrated experiential learning. DMA conference, Flint, MI
8. El-Sayed J (2018) Building an entrepreneurial mindset through experiential learning. 16th annual international conference of the Arab Academy of Sciences, Beirut, Lebanon
9. De Carolis D (2014) We are all entrepreneurs: it's a mindset, not a business model. Forbes Women Files. https://www.forbes.com/sites/forbeswomanfiles/2014/01/09/we-are-all-entrepreneurs-its-a-mindset-not-a-business-model/#172e54efd84f

10. Keisch, P (2015) Five characteristics of the entrepreneurial mindset. LinkedIn Pulse. https://www.linkedin.com/pulse/five-characteristics-entrepreneurial-mindset-paul-keisch/
11. Shickler S (2015) Seven essential mindsets for entrepreneurial success, 7Mindsets. https://7mindsets.com/entrepreneurial-mindset/
12. Rae D, Melton D (2017) Developing an entrepreneurial mindset in US engineering education: an international view of the KEEN project. J Eng Entrepreneurship 7(3). http://bgro.collections.crest.ac.uk/161/1/Rae_Developing%20an%20entrepreneurial_2017.pdf
13. El-Sayed J, Kowalski H (2004) The Kettering University Cooperative Education Model. Conference on Integrating Practice into Engineering, Dearborn, MI
14. El-Sayed J (2010) Co-op Benchmark analysis report. G50 Meeting Kettering University, Flint, MI

Building a Culture of Innovation and Entrepreneurship Through Holistic Development in the Arab World's Higher Education

Mohamed El-Sayed

Abstract Innovation is the action of creating new ideas, products, or processes etc. Creativity is the ability to produce and perform such innovative actions. The continuous nurturing and development of the innovation ability could result in creativity as a cultural attribute. In general, most creativity-inspiring efforts are focused on cognitive abilities, creative thinking, and creative problem solving. These efforts view creativity as a rational cognitive domain process. Fewer efforts address the affective aspect of creativity by focusing on the attributes and motivations of creative individuals. Limited efforts share the process thinking with the cognitive group and the affective aspect of creativity by emphasizing the human desire for fulfillment and self-actualization.

Entrepreneurship is the process of realizing an enterprise from inception to maturation. Depending on the enterprise and prevailing environment, the entrepreneur must have the affective entrepreneurial drive in the form of passion, motivation, or willingness to take risks to initiate, propel, and complete the process. In addition, the entrepreneur must have the entrepreneurial abilities in the form of the knowledge and skills necessary to discover, assess, and seize opportunities.

The learner's development in higher-education settings, including those in the Arab world, is mainly focused on cognitive-domain development. Additionally, cognitive-domain development is mostly focused on the analytical abilities with limited attention to integrative abilities. Furthermore, due to the ever-shrinking educational resource and the lack of opportunities for practice, more emphasis is usually given to theoretical knowledge than skill building in the field of practice. In industrial and technologically advanced societies, the skill building in the learner's field of choice is usually provided by the employers at early career phases. Also, the existence of industrial and technological infrastructures inspires the integrative desire and abilities needed for creative and entrepreneurial activities.

To build a culture of innovation and entrepreneurship in the Arab world, a gradual shift towards a more holistic higher-education system is essential. Consequently,

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balancing the learner's cognitive-domain integrative and analytical development would be a necessary step in the right direction. Also, as evident from the nature of innovation and entrepreneurship, the affective drive is a key factor for success in both endeavors. Accordingly, nurturing and developing the learner's affective domain is another vital step towards motivating the desired cultural change. Furthermore, balanced cognitive development and nurtured affective drives without the skills needed for practice in the learner's chosen field may not be enough to achieve desired results. Therefore, the development of the learner's psychomotor skills is of equal importance in the realization of the desired innovation and entrepreneurship culture.

Keywords Arab world · Education · Innovation · Entrepreneurship · Creativity · Cognitive · Affective · Psychomotor · Learner's development · Educational objectives · Bloom's taxonomy

1 Introduction

To build a culture of innovation and entrepreneurship through higher education it is necessary to address the educational objectives and the learner's development process. It is essential to establish the proper educational objectives and develop the suitable educational programs to achieve these objectives considering the learner's abilities. To understand the learner's abilities, three domains related to educational development were identified by a committee of researchers, led by Benjamin Bloom [1]:

- ***Cognitive Domain***: mental abilities in relation to knowledge
- ***Affective Domain***: emotional abilities in relation to attitude
- ***Psychomotor Domain***: physical abilities in relation to skills

These domains can be considered as areas of development. The different levels of development in these three domains are frequently referred to as Bloom's taxonomy [1]. In educational settings, considering these domains is essential for designing the activities necessary to develop the knowledge, skills, and attitudes required to achieve the educational objectives.

Several studies related to innovation and creativity in learner's development have emerged from the work of different educational movements [2]. Among these educational movements: learner-centered education [3], and humanistic and affective education [4]. Creativity as an educational objective started at the early seventies by moving education towards more creativity in teaching and learning [5, 6].

Early studies of innovation and creativity viewed creativity as a rational cognitive domain process. These studies focused on the cognitive abilities, creative thinking, and creative problem solving [7, 8]. Another group of studies addressed the affective aspect of creativity by focusing on the attributes of creative individuals [9, 10]. A third group of creativity studies shared the process thinking with the cognitive group and the affirmative conception of creativity with the affective group by emphasizing the human desire for fulfillment and self-actualization [11]. The effect of psychomotor-domain development on the creativity psychomotor-domain aspect of creativity has been discussed [2].

The study of entrepreneurship as a behavior from an economic perspective emerged in the 1980s [12, 13]. Subsequently, studies of entrepreneurship as a learner's development objective and experience has continued to arise [14–17]. While behavioral studies consider entrepreneurship from a new venture-creation viewpoint, learner's development studies consider entrepreneurship in terms of entrepreneur's learning and adaptation abilities once the enterprise is established [18].

Guided by Bloom's taxonomy to create a culture of creativity and entrepreneurship, any educational settings must consider the cognitive, psychomotor, and affective domains in learner's development. In the following sections, some of the steps towards more holistic learner's development in higher education in the Arab world are discussed.

2 Innovation and Entrepreneurship as Educational Objectives

To foster a culture of innovation and entrepreneurship through education, it is vital that innovation and entrepreneurship become clear and truly pursued educational objectives. Consequently, a clear understanding of innovation and entrepreneurship natures must be established. In this work, to specify the nature of innovation and entrepreneurship, the following definitions are adopted.

- ***Innovation***: *is the action of bringing new ideas, products, or processes etc. Creativity is the ability to perform and produce innovative actions.*
- ***Entrepreneurship***: *is the process of realizing an enterprise from idea to full existence. To do so, the entrepreneur must have the affective entrepreneurial drive (attitude) in the form of passion, motivation, or willingness to take risks to initiate, propel, and complete the process. In addition, the entrepreneur must have the entrepreneurial abilities in the form of the knowledge and skills necessary to discover, assess, and seize opportunities.*

While the innovator may work with others to complete the innovative activities from inception to full maturation and the entrepreneur may interact with others for realizing the enterprise, it is clear from the definitions that innovators and entrepreneurs would need other abilities in addition to their cognitive abilities. Accordingly, in addition to the learner's cognitive-domain development, the nurturing and development of the affective domain is necessary. However, affective drives for innovation and entrepreneurship without the abilities to practice in the chosen field may not be sufficient for success. Therefore, the development of the necessary psychomotor skills in the learner's chosen field is also essential.

3 Learner's Development

To achieve any desired educational objectives, the holistic development of the learner's cognitive, affective, and psychomotor domains should be pursued during the educational experience. For the cognitive domain, the following are Bloom's progressive development levels:

Cognitive

1. **Knowledge** – information gathering without necessarily understanding, using, or altering it.
2. **Comprehension** – understanding the gathered information without necessarily relating it to anything else.
3. **Application** – using general concept gained through comprehension to solve a problem.
4. **Analysis** – disassembling something down into its fundamental elements.
5. **Synthesis** – creating something new by integrating different elements.
6. **Evaluation** – differentiating the subtle differences in objects or methods.

For the affective domain, the following are Bloom's progressive development levels:

Affective

1. **Receiving** – Awareness and willingness to receive.
2. **Responding** – Willingness and active participation in responding (motivation).
3. **Valuing** – Attaching different worth or value to a particular object or action.
4. **Organizing** – Setting priorities, comparing, relating, and synthesizing different values.
5. **Internalizing** – Behaving based on internalized value system.

For the psychomotor domain, the following are Bloom's progressive development levels:

Psychomotor

1. **Perception** – Guiding motor activity using sensory cues.
2. **Set** – Getting ready to act mentally, physically, and emotionally.
3. **Guided Response** – Starting to learn complex skills through imitation and trial and error.
4. **Mechanism** – Gaining confidence and proficiency in learning complex skills.
5. **Complex Overt Response** – Performing complex movement skillfully.
6. **Adaptation** – Modifying movement patterns to fit specific requirements.
7. **Origination** – Creating new movement patterns.

4 Educational Objectives and Learner's Development

Innovation and entrepreneurship are realization activities aiming creating or altering reality. To establish and achieve innovation and entrepreneurship as educational objective, it is necessary to understand the product and enterprise realization process. Considering any creative realization process, the three main phases shown in Fig. 1 can be identified [2]:

- **Inception**: Idea genesis, development, and Validation
- **Conception**: Concept specification, development, and Validation
- **Maturation**: Creation specification, development, and Validation

Depending on the creative outcome, these three phases cross different activity or realization domains. These realization domains can be identified as the Perceptual reality, Virtual reality, and Physical reality domains. The following product development example demonstrates such interaction.

Example 1 Creative product development process [2].

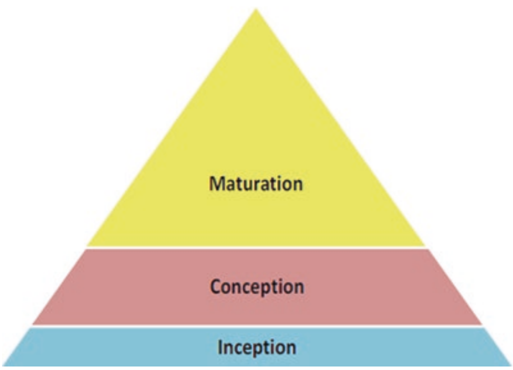
Figure 2 illustrates the phases of a creative product development process. it is clear that the perceptual domain is the source of all creative ideas and inceptions. The perceptual domain is also the leading domain during conception and maturation. Depending on the final outcome of the creative activity the virtual and physical domains may be engaged in the process.

Innovation or creative realization is a process that starts from an idea at the perceptual reality domain to conceptualization and development in the virtual reality or physical reality domains. Therefore, knowledge and skills are needed when dealing with any of the three reality domains. Depending on the field, the lack of knowledge and skills in any of these domains could slow down or stop the creative process.

Considering Bloom's cognitive-domain development levels in dealing with any of the three reality domains, it becomes evident that:

1. Knowledge and Comprehension can be aligned with **understanding the realty**
2. Application and Analysis can be aligned with **utilizing the realty**
3. Synthesis and Evaluation can be aligned with **altering the realty**

Fig. 1 Creative realization processes [2]



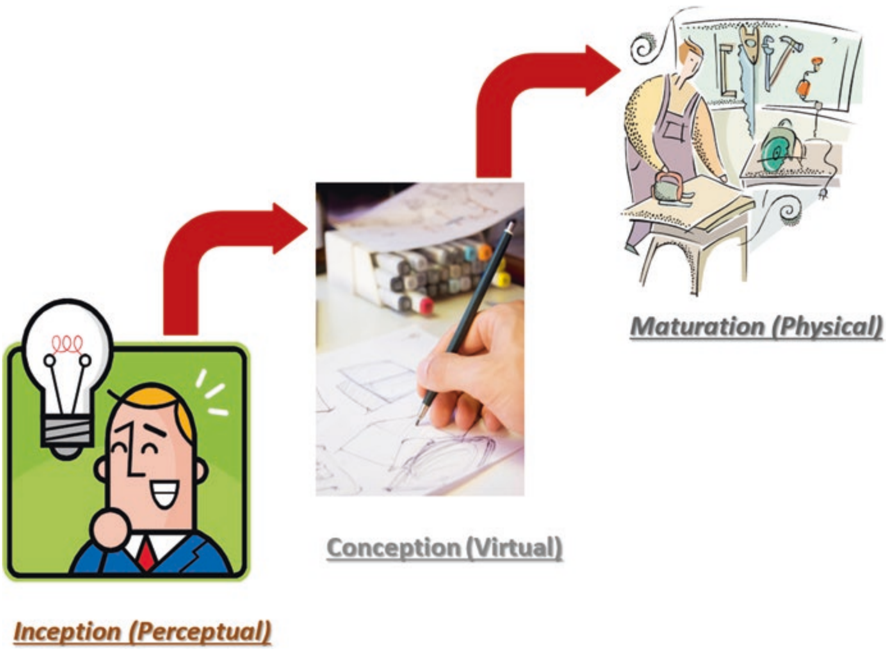
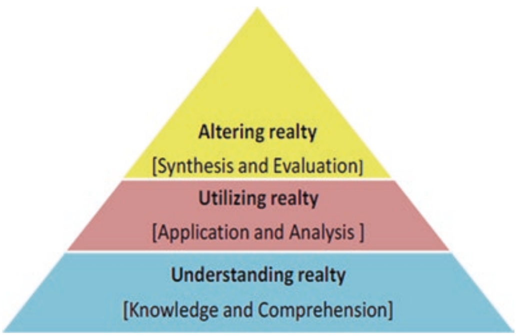


Fig. 2 Creative product development [2]

Fig. 3 Progression of cognitive domain development [2]



Clearly, Bloom's cognitive domain development levels are aimed at progressing the knowledge and skills when dealing with the reality of any field of study. These levels are also well aligned with the natural progression to a higher or enhanced level of realization starting from understanding and ending with altering the reality, as shown in Fig. 3. In fact, Bloom's highest cognitive level of evaluation can only be reached with refined realization at the perceptual domain. Similarly, when dealing with a reality, each of the affective and psychomotor domains levels can be aligned into three ascending realization levels as shown in Figs. 4 and 5, respectively.

Fig. 4 Progression of affective domain development [2]

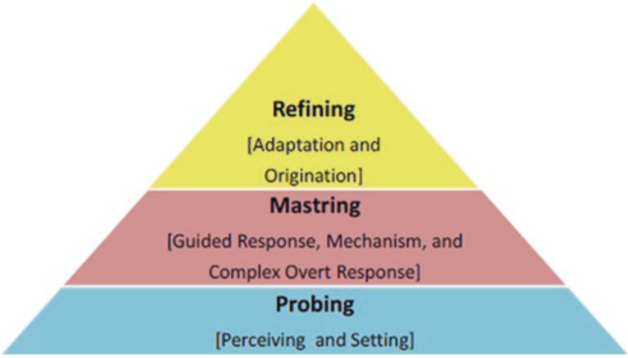


Fig. 5 Progression of psychomotor development [2]

5 Learner's Development for Achieving Innovation and Entrepreneurship

To reach the level of creativity and persistence needed for sustained innovation and entrepreneurship, a learner should attain the level of altering reality of the cognitive domain development shown in Fig. 3. To value pursuing a creative solution, the learner should reach the level of desiring of the affective domain development shown in Fig. 4. Similarly, in many disciplines, such as engineering, surgery, arts, cooking, etc. preparation to reach the skill level needed to initiate and develop a creative solution, the learner should reach the level of mastering the psychomotor-domain development shown in Fig. 5. Therefore, to foster innovation and entrepreneurship, educational programs must be holistic and simultaneously pursue the progressive development of the cognitive, affective, and psychomotor domains.

For holistic learner's development, a framework with the building blocks necessary for developing, sustaining, and continuous refinement of the desired capabilities is shown in Fig. 6 [19]. As shown in the figure, the needed knowledge, skills, and attitude are the developmental inputs to the intrinsic cognitive, affective, and psychomotor domains discussed earlier. Following the framework, the professional, relational, and personal capabilities can be developed to achieve the desired

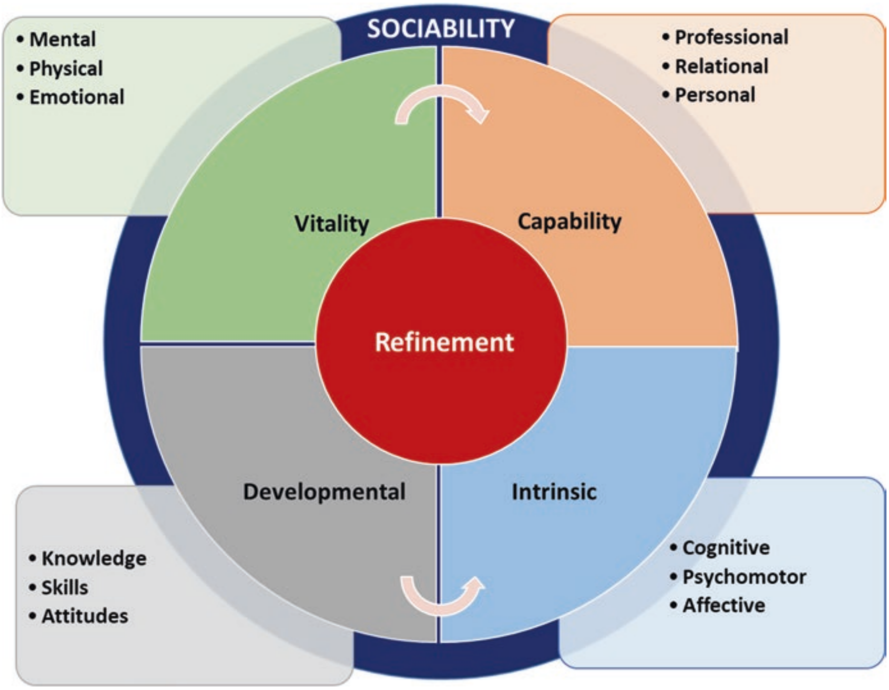


Fig. 6 Holistic learner's development framework [19]

innovation and entrepreneurship objectives. Educational and social setting or sociability, however, are the foundation for providing the needed interactions for the learner's development. Mental, physical, and emotional vitality are nurtured through development for sustained professional, relational, and personal capabilities. Refinement of the desired capability and vitality can be achieved through continuous knowledge, skills, and attitude development.

6 Building a Culture of Innovation and Entrepreneurship

To build a culture of innovation and entrepreneurship both education sides of teaching and learning should be developed. In addition to the learner development, faculty development could also be pursued using the framework of Fig. 6. Accordingly, the full education framework for both teaching and learning through faculty and learner development could be illustrated by the education framework shown in Fig. 7. For achieving the required learner's outcomes, however, it is essential to understand the field of practice reality and the learner's knowledge, skills, and attitudes needed to achieve the educational objectives. Since classroom teaching and learning are mostly perceptual-domain exchanges, shaped mainly by the faculty's

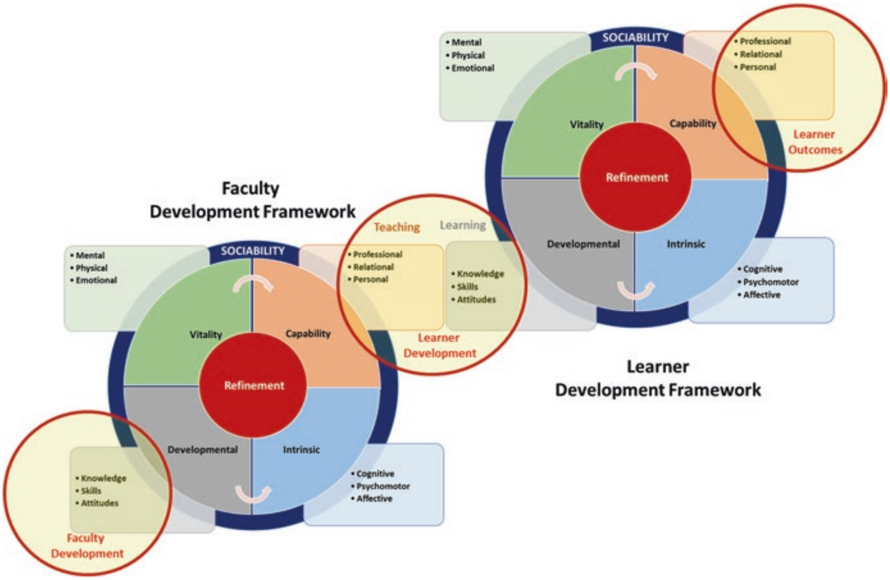


Fig. 7 Education framework

perceptual reality and the learner's style of learning, it is necessary for the faculty to know what is needed to succeed in the field of practice and how to deliver it in synchronization with learner's abilities and learning style. It is also necessary to measure and assess the holistic learner's performance and the progressive development of the cognitive, affective, and psychomotor domains.

7 State of Learner's Development in Higher Education

Learner's development in most higher education settings is focused on development of the cognitive domain. Even cognitive-domain development itself is more focused on analytical abilities than on integrative abilities. During any realization process, both cognitive analysis and integration are used to perform perceptual, virtual, and physical modeling and simulation at different degrees. As shown in Fig. 8, analysis is performed with mostly simulation and some modeling while integration is performed with mostly modeling and some simulation. It is also obvious that both analysis and simulation are logical and analytical in nature while modeling and integration are more holistic and creative in nature. Accordingly, more integrative abilities are needed for creativity and innovations. Most educational programs, however, accentuate analysis and simulation over the creative practices of modeling and integration. For this reason, in addition to the relative ease of developing and assessing analytical skills, most education programs are lacking in achieving creativity as learning outcome.

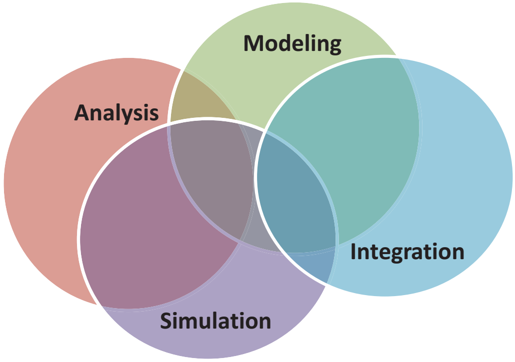


Fig. 8 Realization processes

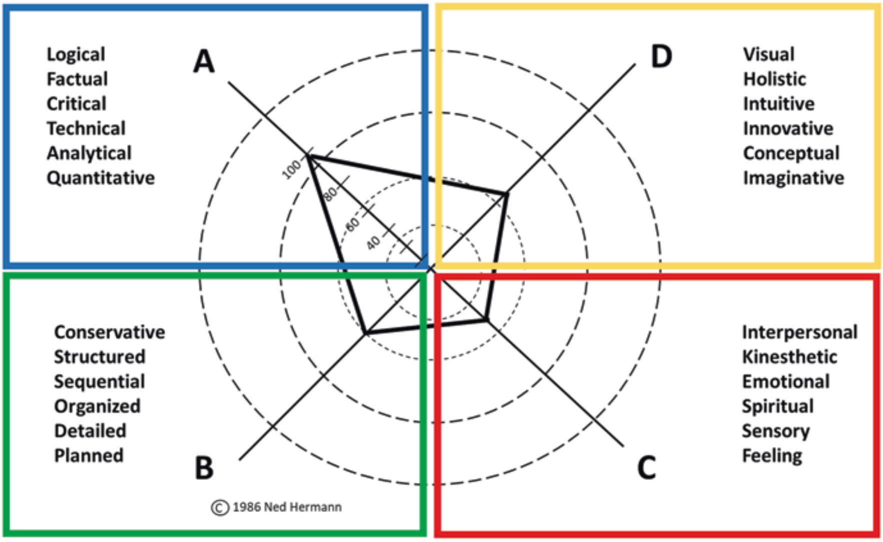


Fig. 9 Thinking preference of engineering students [20]

Furthermore, due to the ever-shrinking educational resource and the lack of opportunities for practice, more emphasis is given to theoretical knowledge than skill building in the field of practice. While in industrially advanced societies the skill building in the learner's field of choice is usually provided by the employers' training at early career phases; in less advanced societies these opportunities are limited.

Example 2 Thinking preferences of engineering students.

The dominance of analytical thinking over integrative holistic thinking is demonstrated in Fig. 9, from a study on thinking preference of engineering students [20]. As shown in the figure, students demonstrate a high level of analytical, logical, and quantitative thinking in comparison to innovative, holistic, and conceptual thinking.

8 Learner's Development in Higher Education in the Arab World

By analyzing the state of Arab World higher-education programs in comparison with the holistic education needs, it is evident that:

- Similar to most higher-education programs, higher-education systems in the Arab world are more focused on cognitive development with emphasis on analytical skills.
- Less emphasis on psychomotor development in the learner's field of practice. Due to the limited educational resources and the lack of opportunities for practice, more emphasis is given to theoretical knowledge than skill building. While in leading industrial societies, skill building in the learner's field of choice could be provided by the employers at early career phases, in the Arab world these opportunities are limited.
- Limited attention, if any, to the learner's affective development. Accordingly, learners are mostly motivated for attaining the certification than acquiring field knowledge and skills.

To foster innovation and entrepreneurship in the Arab higher education, it is imperative to:

- Balance the cognitive-domain integrative and analytical development by providing integrative experience through curricula. Promote creativity and entrepreneurship as education objectives. To achieving the required outcomes, it is essential for faculty to understand the learner's field of practice and the required knowledge, skills, and attitudes needed for learner's development. Since classroom teaching and learning are mostly perceptual domain exchanges, shaped mainly by the faculty's perceptual reality and the learner's style of learning, it is necessary for the faculty to know what is needed for success in the field of practice and how to deliver it in synchronization with learner's learning abilities and style. It is also necessary to assess the holistic learner's performance and the progressive development of the cognitive, affective, and psychomotor domains.
- Develop the essential psychomotor skills for field practice through experiential learning experiences such as internships, cooperative education, and community engagements. For some educational fields the development of the learner's psychomotor domain is necessary for fostering innovation and entrepreneurship, in professional practices. Unless the field of practice is completely cognitive the educational program will not fully achieve innovation and entrepreneurship objectives by focusing only on the cognitive development. Psychomotor abilities do not only facilitate learner's practices but also motivates the learner to try

different alternatives. A higher level of learner's psychomotor mastery can lead to a lower level of frustration, a higher level of motivation, and ultimately higher desire and ability for innovation and entrepreneurship,
- Nurture the learner's affective domain, through emotional development and entrepreneurial initiatives. In addition to having the entrepreneurial abilities necessary to discover, assess, and seize opportunities, the entrepreneur must have the affective entrepreneurial drive in the form of passion, motivation, or willingness to take the risks needed to initiate, propel, and complete the enterprise realization.

9 Conclusions

To build a culture of innovation and entrepreneurship in the Arab world, a gradual shift towards a more holistic higher education system is essential. This can be achieved by:

- Balancing the learner's cognitive domain integrative and analytical development. Achieving this balance in cognitive development would be the first step in the right direction.
- Developing the learner's psychomotor skills. Balancing cognitive development without the skills needed for practice in the learner's chosen field may not be enough to achieve desired results. Therefore, psychomotor development is of equal importance in the realization of the desired innovation and entrepreneurship culture.
- Nurturing and developing the learner's affective domain. It is evident from the nature of innovation and entrepreneurship that the affective drive is a key factor for success in both endeavors. Therefore, nurturing the affective domain of the learner would another a vital step towards motivating the desired cultural change.

References

1. Anderson LW, Krathwohl DR, Airasian PW, Cruikshank KA, Mayer RE, Pintrich PR, Raths J, Wittrock MC (2001) A taxonomy for learning, teaching, and assessing: a revision of Bloom's taxonomy of educational objectives, abridged edition. Longman, White Plains. ISBN 10: 080131903X/ISBN 13: 9780801319037
2. El-Sayed M, El-Sayed J (2012) Importance of psychomotor development for innovation and creativity. Int J Process Educ 4(1):89–94. http://www.ijpe.online/2012/psychomotorh.pdf
3. Rugg H, Shumaker A (1928) Child-centered school: an appraisal of the new education. World Book Company, New York. ASIN: B00201EOTU
4. Combs AN (1962) Perceiving behaving becoming: a new focus for education. Association for Supervision and Curriculum Development, NEA, Washington, DC. https://epdf.pub/perceiving-behaving-becoming-lessons-learned.html

5. Cole HP (1972) Process education. Educational Technology Publications, Englewood Cliffs. https://books.google.com/books?hl=en&lr=&id=CbAb-ToR3WwC&oi=fnd&pg=PR7&dq=5.%09Cole+HP+(1972)+Process+education.+Englewood+Cliffs,+NJ:+Educational+Technology+Publications&ots=qgm8XFpEoy&sig=fFptXRs3YRSblKS7A47pZYQyav0#v=onepage&q&f=false
6. Treffinger DJ, Isaksen SG, Firestien RL (1983) Theoretical perspectives on creative learning and its facilitation: an overview. J Creat Behav 17(1):9–17. https://onlinelibrary.wiley.com/doi/pdf/10.1002/j.2162-6057.1983.tb00970.x
7. Wertheimer M (1945) Productive thinking. Harper & Row, New York. ISBN 10: 0061315893 ISBN 13: 9780061315893
8. Torrance EP (1974) Torrance tests of creative thinking. Ginn/Personnel Press, Lexington. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.454.8488&rep=rep1&type=pdf
9. Skinner BF (1968) The technology of teaching. Appleton, New York. ISBN 978-0-9964539-2-9
10. Ericsson KA (1999) Creative expertise as superior reproducible performance: innovative and flexible aspects of expert performance. Psychol Inq 10(4):329–333. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.477.1288&rep=rep1&type=pdf
11. Maslow AH (1959) Creativity in self-actualizing people. In: Anderson HH (ed) Creativity and its cultivation. Harper & Row, New York. http://agris.fao.org/agris-search/search.do?recordID=US201300601170
12. Casson M (1982) The entrepreneur: an economic theory. Rowman & Littlefield. ISBN 0-389-20328-9
13. Hébert RF, Link AN (1988) The entrepreneur: mainstream views and radical critiques. Praeger, New York. http://pdfalldogen.com/the-entrepreneur-mainstream-views-and-radical-critiques-robert-f-hebert-a-list-of-book-download-free.pdf
14. Gartner WB (1988) "Who is an entrepreneur?" is the wrong question. Am J Small Bus 12(4):11–32
15. Gartner WB (1989) Some suggestions for research on entrepreneurial traits and characteristics. Entrep Theory Pract 14(1):27–38. https://www.researchgate.net/profile/William_Gartner3/publication/237360637_'_Who_Is_an_Entrepreneur_Is_the_Wrong_Question/links/00b4953c92c60ccbfb000000/Who-Is-an-Entrepreneur-Is-the-Wrong-Question.pdf
16. Rae D (2000) Understanding entrepreneurial learning: a question of how? Int J Entrep Behav Res 6(3):145–159. https://www.researchgate.net/profile/David_Rae4/publication/235262035_Understanding_entrepreneurial_learning_A_question_of_how/links/53e4c3e80cf21cc29fc91ea6/Understanding-entrepreneurial-learning-A-question-of-how.pdf
17. Rae D, Carswell M (2000) Using a life-story approach in researching entrepreneurial learning: the development of a conceptual model and its implications in the design of learning experiences. Educ + Train 42(4/5):220–228. https://www.researchgate.net/profile/David_Rae4/publication/228314136_Using_a_Life-Story_Approach_in_Researching_Entrepreneurial_Learning_The_Development_of_a_Conceptual_Model_and_Its_Implications_in_the_Design_of_Learning_Experiences/links/574df11908ae061b33038773/Using-a-Life-Story-Approach-in-Researching-Entrepreneurial-Learning-The-Development-of-a-Conceptual-Model-and-Its-Implications-in-the-Design-of-Learning-Experiences.pdf
18. Cope J (2003) Entrepreneurial learning and critical reflection: discontinuous events as triggers for 'higher-level' learning. Manag Learn 34(4):429–450. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.831.3377&rep=rep1&type=pdf
19. El-Sayed M (2018) Fundamentals of integrated vehicle realization. SAE, Warrendale. ISBN: 9780768083835
20. Lumsdaine M, Lumsdaine E (1995) Thinking preferences of engineering students: implications for curriculum restructuring. J Eng Educ 84(2):193–204. https://onlinelibrary.wiley.com/doi/abs/10.1002/j.2168-9830.1995.tb00166.x

Arab Higher Education and Scientific Research

Sultan T. Abu-Orabi, Abdallah Al-Zoubi, and Razan Aladwan

Abstract Arab higher education is going through a period of transition and transformation characterised by poor quality and fragmentation. Universities have endured a series of setbacks manifested in the destitute state of scientific research. Evidence on the performance of Arab higher education, scientific research, and innovation show limited impact on socio-economic development. The concept of internationalisation of higher education and how this may present a small window in the path towards modernizing higher education, reforming universities, and empowering research and development is described.

Keywords Arab higher education · Universities · Scientific research · Internationalisation · Innovation

1 Introduction

Civilizations rise and fall through the windows of knowledge. Arab civilization reached its pinnacle when its leaders placed value in creating new knowledge and ensured liberty of mind as the pillar for progress and advancement. Today, the Arab world faces daunting challenges of reducing the knowledge chasm with the rest of the world in many fields of endeavor. The modern history of education reform in the region is a tale of ambition and accomplishment but falling short in achieving socio-economic development [1]. The gap between ambition and reality is continuously

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widening as schools, universities, and education systems stumble in the road to meet and achieve current and future development objectives. In addition, Arab countries continue to lag behind many comparator countries since the link between education and economic growth and poverty reduction is weak. Elevation of education has become an imperative matter of urgency, which must top national priority issues throughout the Arab world.

On the other hand, analysis of the scientific landscape in the Arab world depicts an even gloomier image. Such analysis usually focuses on economic dimensions, and in some cases coupled to political elements such as lack of freedom, weakness of democratic mechanisms, and domination of pre-modern administrative patterns in scientific institutions. However, cultural problems encountering the Arab world must be deeply analyzed from a historical perspective in order to identify the enormous impediments that hinder progress and advancement of Arab science, society, and nation. In particular, the counterrevolution mind, which dominated Arab culture since the Middle Ages, casts a heavy blow to all social fabrics including economic, political, and administrative environments and structures. The prevailing conditions urgently demand renewal and require revitalizing a new scientific culture which comprises the basis of an effective and influential future knowledge industry. Major fundamental reform of higher education has become a top priority in the quest to fulfill the aspirations of future generation and modernize Arab countries.

Thus, immediate actions are called for to create a schema to essentially initiate a process of translating the perception of science as a historical cultural project into a national collective consciousness. In this chapter, the state of Arab universities and higher education as well as scientific research is described. Light is then shed on the concept of internationalization of higher education and how this may present a small window in the path towards modernizing higher education, reforming universities, and empowering research and development leading to innovation and entrepreneurship. The Association of Arab Universities has played a pivotal and vital role in this cause through numerous activities and initiatives that are presented and discussed as a vehicle of dialogue interlocutor amongst the academic community and political leadership and the elite.

2 History of Arab Universities

Arab universities date back to the eighth century when Al-Zaytounah University was first established as a mosque in Montfleury, Tunisia in 734 (modernized in 1956) and consequently became a centre for theology and religious studies. It currently consists of two Islamic Civilization centres, one in Tunis and the other in Kairouan. Bayt al-Hikma (The House of Wisdom) was another major intellectual center founded as a library by the Abbasid Caliph Harun al-Rashid around year 800 in Baghdad and culminated in prominence under his son al-Ma'mun who is credited with its formal institution which then became a center for translation, and transformed later into a center for scientific research and composition. In addition, the first known continually operating non-profit private university was founded by Fatima al-Fihri in 859 in Fez, Morocco as al-Qarawiyyin mosque and its associated madrasa, and today represents the oldest existing degree-awarding educational institution in the world. In 1963, University of al-Qarawiyyin was credited as a modern higher-education institution and incorporated into the state system. In Egypt, Al-Azhar University was founded in 970–972 by the Fatimids as a centre of learning of Quranic and Islamic law, Arabic, rhetoric, and logic. In 1961, additional non-religious subjects were added to its curriculum while still stands today as a prominent centre of Arabic literature and Islamic learning in the world. Mustansiriya University in Baghdad is another scholarly example of historical Arab universities. It originates to Mustansiriya Madrasah that was established in 1227 by the Abbasid Caliph Al-Mustansir on the bank of Tigris River. In 1963, the modern Mustansiriyah University was re-established to mainly provide evening courses, and a year later given the status of a semi-state institution and then moved to a new campus to the north of the city centre and converted into a public university in 1968 [2].

Higher education is thus deeply rooted in the history and societies of the Arab world, some of which were the first established universities in the world with endowment funding or Islamic Waqf. They had actually initiated an intellectual movement which nurtured the subsequent flourishing of world knowledge and scholarship and established and disseminated educational standards that are still applied in present-day universities. Arab higher education has, however, experienced a state of slackness and paralysis with the decline of Arab-Islamic civilization that was marked by foreign invasions, occupation and colonization, and internal political and religious turmoil, struggle, and fragmentation. For almost seven centuries, Arab higher education had witnessed a state of demise and termination during which science and education have taken a back seat and Arabs went away from science. This dark era has persisted until the mid-nineteenth century when the American Board of Commissioners for Foreign Missions established a college of higher learning in Beirut named the Syrian Protestant College in 1866, and consequently renamed the American University of Beirut in 1920. The foundation of the Université Saint Joseph in Beirut followed in 1875 by the French Jesuit Mission. In the same year, Université La Sagesse was established in Beirut by Archbishop of the Maronite Archdiocese in order to lead the adventure of a cultural revival through teaching civil law and Islamic Fiqh [1].

Qasr El Eyni hospital, on the other hand, may be considered as the nucleus of present-day University of Cairo. Muhammad Ali, the Viceroy of Egypt, reorganized it in 1827 as a resumption of a hospital built by Napoleon for his troops in 1799. The Viceroy actually relied on and recruited doctors from Europe to manage and maintain the hospital in order to keep his army in good health. University of Cairo itself was first established as the Egyptian University in 1908 until 1940 and King Fuad I University between 1940 and 1952, when the Egyptian revolution toppled the monarchy. University of Khartoum, on the other hand, was founded under the name Gordon Memorial College. It was built between 1899 and 1902 as part of Lord Kitchener's educational reforms and named in honour of General Charles George Gordon, the British army officer who was killed during the Mahdi uprising in 1885.

The college was renamed again in 1956 to University of Khartoum when Sudan gained its independence.

Similarly, the University of Algiers stemmed out of 4 higher education institutions created in 1879, by the university reform of the French Republic for medicine-pharmacy, sciences, and law, in order to train the Muslim cadres of religion, justice, and administration under Islamic law. The four schools or faculties were then transformed into the University of Algiers under the Law of 1909. It allowed students to pursue a complete curriculum up to the doctorate level. Most students initially came from European families installed in North Africa.

In Lebanon again, the American School for Girls was established in Beirut in 1835 by American Presbyterian missionaries as an important shift in education for women in Syria and the surrounding region. After a sectarian conflict in 1860, it was renamed Beirut Female Seminary and has subsequently undergone some difficult transformations, including occasionally shutting down, before reverting to its original name in 1868, and becoming a popular school for women which included secondary education. In 1924, the school started a two-year junior college curriculum that was mandatory at the time for young women wishing to pursue bachelor's degrees at AUB, and in 1933 it moved to what is now the Lebanese American University. Meanwhile, the Lebanese Academy of Fine Arts was originally a stand-alone Lebanese institute, founded in 1937 by a group of young classical musicians and now one of the faculties at the University of Balamand established in 1988. In Syria, Damascus University was founded in 1923 through the merger of the School of Medicine which was established 1903 and the Institute of Law established 1913. It was first named the Syrian University, but the name changed after the founding of the University of Aleppo in 1958. Meanwhile, in 1938, two faculties of Arts and Law of then Fouad University formed the nucleus of Farouk University which became a separate entity in 1942 with four additional faculties: Science, Commerce, Medicine, and Agriculture, and renamed Alexandria University with the Egyptian Revolution of 1952. In brief, only 15 universities existed in the Arab world before 1953, and only 5 Arab countries had universities prior to the twentieth century and only 15 Arab universities existed just after the Second World War as shown in Table 1.

3 Arab Higher-Education Landscape

With independence of Arab countries, higher-education institutions and student enrollment quickly multiplied and public state-run institutions and universities were largely dominating the landscape. During the fifties and the sixties of the last century, many Arab universities were established in the capitals of the Arab countries such as Baghdad University in 1957, Mohamad V University in Rabat in 1957, King Saud University in Riyadh in 1957, University of Jordan in Amman in 1962, and Kuwait University in 1966.

Table 1 Arab Universities Founded before 1953

Country	University	Year
Egypt	Al Azhar	970
	Cairo	1908
	American University Cairo	1919
	Alexandria	1938
	Ain Shams	1950
Lebanon	American University of Beirut	1866
	Saint Joseph	1875
	Lebanese American	1933
	Lebanese	1951
Syria	Damascus (Syrian)	1923
Iraq	Al-Mustansiryah	984
Algeria	Algiers	1909
Morocco	Al-Qarawiyeen	859
Tunisia	Al Zaytounah	734
Sudan	Khartoum (Gordon Memorial College)	1902

Reform in Arab higher education began in the early 1980s and continues today, including increasing privatization, greater access, fulfilling needs and demands of society, matching educational "outputs" with labor market needs, and negotiating a competitive global education market. During the last 40 years, the number of private universities in the Arab word has increased rapidly as public universities could not absorb all high-schools graduates, and private universities were established in many Arab countries, the Al-Ahliyya Amman University in Jordan being the first private for-profit university in 1990. In fact, the number of Arab universities expanded from 233 in 2003 to 286 in 2006, of which are 153 state and 133 private, and today the numbers stand at 292 private and 264 state universities with 611 colleges. In 2019, the number of students stands at 12 million students, 90% in undergraduate programmes, and female students constitute 55% of total enrollment, while the number of faculty members exceeded 450, 000. Approximately 78% of academic programmes are in humanities while 22% are in scientific disciplines. Figure 1 shows the rapid increase in the number of universities in Arab countries while detailed statistics on higher education in the Arab world for the year 2019 are shown in Table 2.

The Arab world today faces mounting problems and challenges when it comes to higher education and scientific research, including the lack of clear focus in research priorities and strategies, insufficient time and funding to meet research goals (low quality of infrastructure needed for research), low awareness of the importance and impact of good scientific research, inadequate networking opportunities and databases, limited international collaborative efforts, and of course, the brain-drain. Despite over a decade of dramatic achievement, reform, and expansion, higher education in the Arab world continues to fall far short from fulfilling the needs of society and to meet the growing demands of Arab youth. In addition to being relatively

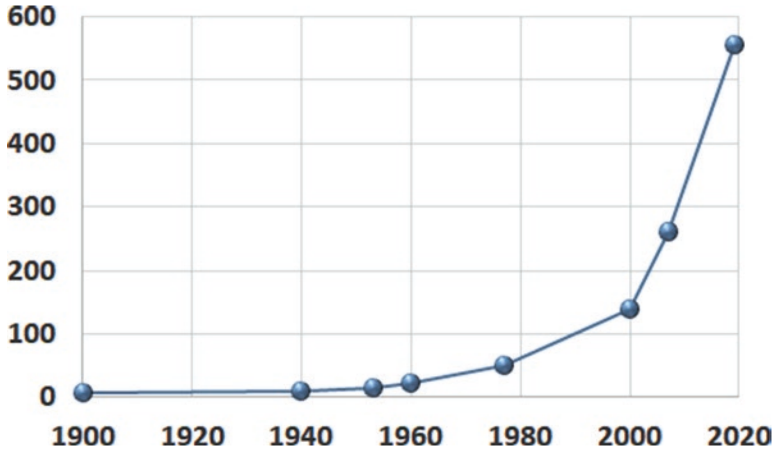

Fig. 1 Growth of Arab universities until 2019

new with 75% of Arab universities established after 1975, higher education institutions suffer from a lack of clear vision and well-designed educational missions. In addition, most Arab universities lack key human and physical resources and suffer from overcrowding and poor quality. Moreover, the Arab educational system is currently producing graduates with skills and competences that do not match the needs to succeed in the modern global economy as reflected by high unemployment among university graduates. The quality of Arab higher education has not kept pace with international standards. This dual challenge of quantity and quality requires a comprehensive reform agenda for the higher education system to address the skills gap, fuel economic development, and put the region on better footing for advancement and competition in a technologically driven, knowledge-based world. They also lack autonomy as they are under direct control of various authoritarian regimes. This leaves minimal room for freedom for curriculum, expression, research, original thought, and publications. In fact, Arab universities are not knowledge-production centres but rather a merely transmission of what is already known. The early spirit of Arab researchers of the Middle Ages has almost disappeared. Strong political will to revive research culture and spirit is called upon. Arab governments should trust and count on the educational sector to open up their societies and enable them cope and keep abreast with the latest pedagogical, scientific, and technological advancement to achieve socio-economic progress. In brief, Arab higher education still has a critical role to play as the engine of social and economic progress particularly in restructuring itself and breaking free from the obstacles that have held back meaningful educational changes in the past.

Table 2 Statistics on higher education in the Arab world for the year 2019

Country	Students			Faculty Members	Universities/Colleges			
	Undergraduates	Postgraduates	Total		Colleges	Private	State	Total
Algeria	1,578,920	76,202	1,655,122	60,000	56	0	50	106
Bahrain	42,343	644	42,987	2724	4	9	3	16
Egypt	2,333,762	366,238	2,700,000	122,577	158	26	25	209
Iraq	647,770	29,474	677,244	41,233	59	12	35	106
Jordan	270,158	18,885	289,043	10,921	0	25	10	35
Kuwait	44,071	1529	45,600	2177	9	4	2	15
Lebanon	157,985	33,822	191,807	7500	12	36	1	49
Libya	325,835	21,860	347,695	11,639	78	6	14	98
Mauritania	31,253	916	31,229	743	0	7	1	8
Morocco	811,344	75,847	882,191	13,820	31	5	14	50
Oman	128,224	1688	129,912	14,096	22	7	1	30
Palestine	183,326	8724	192,050	8159	10	12	9	31
Qatar	30,840	1037	31,877	2556	6	8	2	16
Saudi Arabia	2,007,888	65,223	2,073,111	83,884	21	12	27	60
Sudan	840,304	102,734	943,038	22,588	53	19	35	107
Somalia	49,797	1674	51,471	1419	0	17	1	18
Syria	486,940	24,824	761,946	11,650	4	22	8	34
Tunisia	259,252	35,234	282,204	22,819	29	15	13	57
UAE	138,305	5762	144,067	6994	41	30	3	74
Yemen	261,002	21,773	282,775	9290	18	20	10	48
Total	**10,629,319**	**894,090**	**11,755,369**	**456,789**	**611**	**292**	**264**	**1167**

4 Research in the Arab World

According to the UNESCO Science Report: Towards 2030, the world spent 2.228% of its total GDP on research and development in 2015 [3]. In fact, global spending on R&D has reached a record high of almost US$1.78429 trillion with only 10 countries, as shown in Fig. 2, which account for 80% of spending. The leading countries on R&D are characterised by their strong spending by the business sector which is truly an underlying factor for success. Countries all over the world must commit and pledge to substantially increase public and private R&D spending as well as the number of researchers in order to sustain and achieve national development goals. Furthermore, several countries currently try to stimulate greater investment in both private and public sectors by setting national targets for R&D spending as a share of GDP [1].

Fig. 3 presents the percentage distribution of researchers across the world by region for the year 2014, with North America and Western Europe having the greatest share of 47.5%, followed by East Asia and the Pacific 38.6%, then Central and East Europe 4%, South and West Asia 4.2%, followed by Latin America and the Caribbean 3.6%, Arab States 1.1%, Sub-Saharan Africa 0.8% and finally Central Asia 0.2%. The share of Arab states is in fact much less than what it should produce in accordance with its population, which stands at 5.2% of the world population. The Arab world should therefore generate 5 times the current magnitude of research in order to reach world average.

The number of researchers per one million inhabitants by region for the same year 2014 is shown in Fig. 4, while the same indicator for Arab and some other emerging countries in the region is shown in Fig. 5.

Scientific production in the Arab world in particular has been rapidly transforming over the last decades and several countries gained a good share of scientific contribution and number of documents produced and cited. Several studies highlighted the rapid growth in this scientific production over time and its relative prominence when compared with the total production of documents in the region and worldwide [4]. Such studies are vital and invaluable tools in enlightening leaders

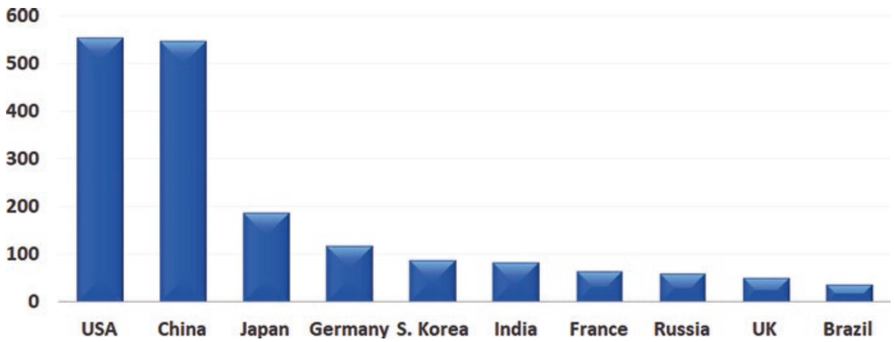

Fig. 2 Leading countries by gross R&D expenditure in 2018 (in billion U.S. dollars)

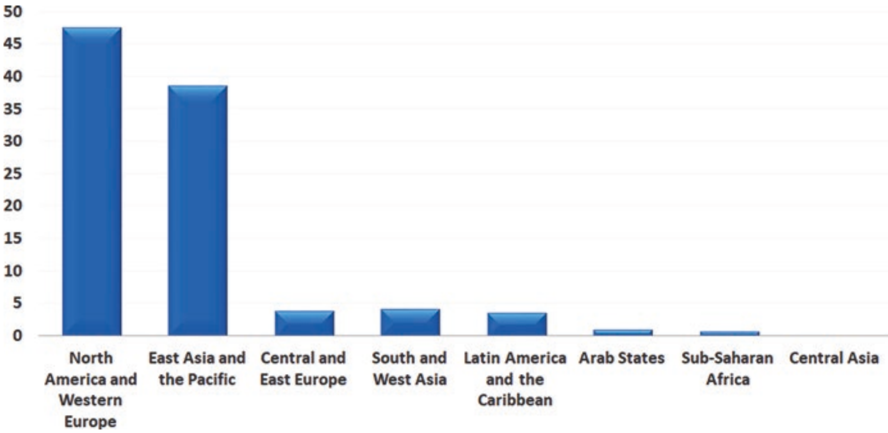

Fig. 3 Distribution of researchers across the world by region in 2014

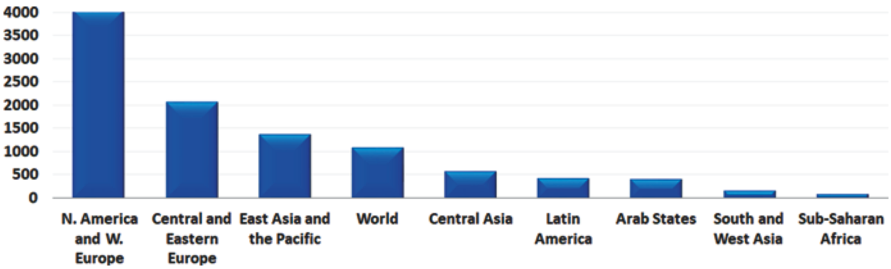

Fig. 4 Researchers per one million inhabitants by region, 2014

and policy makers to improve the research and scientific production in Arab countries that fall well below the world average, and to create new alliances with leading and emerging countries [1].

However, science-policy analysts need appropriate tools to monitor the state of publications and to roughly categorize scientific development, progress, and make comparisons with other countries. Scopus raw data provided by Elsevier, Thomson Reuters Web of Science, and Essential Science Indicators database, all allow measurements of scientific output performance and scientometrics of individual states over long periods of time. The SCImago Journal and Country Rank database was used to extract research data which implements metrics that are calculated using the Scopus raw data provided by Elsevier [5]. The database allows for measurement of a performance of a single country year by year covering two decades from 1996 to 2017. The data, contained in spreadsheets available online, www.scimagojr.com, provides information on the number of citable documents published and on citations to such documents. The data available for all 21 Arab countries in the Middle Eastern and North Africa were compared to Iran, Israel, Turkey, and South Africa.

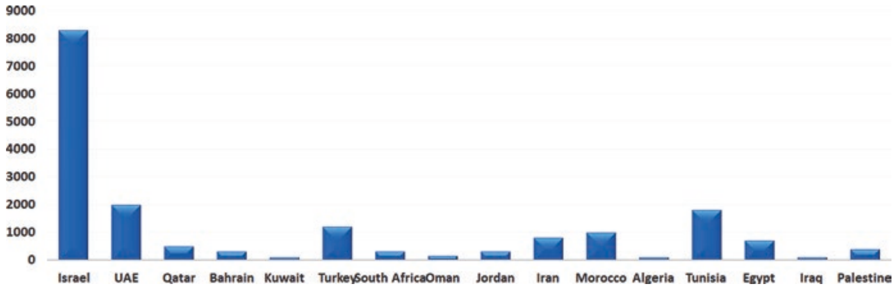

Fig. 5 Researchers per one million inhabitants in Arab and other emerging countries, 2014

The data analyzed show a general increase in the number of productions for most countries over the last few years as shown in Fig. 6, consistent with the general world trend. Saudi Arabia has emerged as the leading Arab country in scientific publications since 2012, overtaking both Egypt and Israel and just equaling South Africa. However, Turkey and Iran have dominated the region in terms of the volume of publications in the last decade, particularly Iran, which has been making steady progress and overtaking Turkey in recent years. In fact, Iran has topped the list in the number of publications in 2017, as compared to the 5 top Arab countries, Turkey, Israel, and South Africa, as shown in Fig. 7.

The same trend is also observed when analyzing the total number of citations per document per country where Iran, Turkey, Saudi Arabia, South Africa, Israel, and Egypt take the lead respectively, with minor differences between the last four, as shown in Fig. 8.

The h-index at the country level, however, tells a different story. Israel actually leads all countries in this indicator standing at 584, followed by South Africa at 361, Turkey at 339, Saudi Arabia at 241, Iran at 234, and Egypt at 213. All other Arab countries have an h-index below 157, as shown in Fig. 9.

The analysis shows that Israel remains the region's leader in scientific research, while Turkey and Iran were in the lead in terms of documents produced, and together with Egypt and Saudi Arabia, were among the emerging countries in scientific production. However, the analysis clearly demonstrates that the state of scientific research in the Arab world remains weak when compared with other emerging economies in the region, and has still to reach world average. There are several challenges that describe this fragmentation and weakness including low rates of expenditure and outputs of publications, absence of national policies or strategic plans, and hence poor impact on sustainable development. However, when scientific production data of all Arab countries are put together, the whole situation may reverse as elucidated by the total citations for Arab countries compared with others in the region, as depicted in Fig. 10.

Furthermore, patent development activity in the region pales in comparison to other countries worldwide, and is reflective on a lack of an innovation-friendly culture in the Arab world.

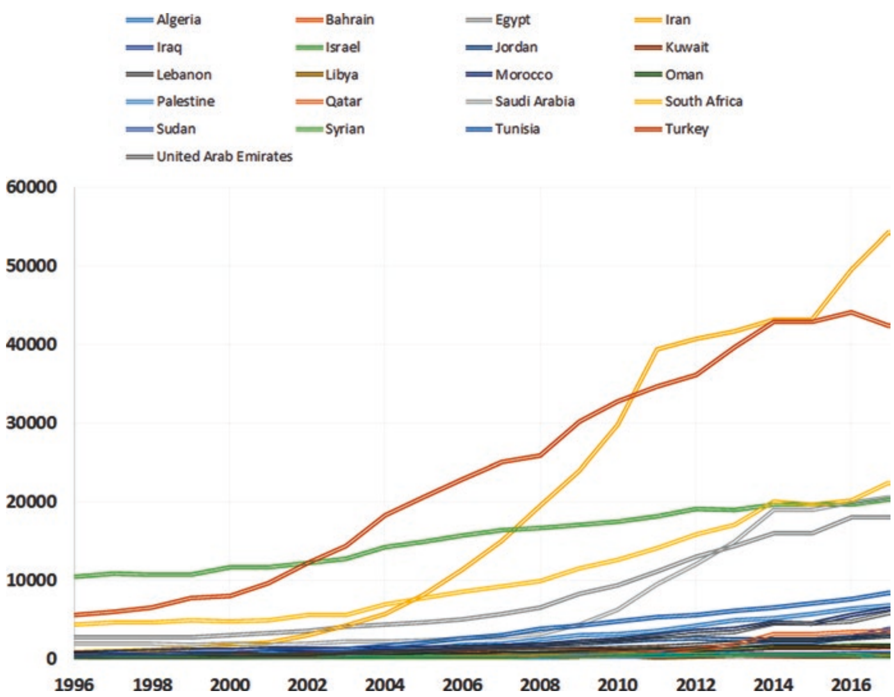

Fig. 6 Number of published documents per country over the period 1996–2017

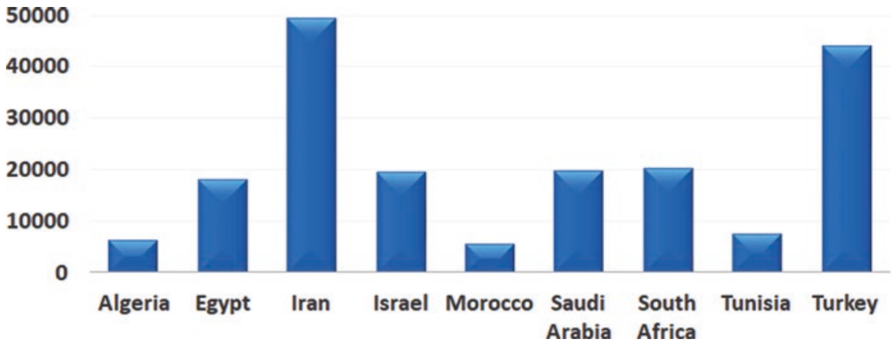

Fig. 7 Number of published documents in 2016 for leading countries in the region

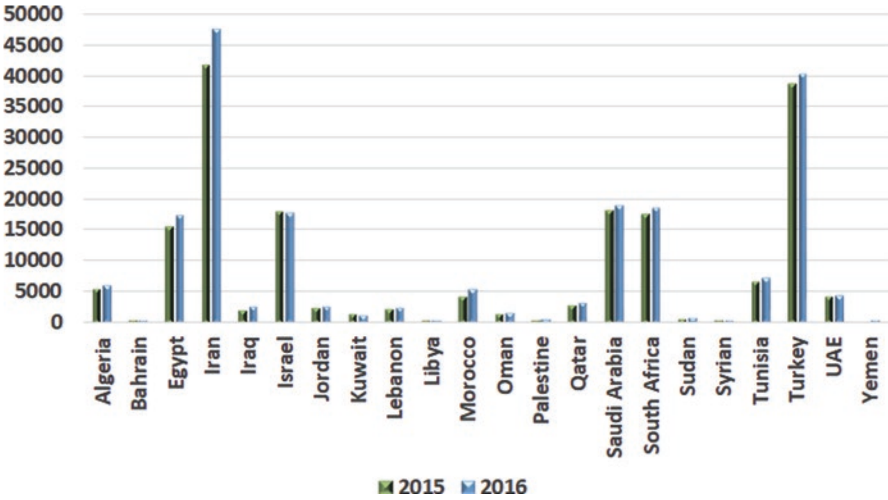

Fig. 8 Total number of citations per document per country for the years 2015, 2016

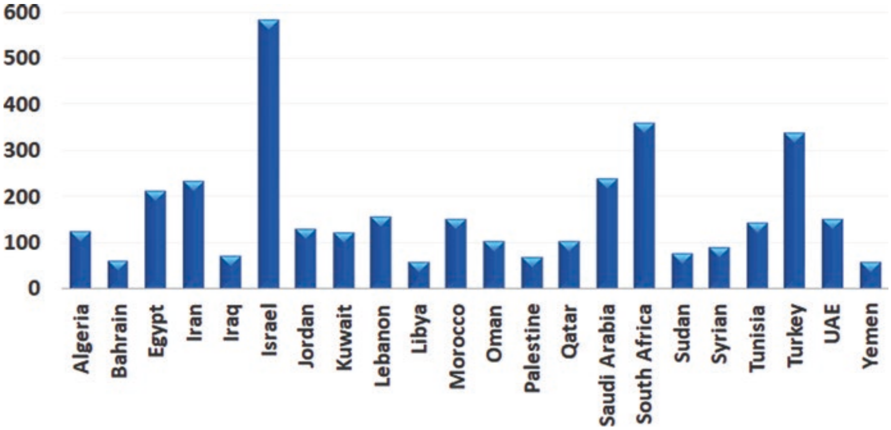

Fig. 9 H-index for 2016 for Arab and neighboring countries

According to World Intellectual Property Organization (WIPO) report on "World Intellectual Property Indicators" in 2016, patent applications worldwide grew by 1.9% in 2015 with around 2.9 million patent applications filed across the globe [6]. Driving that strong growth were filings in China, which received about 174,000 of the nearly 208,000 additional filings in 2015 and accounted for 84% of total growth. The next largest contributors were the U.S. and Europe, combined they accounted for 8.6% of total growth. Data extracted from the WIPO statistical databases on the total number of granted patents for residence and non-residence and abroad, for the period 2007–2016, show that Israel leads the race with over 74,378 patents, followed by Iran with 50,891, South Africa with 46,644 and Turkey with 14,555. All

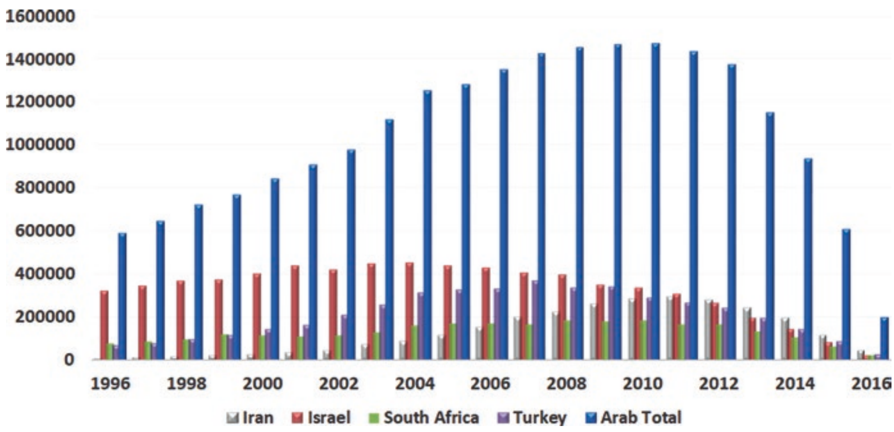

Fig. 10 Total citations for Arab countries compared with others in the region

Arab states have been granted only 28,932 in this 10-year period, as shown in Fig. 11, which is less than double the patents granted for Israel or Iran in year 2016 only.

The poor commercialization of science in the Arab world is again demonstrated by the indicator on total equivalent country patents by origin of applicant on direct Patent Cooperation Treaty (PCT) national phase entries for the year 2016 as shown Fig. 12. This time, Iran slightly leads Israel, followed by Turkey and South Africa. However, both Saudi Arabia and Egypt are making progress while the rest of Arab states merely produce 26% of that of Saudi Arabia, which *improved its world ranking to 34 in term of patent applications as shown in* Table *3*. Patent data refer to number of equivalent patent applications, mark data refer to number of equivalent trademark applications based on class counts, and design data refer to number of equivalent industrial design applications based on design counts.

However, one should observe that the U.S. is a major home for Arab inventors. In the period 2009–2013, there were 8786 patent applications representing 3.4% of the total, which had at least one Arab inventor, despite the fact that Arabs represent only 0.6% of the total population of that country. As patents usually have multiple inventors, and Arab inventors often patent jointly with non-Arabs, 2962 patents, or 1.2%, can be contributed exclusively to Arab inventors. California serves as a home for more than one-third of Patent Cooperation Treaty (PCT) patent applications from Arab inventors with 1134 patents, equivalent to 16% of all Arab patents worldwide [7]. Similarly, the European Union saw 1424 patent applications from Arabs, and looking specifically at countries, France with 513 patent applications in the five-year period, Germany had 342, and the United Kingdom with 273. Canada had in fact 361 patent applications from Arabs in the five-year period. Arab women inventors are still a minority, and the share of female inventors varies across technical fields, and requires further investigations and analysis. Nevertheless, the relative success of Arab scientists in the west is counterbalanced by the phenomena of brain-drain, which has affected the Arab world for decades and is still on the rise [7].

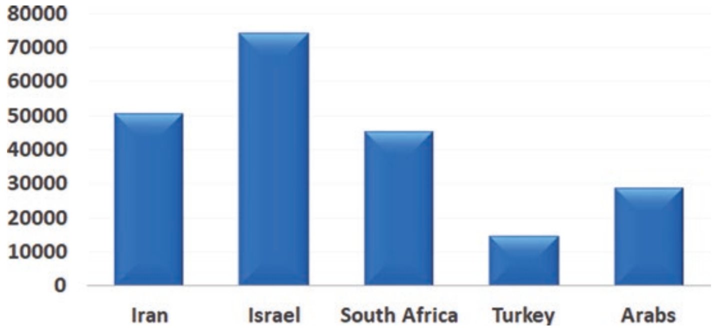

Fig. 11 Total granted patents in the period 2007–2016

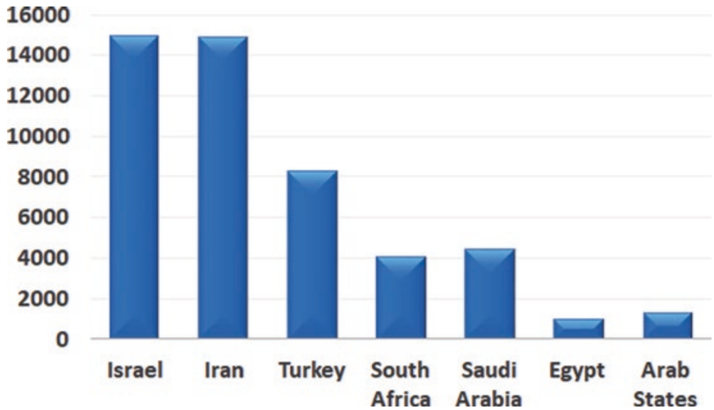

Fig. 12 Total equivalent count patents by origin of applicant for the year 2016

Table 3 Rankings of total (resident and abroad) IP filing activity by origin, 2015

Country	Patents
Israel	15
Iran	17
Turkey	23
Saudi Arabia	34
South Africa	36
Egypt	48
UAE	61
Morocco	64
Syrian	75
Tunisia	76
Qatar	81
Jordan	82
Lebanon	85
Algeria	88

Table 4 Country ranking according to the Global Competitiveness Index" and some of its constituent pillars

Country	Global competitive index	Capacity to retain talent	Capacity to attract talent	Higher education	Innovation	Technological readiness
Israel	16	19	37	21	3	7
UAE	17	2	2	36	25	24
Qatar	25	9	7	37	21	34
Saudi Arabia	30	27	24	43	40	44
Bahrain	44	31	22	39	45	31
Kuwait	52	86	89	95	103	68
Turkey	53	82	103	48	69	62
South Africa	61	78	66	86	39	54
Oman	62	36	29	71	76	59
Jordan	65	66	78	63	46	67
Iran	69	104	108	51	66	91
Morocco	71	90	69	101	94	82
Algeria	86	123	127	92	104	98
Tunisia	95	111	119	62	99	85
Egypt	100	103	116	100	109	94
Lebanon	105	105	105	74	58	64
Mauritania	133	113	126	137	136	132
Yemen	137	130	129	136	143	136

According to the UNDP 2014 report on Arab Knowledge [8], the region is one of the most affected by the emigration of highly skilled academics and researchers and graduates of higher-education institutions standing at 9%, which is twice the world average [9]. In fact, 31% of the total brain-drain from developing countries are from Arab countries, 50% of them are medical doctors and engineers, while 15% of Arab talents goes to Europe and USA, and 54% of Arab students who study abroad do not return home. The rate increases to reach 35% in Lebanon and 17% in Morocco. The main reasons of the brain drain are political instability, social injustice, and absence of appropriate research environment, facilities and quality standards, lack of motivations and incentives, and low salaries.

The performance of a number of Arab countries on several indicators within the "Global Competitiveness Index" [10] is shown in Table 4, which depicts world ranking in the overall index and sub-indicators that constitute its pillars. Israel leads the region in the global competitiveness index but most of the Gulf States are not far behind and better positioned in their capacity to retain and attract talent. However, the remaining Arab countries actually suffer from the phenomenon of brain-drain and their ability to provide job opportunities to university graduates and keep national capabilities and competences. Apparently, competing countries in the region such as Iran and Turkey, and even South Africa, face similar challenges.

However, it is evident that Israel has the edge due to its strong innovation capacity, technological readiness, and the quality of its higher-education system.

Science is becoming an increasingly international enterprise addressing questions of global significance. According to the "UNESCO Science Report: Towards 2030" [3], there were 7.8 million full-time-equivalent researchers in 2013, accounting for 0.1% of the global population. The Global R&D Funding Forecast also revealed that global R&D investments increased to a total of $1.948 trillion in purchasing power parity (PPP) in 2016. In addition, there are 28,100 active scholarly peer-reviewed journals, publishing 2.5 million new scientific papers each year. Consequently, scientific collaboration patterns are changing. The Arab world may benefit significantly from international opportunities and cooperation that can be harnessed to tackle regional problems effectively and professionally.

In recent years, internationalization has steadily moved from a useful add-on to a strategic core pillar for almost all universities aspiring to global significance. Many institutions have moved towards developing mature internationalization agendas that incorporate recruitment, research collaborations, and capacity building. One important type of cooperation had taken the form of alliances, both bilateral and multilateral. The universities within these alliances usually share common values, vision goals, commitment, academic diversity, and international collaboration. The Association of Pacific Rim Universities (APRU), International Worldwide Universities Network (WUN), Alliance of Research Universities (IARU), the League of European Research Universities (LERU), and Europaeum, are just few examples of multilateral, global university alliances designed to share common learning and confront common concerns together. The alliances actually offer opportunities for scholars, leaders, academics, and graduates through international conferences, summer schools and colloquia, and enable leading figures from the worlds of business, politics, and culture to take part in transnational and interdisciplinary dialogue with the world of scholarship [11].

Arab universities can benefit from building on longstanding connections between academics in prestigious international universities to further strengthen ties and relationship, research collaboration, student exchange, and a joint postdoctoral programme. Arab universities are also expanding their international reach as an overarching priority of their strategic plans. In fact, many universities are beginning to participate in valuable alliances with other universities across the globe through which these groups undertake joint educational and research initiatives, create international opportunities for students, allow space to work with peer institutions on topics of mutual interest such as research funding, and facilitate good practice sharing between institutional leaders. Accordingly, opportunities of international collaboration are constantly being realized that may be harnessed to tackle global problems effectively. Today, Arab states find it very important to contribute to the institutionalization of the process of internationalization in Arab universities. In order to reach this objective, the strategies and the models for an integrated internationalization management should take into account the regional needs and learn from international experiences, and to contribute to the enhancement of efficient structures that will improve governance procedures within university hierarchy.

5 Ranking of Arab Universities

University ranking implements a number of indicators such as quality of teaching, volume and quality of research, citations per faculty member, faculty-to-student ratio, ratio of international faculty and students, industry collaboration, and number and quality of awards. The most important and influential global rankings are the Academic Ranking of World Universities (ARWU), best known as Shanghai, the Times Higher Education (THE), and Quacquarelli Symonds (QS). All of these global rankings, which usually measure research performance of universities with much higher weight for teaching, and much debate and criticism have been voiced on the validity of the data available.

Arab universities have recently entered the game of ranking and regional systems have been established by QS and THE specifically for Arab universities. THE implements 13 calibrated performance indicators, grouped into five areas: teaching, research (volume, income and reputation), citations representing research influence, international outlook reflecting presence of staff, students and research; and industry income and knowledge transfer. QS Ranking utilizes 10 indicators encompassing academic reputation, employer reputation, faculty/student ratio, international research network, web impact, proportion of staff with PhD, citations per paper, papers per faculty, and proportions of international faculty and students. Egypt and Saudi Arabia have dominated both ranking in 2019 as shown in Fig. 13 due to their large number of universities and available budget in the case of the latter. In the prestigious ARWU, four universities from Saudi Arabia and one from Egypt appeared in 2018. The dominance is again reflected by the number of papers published by universities in Saudi Arabia and Egypt (which are members of the Association of Arab Universities-AArU), in the period 2014–2016, as shown in Table 5, both producing over two thirds of the total research papers in the entire cohort of Arab universities.

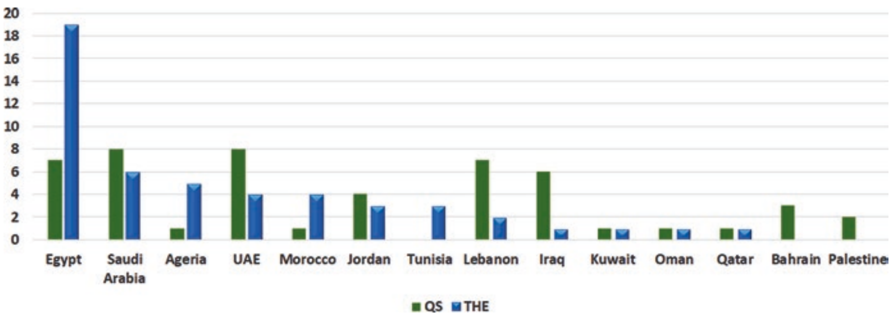

Fig. 13 QS and THE ranking of universities in Arab countries

Table 5 Number of research papers by universities members in AArU, 2014–2016

Country	Number	%
Egypt	47,276	36.11
KSA	39,994	30.55
Jordan	7790	5.95
Morocco	5915	4.52
Iraq	5165	3.95
Tunis	5075	3.88
Qatar	3590	2.74
Emirates	3023	2.31
Algeria	2818	2.15
Oman	2657	2.03
Lebanese	1925	1.47
Kuwait	1779	1.36
Palestine	1302	0.99
Sudan	1126	0.86
Syrian	793	0.61
Yamen	383	0.29
Bahrain	209	0.16
Libyan	96	0.07
Somali	3	0.00
Mauritania	0	0.00
Total	**130,919**	**100**

6 Mobility of Arab Students

In recent years, globalization has fostered the growth of a global higher-education industry. The "Open Doors" report on international educational exchange for the year 2013, for example, states that the number of international students at colleges and universities in USA increased by 7% to a record high of 819,644 students in the 2012/13 academic year, an increase of 55,000 students on the previous year, while USA students studying abroad increased by 3% to an all-time high of more than 283,000 [12]. Currently, international students make up slightly fewer than 4% of the total student enrollment at the graduate and undergraduate level combined, contributing approximately $24 billion to the US economy. The number of students from Saudi Arabia in the USA alone has reached 111,000 in 2014, up from 10,000 in 2007, mainly through funding from the King Abdullah Foreign Scholarship Programme, which allocated more than $2.6 billion (SAR10 billion) for this purpose.

Student mobility is thus one main aspect of Arab higher education that warrants specific note and urgent actions. Arab youth, estimated at 108 million under the age of 25 and constituting an estimated 60% of population [13], is seeking to enter a system of higher education that continues to fall far short from fulfilling the needs of society. This young generation of Arab students has heightened and legitimate expectations but face economic and political constrains that need to be addressed

Table 6 Number of Arab students studying abroad, 2019

Country	Arab	USA	Europe	Asia	Other	Total
Algeria	1580	344	17,700	375	1785	21,784
Bahrain	2667	700	1617	735	0	5719
Egypt	13,600	3461	13,261	1500	0	31,822
Iraq	10,600	1930	12,961	4100	2231	31,822
Jordan	12,000	2288	8204	1500	0	23,992
Kuwait	8100	9703	3206	600	0	21,609
Lebanon	1490	1415	13,107	170	0	16,182
Libya	300	1318	7462	2847	200	12,127
Mauritania	1120	94	3330	100	0	4644
Morocco	1646	1477	43,530	700	1100	48,453
Oman	7530	3024	4437	1000	0	15,991
Palestine	17,500	595	5023	1400	0	24,518
Qatar	1195	1664	3071	450	0	6380
Saudi Arabia	11,866	94,165	21,701	12,182	0	139,914
Sudan	2500	270	9218	500	500	12,988
Somalia	1907	62	1957	1540	0	5466
Syria	23,602	993	18,305	1291	600	44,791
Tunisia	1251	695	18,002	133	0	20,081
UAE	400	3156	6547	1300	100	11,503
Yemen	15,166	730	2549	5563	0	24,008
Total	**136,587**	**128,122**	**216,543**	**38,323**	**6516**	**526,091**

and resolved instantly. In 2002, UNDP issued a report on Arab human development, which called for a radical revision of education systems in the Arab world [14]. In post-World War II era, pan-Arab students' mobility has also been an integral part of Arab higher education since its inception in the middle of the twentieth century when students from all corners of the Arab World found Cairo, Damascus, Baghdad, Beirut, Khartoum, and Fez as favorite destinations to seek university education, which was crucial for socio-economic development of Arab countries. Egypt in particular attracted masses of Middle Eastern students for a long time. By the turn of the century, the share of mobile students studying within the Arab World, for example, increased from 12% to 26% between 1999 and 2012. In total, over 308,000 Arab students studied abroad in 2012, rising to over half a million in 2019 and representing over 4.47% of the total student body in Arab higher education. The majority of these Arab students study in Europe, followed by the Arab countries themselves, then the USA and Asia. Table 6 gives a detailed distribution of Arab students studying in countries other their own.

Many universities in the Arab world are familiar with European higher education through EU funding programmes and through adoption by some countries of the Bologna process which may actually act as a model that could be emulated in the Arab world and a pan-Arab mobility programme has been proposed along the lines of Tempus and Erasmus. There is a growing awareness of the need for a kind of joint framework to enhance all the collaboration going on. In fact, European programmes had shaped protocols and tools for mobility, shared experiences in managing mobility programmes for students and staff, enhanced internationalization, and helped cultivate institutional partnerships. As no such programme exists yet between Arab countries, except for the Arab Council for Training Students of Arab Universities, there is a vested interest in developing and supporting an Erasmus-like mobility programme for the Arab region, which could have a considerable impact on regional cooperation more generally.

Arab countries, particularly in the Middle East and North Africa, were first involved in Action 1 of this programme in 2004. This action was focused on joint master and PhD programmes (138 masters and 42 PhD) which have facilitated training for more than 15,312 students from all over the world during a period of almost 10 years (2004–2014). Only 730 Arab students participated in Erasmus Mundus Acton 1 Programme, which is equivalent to 4.8% of the total scholarships, while Brazil had 622, China 1426 and India 1606 students. For the period 2009–2013, 5300 master students and 440 doctorate students from other developing countries were awarded scholarships. In 2007, Action 2 of the programme was initiated and opened to countries all over the world, focusing on student and staff exchange. The number of projects, in which Arab universities were involved in, exceeded 40 since 2007, starting with projects such as Averroes in North Africa and JoSyleen in the Middle East. Over 6431 students and staff have benefited from scholarships to Europe, including BSc, MSc, and PhD, with a distribution as depicted in Fig. 14.

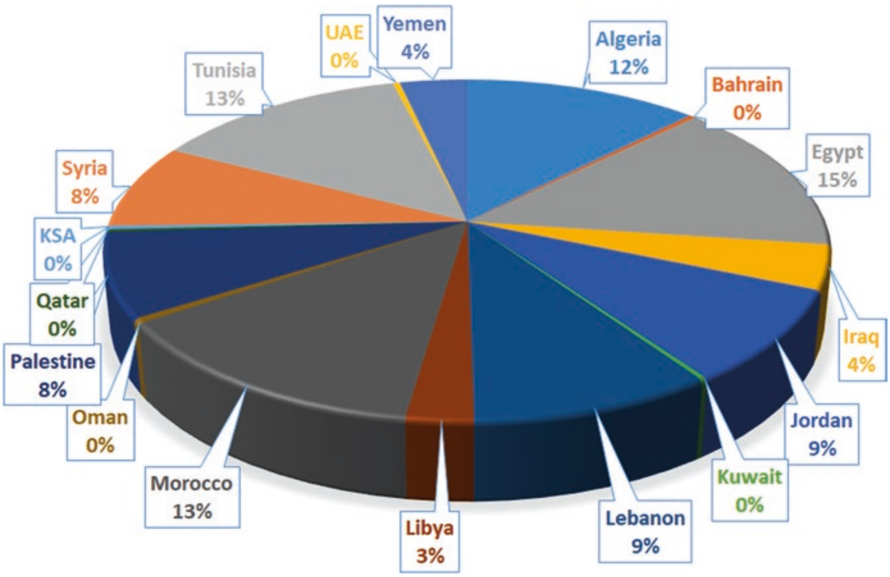

Fig. 14 Arab Erasmus Mundus Action 2 scholarship distribution to Europe in the period 2007–2013

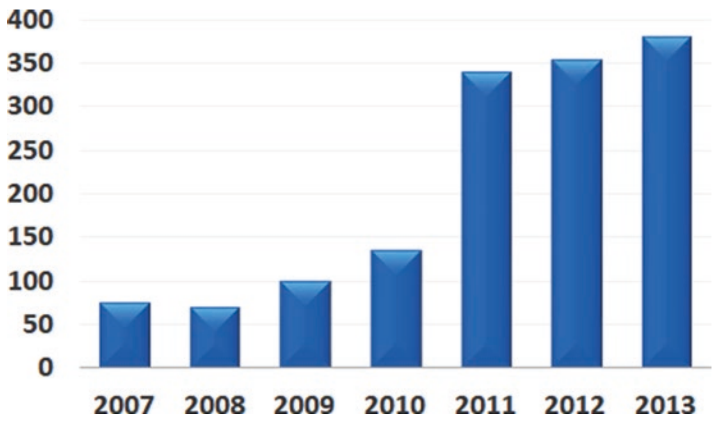

Fig. 15 Number of European Erasmus Mundus Action 2 scholarship to Arab universities

In the other direction, from Europe to the Arab countries, over 1464 scholarships were awarded as shown in the histogram of Fig. 15.

7 Distance and Open Learning in the Arab World

Many initiatives and numerous experiences have emerged in recent years in the field of open and distance learning in the Arab world, and several open and online universities have been established, most notably: Al-Quds Open University; Palestinei, Saudi Electronic University; Saudi Arabia, Hamdan Bin Mohammed Smart University; UAE, The Open Educational College; Iraqi, Open University of Sudan; Sudan, Virtual Syrian University; Syria, Arab Open University; Kuwait, Takwin University of Distance Education; Algeria and E-Learning University; Egypt. However, open and distance learning carries serious concerns to Arab governments and quality-assurance agencies. These include safety of national systems, legitimacy of providers toward protecting users from fake providers, program quality, etc. In addition, numerous challenges and barriers that confront open and distance learning in the Arab world, which can categorized by lack of management and policy issues, human resources, financial, technical, and delivery systems, and pedagogical and student-support services. Future trends of open and distance learning in the Arab world include expected growing enrolments in accredited lower-cost programs, and increased emphasis on lifelong learning to meet the rapidly changing skills needed.

Major reform is needed to overcome challenges such as the integration among Arab open and distance learning universities to benefit from shared experiences and adaptation of an awareness policy regarding the culture of the open and distance learning institutions, namely values, morale, interrelationships, commitment, diversity, and a sense of belonging. It is also important to eliminate employers' reluctance to accept online qualifications. Partnerships with local, regional, and international institutions to provide good facilities to deliver the best courses are essential in building a solid technical and pedagogical base, while upgrading the infrastructure and resources and coordinating efforts among universities to decrease expenses and spread risks. It is also vial to open up new paths to allow online graduate students to pursue further education and transfer credits from traditional universities while setting stringent rules and regulations in order to ensure the authenticity and integrity of qualifications. In technical terms, it is vital to establish specialized centers to design, develop and produce e-Learning material and follow up upon students and staff progress to provide continuous feedback. This necessitates serious revision of promotion and incentive systems to support the process of change, and ensure high motivation of teaching and supervisory staff.

8 University Governance

Arab universities cannot be considered as key drivers of change in Arab societies. As such, universities need to re-think and re-define means and ways to implement strategies, manage institutions, and consolidate achievements. Quality must be on the agenda of all university leaders and decision-makers as it is key to modernize university management, support developments, and enhance performance [15]. In this context, benchmarking has become an essential tool in the quest to measure the extent to which Arab universities follow good governance practices, realize strategies, and achieve goals. In fact, benchmarking is considered as the first step toward building a system to monitor performance and make evidence-based policy decisions. University leaders need indicators and benchmarks to make informed choices for strategic developments and support the competitiveness of higher education institutions on the international scene. This will help in transforming universities to become efficient and effective tools for achieving the demands of current Arab youth, especially producing employable graduates, promoting knowledge and innovation-based economies, and developing a reform process to build open and democratic societies. Concepts and practices of benchmarking have recently emerged as a popular strategic tool to enhance the quality and effectiveness of institutional management. One main objective of benchmarking is to enable Arab universities develop reference points to demonstrate and increase their comparative quality and to follow good governance practices aligned with their institutional standards. Each university may have its own assessment and be able to plan institutional reforms and monitor progress over time, use data to develop policies and systems that encourage good governance.

University governance, a relatively new concept, addresses how universities and higher education systems define and implement their goals, manage their institutions physical, financial, and human resources, academic programs, student life and monitor their achievements. Governance and steering of higher education has evolved in the last two decades, spurred on by the growing number of higher-education institutions, the diversification of their missions, student bodies, roles, and the rise of "new public management" principles [16].

University governance is a key element that can lead to improving outcomes. To initiate reforms conducive to improved outcomes, one needs to analyze university governance. It is also an important driver of change: how institutions are managed is one of the most decisive factors in achieving their goals. Altbach and Salmi report that the important characteristics of successful world-class universities are: leadership, government policy, funding, the ability to continually focus on a clear set of goals and institutional policies, development of a strong academic culture, and quality of the academic staff [17]. Governance patterns are complex and context-sensitive and there is no single model or "one size fits all" approach to university governance. Correlating governance models with performance indicators such as student learning outcomes, skills developed, R&D capacity and insertion in the labor market is critical for policy development and improvement.

One benchmarking tool is the University Governance Screening Card (UGSC) developed through a project supported by the World Bank and the Centre for Mediterranean Integration to assess to what extent Arab universities follow good governance practices aligned with their institutional goals. UGSC was then endorsed as a regional Arab League Initiative during the biannual Conference of Arab World Ministers of Higher Education held in Abu Dhabi in December 2011, and has been so far applied to over 100 universities, public, private and non-for, profit across 10 Arab states in two rounds, one in 2012 and the other in 2015–2016 [16].

The University Governance Benchmarking exercise aimed to identify the governance practices followed by universities in the region and to provide a framework to analyze and compare university governance. It did not aim to evaluate individual institutional performance, but rather to provide an analysis and a reference point, which can guide change and reform. By facilitating a better understanding among universities of the strengths and weaknesses of the governance approaches being used, universities can then identify areas for change. This ultimately helps universities to improve their functioning and performance to better serve the needs of their stakeholders using an instrument that takes into account the underlying principles of transparency, openness, accountability, and voice participation of stakeholders in decision making. UGSC takes into consideration the multidimensional nature of governance and focuses on five dimensions or axes as follows [16]:

Axis 1: Context, Mission, and Goals: which asks questions such as: Is the general mission of the higher education institution stated? Are the specific goals of the institution stated? Where are they stated? Which actors participated in the elaboration of the mission? This axis also contains a section on the legal framework which refers to the country rather than the university and poses questions like: Is there a "National Legal Framework" that defines the status of higher education institutions? How many times has this National Legal Framework been modified in the last 10 years? What is the event that better explains the last changes in the National Legal Framework?

Axis 2: Management Orientation: this refers to strategy, selection of decision makers, performance and evaluation of the staff as well as day-to-day decisions of operating the institution, admission, registration, and certification of degrees for students; appointment, remuneration, and promotion of the academic and other staff; and the construction and maintenance of facilities.

Axis 3: Autonomy: this refers to academic, financial and human resources management autonomy and contains questions on structure of curricula, type of degrees, assessment of students and learning outcomes, format of exams, partnerships with other institutions, hiring, promoting and dismissing of administrative and academic staff, and developing staff training programs.

Axis 4: Accountability: this pertains to the process for evaluating the completion of institutional goals; the dissemination of information; methods used for evaluating the performance of students, teaching staff, administrative staff, and managerial staff; financial auditing; and the process for risk management and dealing with misconduct.

Axis 5: Participation: this analyses to what extent the institution is engaged with the community and stakeholders are represented, considered and what is the role they play in the decision-making process.

Sets of indicators for each dimension were identified as shown in Fig. 16 and a detailed questionnaire was built from which governance indicators can be scored. Then a weighting system was developed to aggregate those indicators and transform the questionnaire onto a scoring instrument in order to record the results per institu-

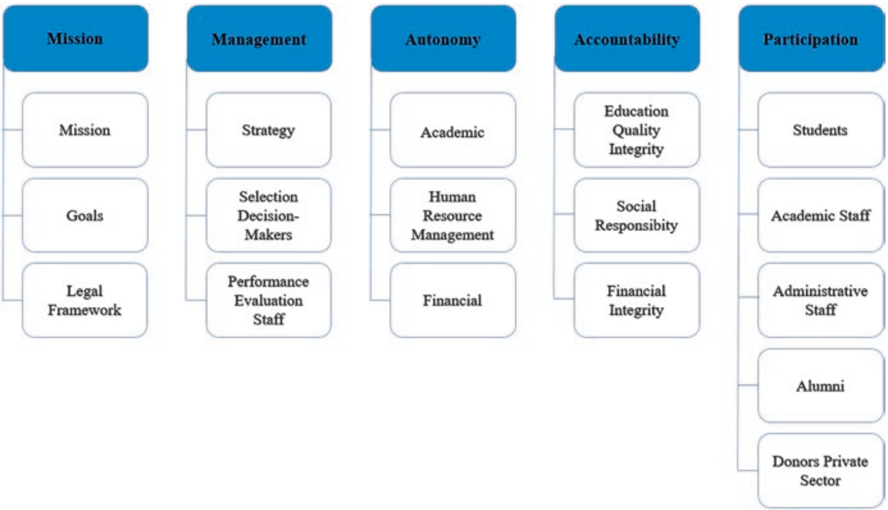

Fig. 16 Dimensions and sub-dimensions of UGSC

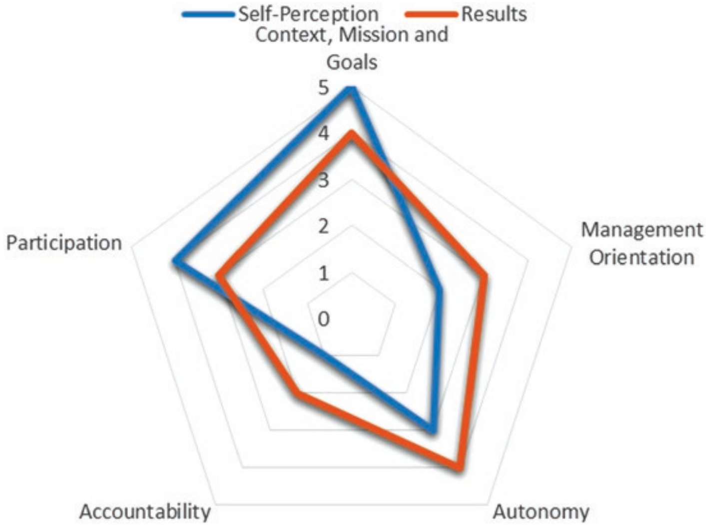

Fig. 17 Hypothetical results from a UGSC

tion. The UGSC does not produce an index of good governance, nor does it provide an aggregate score. In order to present the results, a spider chart was used to provide a visual representation of the university's position on each of the five dimensions. The score in each dimension is conceived as an indication of the universities' situation vis-à-vis one of the global trends in governance practices.

In addition to the questionnaire, the UGSC included a self-perception tool to assess the extent to which universities were aware of the governance model and practices they follow. This was based on a single question per dimension, which respondents rated on a scale of 1–5. Thus each institution has a self-perception report for the five dimensions of governance and a scored result based on the answers provided to the questionnaire. This reveals the degree of alignment between the university's self-perception of its governance practices and a quantitative measurement of them. The UGSC is available online and can be filled and submitted once the institution is provided with appropriate access information. The questionnaire is usually followed by site visits or interviews by focal points personally, virtually or over the telephone. The results are made available to the institution with suggestions and recommendation to allow for monitoring progress and comparison with peer institutions with similar characteristics. Typical hypothetical results are shown in Fig. 17, which compares self-perception and actual results of the questionnaire and interviews [16].

Participating in this exercise has resulted in significant benefits to various stakeholders. In addition to raising awareness among the participating countries on the need to produce, collect, and disseminate performance-related information, this exercise has created opportunities to build large databases and to establish links between governance and other aspects important for policy development. Its most obvious benefit is seen in the formation of the "communities of practice," professional communities that create, validate, and share good practices. Leaders of regional institutions worked together to deepen their understanding of their own institutions and of others. The UGSC provided a framework for dialogue and a sharing of practices, and gave leaders a common set of data and concepts with which to talk about the strengths and weaknesses of their institutions, and to subsequently identify strategies for improvement or change. In a sense, the UGSC provided them with a "language" to discuss the practice of university governance.

For ministries and quality-assurance agencies, communities of practice are cost-effective forums for communication and improvement. They offer the benefit of the effective transfer of good practices between institutions without the administrative burden of central collection and verification of data. Participating universities found the UGSC exercise to be very beneficial. It enabled them to reflect on their models of governance and discover strengths and weaknesses. It also allowed them to identify areas for reform and to initiate concrete actions. Participation elicited a call for action and reform. UGSC has actually been a successful best practice in introducing a culture of benchmarking in Arab universities while identifying various governance models and comparing self-assessment, self-awareness and perception with reality.

9 Conclusions

Major reform in Arab higher education is urgently required in order to serve socio-economic developmental goals in all Arab countries. The state of scientific research in particular remains much lower than national aspirations and as such needs alignment with the actual needs of society and state. Governments must prepare national and regional strategic plans for science, technology and research in order to align all sectors within the state to work together towards common socio-economic objectives. In particular, efforts must be made to transform universities into innovative institutions based on the concept of the knowledge triangle; with its three pillars: education, research, and innovation. Such a model may create a proactive environment for creativity, innovation, and invention, which seem to be absent from the scientific Arab scene for the past five centuries. Arab countries also need to build a system of science and technology in a way that effectively integrates universities and state administrative structures across the national economy and empower scientists and researchers, including the diaspora, to shift from traditional to productive research and innovation through hosting incubators, promoting patent production, disseminating of an intellectual property culture, encouraging technology, commercialization, and spin-offs and establishing cooperation with national, regional, and international enterprises that lead to the foundation of science parks at their premises.

Universities may also play an important role in instituting appropriate ecosystems for entrepreneurship development and support in cooperation with international organizations in order to build the capacity of the academic community and enable it participate in the elevation of the entrepreneurial spirit in the Arab world. In addition, universities may help launch and implement initiatives to assist researchers and entrepreneurs prepare feasibility studies, provide support services and incubators, seek funds, set-up and manage startups, network and exchange experience and knowledge with regional and international partners. Consequently, governments are called to devise and manage a vibrant top-down state structure and hierarchy to implement the strategic plan for science, technology, and research, which should be connected to the state head. In this way, universities are integrated onto the economic and industrial sectors in order to serve the goals and objectives of people, society, and state.

References

1. Al-Zoubi A, Abu-Orabi S (2019) Impact of Internationalization on Arab Higher Education The Role of Association of Arab Universities. J Educ Hum Dev 8(1):69–85. https://doi.org/10.15640/jehd.v8n1a9
2. Hanafi S, Arvanitis R (2015) Knowledge production in the Arab World: the impossible promise, 1st Ed. Routledge Advances in Middle East and Islamic Studies. ISBN-13 978–1138948815
3. UNESCO Science Report: Towards 2030 (2015) https://en.unesco.org/unesco_science_report
4. Cavacin A (2016) Recent trends in Middle Eastern Scientific Production. Scientometrics 109(1). https://doi.org/10.1007/s11192-016-1932-3
5. Moed HF (2016) Iran's scientific dominance and the emergence of South-East Asian countries as scientific collaborators in the Persian Gulf Region. Scientometrics 108(1):1–10. https://doi.org/10.1007/s11192-016-1946-x
6. World Intellectual Property Organization Report: World Intellectual Property Indicators (2016) https://www.wipo.int/publications/en/details.jsp?id=4138
7. Mahroum S, Zahradnik G, Dachs B (2017) Research: Arab inventors make the U.S. More Innovative. Harvard Business Review https://hbr.org/2017/02/arab-inventors-make-the-u-s-more-innovative
8. UNDP Arab Knowledge Report: Youth and Localisation of Knowledge (2014) https://www.undp.org/content/dam/rbas/report/UNDP-GENERAL-REPORT-ENG.pdf
9. Elhedeny A, Moussa G (2016) Brain Drain and educational polices in The Arab World: is there a link? Proceedings of 3rd International Conference on Education and Social Sciences (INTCESS2016), Istanbul, Turkey http://www.ocerint.org/intcess16_epublication/papers/60.pdf
10. The Global Competitiveness Report (2017-2018) http://reports.weforum.org/global-competitiveness-index-2017-2018/
11. Gunn A, Mintrom M (2013) Global university alliances and the creation of collaborative advantage. J High Educ Policy Manag 35(2):179–192. https://doi.org/10.1080/1360080X.2013.775926
12. Open Doors Report (2013) https://www.iie.org/en/Why-IIE/Announcements/2013/11/2013-11-11-Open-Doors-Data
13. Middle East and North Africa: Youth Facts www.youthpolicy.org/mappings/regionalyouthscenes/mena/facts/
14. UNDP Arab Human Development Report (2002) http://hdr.undp.org/sites/default/files/rbas_ahdr2002_en.pdf
15. Mazawi E (2011) The Arab Spring: The Higher Education Revolution That Is Yet to Happen. International Higher Education 65:12–13. https://doi.org/10.6017/ihe.2011.65.8580

16. El Hassan K, Abu Orabi S, Al-Zoubi A (2018) Benchmarking Tools for Good Governance in Arab Universities. Journal of Association of Arab Universities for Higher Education Research 38(2):1–24
17. Altbach P, Salmi J (2011) The Road to Academic Excellence: The Making of World-Class Universities. The World Bank, Washington, DC. https://openknowledge.worldbank.org/bitstream/handle/10986/2357/646680PUB0acad00Box361543B00PUBLIC0.pdf?sequence=1&isAllowed=y

Turnitin: Building Academic Integrity Against Plagiarism to Underpin Innovation

Marwan El-Muwalla and Adnan Badran

Abstract Plagiarism is considered one of the most sensitive issues in academia. Indeed, the increase in the number of research projects conducted worldwide has made awareness of scientific honesty and knowledge of the culture of non-plagiarism a topic of utmost importance for educational institutions and fundamental to underpinning successful innovation and entrepreneurship. Nevertheless, cases of plagiarism are still recorded, intentionally or unintentionally. To this end, multiple software systems, such as Turnitin are used to detect plagiarism. Although the use of this software has become common practice in educational institutions, there are conflicting views associated with the benefits accrued from its implementation. This chapter reviews some of the supporting and opposing views associated with the use of this software, and considers how this medium can encourage scientific research of demonstrable integrity and facilitate its publication and potential exploitation.

Keywords Turnitin · Plagiarism · Scientific honesty · Scientific research · Educational institutions

1 Introduction

It is a well-known fact that knowledge does not operate in a vacuum; rather, it builds on previous knowledge and research. Accordingly, researchers usually rely on the work of their predecessors to develop a theory, a concept, a belief, or an idea. To produce scientifically accepted research results that confirm or refute a proposition, reference to work previously conducted in the same area of study is considered compulsory provided that the researchers acknowledge the original work alluded to in their research. Once reference to works cited is maintained in research papers, academic integrity is achieved.

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According to Fleming and Somogyi [1], academic integrity refers to honesty and transparency in academic writing whereby researchers provide proper attribution to the author(s) cited in their works. Indeed, the growing importance of original research, especially in institutions of higher education, has culminated in more stringent regulations with regard academic integrity, making this practice an integral part of academic research. Consequently, many universities emphasize the concept of academic integrity or dishonesty on their websites as part of their mission statements, and any violation of the institutions' academic integrity rules and regulations can jeopardize a faculty member's academic career path and a student's academic achievement.

Although academic integrity has been given due attention in academia, copying texts or ideas without clear acknowledgment continues to be noted in academic research. Needless to say, in some cases this 'action' may be intentional, while in others it is unintentional and is the result of negligence on the researcher's part. In both cases, this practice is considered 'dishonest' and is regarded as an act of 'plagiarism'.

During the past few years, detecting plagiarism has become one of the challenges that universities face, for many faculty members may not know what plagiarism is or how to detect it. Even when they are aware of this practice, obstacles like the lack of detection tools, time limitations due to heavy workloads, and lack of administrative support may aggravate the problem.

Batane [2] and Walker [3], quoted in Ison [4], point out that there is a wide range of definitions and categorizations for plagiarism. In fact, some sources emphasize that plagiarism involves the unethical reproduction of existing texts; while others are more flexible in the way they view plagiarism, indicating that plagiarism comes in different forms. Some researchers make distinctions regarding whether the suspicious reuse of text was intentional or conducted out of ignorance of proper citation methods or the inability to paraphrase properly. However, there is unanimous agreement that plagiarism is "simply a form of cheating in which copying another's work is not acknowledged or cited properly in the text references" [5]. Yet other scholars consider that plagiarism is also a problem associated with some academic cultures. For example, foreign students using English as a second language borrow phrases and sentences from original work written in English because their paraphrasing skills are weak [5].

Plagiarism is currently considered one of the most sensitive issues in academia since it can affect the reputation of a program of study and deplete a university's time and resources in the process of assessing, evaluating, and managing plagiarism incidents. Ewing et al. [6] claim that since "failing to address plagiarism undermines academic rigor and affects the use of higher order skills," institutions of higher education must give awareness of scientific honesty and the culture of non-plagiarism the attention they deserve. This is the reality because cases of plagiarism are still recorded, whether intentionally or unintentionally, although considerable efforts have been exerted to reduce this 'act'.

Ewing et al. [6] also note that plagiarism at academic institutions is an ongoing problem. In a review of the literature that discusses this practice over the past

60 years with specific reference to student academic dishonesty, the researchers revealed that this practice ranged between 23% and 25% in the 1940s, reached 59% in the 1960s, and witnessed an increase that amounted to between 60% and 76% in the 1990s. The literature also shows that between 63% and 87% of students in secondary schools admitted that they had plagiarized their research. A qualitative study conducted by McCabe, Trevino, and Butterfield [7] confirms the results reached by other researchers regarding student academic dishonesty. The study revealed that out of 4285 college students 75% admitted to some form of plagiarism; a clear indication that the students are aware of their 'dishonest' act, but refrain from doing anything to avoid it. A study conducted by Owunwanne, Rustagi and Dada [8], which surveyed 5331 students at 32 graduate schools in the United States, further confirms the aforementioned results, for the researchers found that between 47% and 56% of the students self-reported cheating and plagiarizing. The researchers attribute the high percentage of plagiarism, especially during the past couple of years, to the availability of information on the internet. McCabe [9] indicates in a study conducted on 70,000 undergraduate students and 10,000 graduate students that 62% and 59%, respectively, admitted that they had adopted the strategy of 'cut and paste' when they used material from online sources in their research.

Researchers, therefore, distinguish between inappropriate copying and dishonesty, and claim that the fine line between these two actions has made some universities abandon the term plagiarism. This is the case because many reviewers and researchers believe that there are levels of plagiarism based on whether this activity is carried out intentionally or out of ignorance of proper citation. Others are of the viewpoint that 'cut-and-paste' from the internet has become a 'common' behavior to the extent that some users claim that information on the internet is public knowledge that need not be cited.

To overcome plagiarism and to help students develop high-quality academic writing and referencing skills, many educational institutions, whether schools or universities, require their teachers to use plagiarism-detection tools. This approach is adopted to enhance students' understanding of plagiarism and provide them with the means needed to avoid such practice in their writing.

Over the years, and with the improvement in information technology, a number of software systems that detect plagiarism have been introduced. One of these systems that is widely used in academic circles worldwide is Turnitin.

2 Turnitin

Turnitin, a tool for detecting plagiarism was launched in 1997 by four university students as a peer-review application. It is an internet-based plagiarism-detection licensed software website, and relies on available databases or memory banks [10].

In 2000, Turnitin.com launched and introduced a plagiarism-prevention service. It has been used successfully for detecting plagiarism in academic environments, and is considered as the best software detection system in comparison with other systems and was rated the highest. Turnitin claims that they are “deterring plagiarism for five million worldwide” [10].

On its website, Turnitin.com presents some important historical milestones; some of these include:

- In 2002 one million submissions in Turnitin’s paper database.
- In 2007 Turnitin’s partners with CrossRef to develop the world’s largest scholarly database.
- In 2007 Turnitin registered 16 million users.
- In 2007 Turnitin’s database reached100 million submissions.
- In 2014 26 million students and instructors used Turnitin globally.
- In 2014 Turnitin’s database reached 500 million submissions.
- Turnitin currently provides convenient plagiarism detection for instructors at 15,000 institutions.

Once the sample of research is uploaded to Turnitin, any overlap with previous work will be detected. When using Turnitin, written papers, assignments, and articles are submitted to the software and are compared to millions of papers, articles, web pages, PDFs and online publications that have been archived in the tool’s databases. Then, Turnitin provides an originality report that identifies percentage of similarity, and the text strings are compared with documents in its database. Identical content is highlighted, underlined, color-coded, and matched to the original source, and similar or matching text is expressed as a percentage; however, careful analysis is needed to make a valid assessment [10].

Although Turnitin is used extensively by members of staff and students in many educational institutions, it has been criticized because of the privacy concerns its use has aroused, teachers’ complaints, and students’ ability to make a few changes to their essays and research papers to avoid accusations of plagiarism. As a result, Turnitin released the writing tool: “Revision Assistant” to solve the aforementioned problems. The new tool works as an assistant for students and allows teachers to see more of what goes on during the students’ writing process.

3 Proponents and Opponents of Turnitin

Although plagiarism detection software tools like Turnitin are employed at educational institutions all over the world, the users of these tools are divided into two categories: the proponents and the opponents. While the proponents only see the benefits and advantages of such a software, the opponents base their opinions on the disadvantages noted when these tools are used.

According to the Turnitin website, this tool is widely used across the education world, and provides convenient plagiarism detection for instructors at 15,000 institutions. Indeed, the website claims that originality checking allows educators to check students’ work for improper citation or plagiarism by comparing it against databases that are updated regularly.

The Grand Canyon University [11] states that Turnitin is a useful tool because every "Originality Report" gives members of staff the opportunity to teach students proper citation; the University also claims that using the software secures the students' academic integrity and safeguards the University's academic reputation. In fact, the University lists a number of features and benefits for using Turnitin,

- Encourages Proper Citation
- Over 12 Billion Web Pages Crawled & Archived
- Over 90 Million Student Papers
- Over 12,000 Major Newspapers, Magazines & Scholarly Journals
- Thousands of Books Including Literary Classics
- Printable Reports
- Side-By-Side Comparison

Oxford University also encourages the use of Turnitin because it can "help students improve their academic writing, paraphrasing, referencing and citation skills" [12]. In fact, Fresen [12] states that the use of this software has been growing among academics and administrators at Oxford University.

On its website, the University of Reading considers Turnitin a tool that helps students with their referencing and a means to university success [13]. The students are given an overview about Turnitin, how to use it, and the advantages gained from its usage to test the integrity of their work, and an explicit invitation to use this detection tool during their enrolment at the University.

The West University of Timisoara in Romania is also an advocate of using Turnitin. Research on the merits of using Turnitin reveals that after adopting the software, two thirds of the plagiarism incidents previously detected were reduced. This is definitely an added advantage in Romania where plagiarism is a "widespread problem in schools and universities" [14].

In his study conducted on plagiarism at the University of Botswana, Batane [2] revealed that there was a "4.3% decrease in the level of plagiarism among students" when they were informed that a plagiarism-detecting tool would be used on their research papers to measure academic dishonesty.

Also, Buckley and Cowap [15], when discussing their research results on plagiarism conducted at a UK University, indicated that the staff identified many advantages associated with the use of Turnitin. For the members of staff, this tool is considered useful in two ways: detection of academic dishonesty and electronic marking.

In contrast, the parties that oppose the implementation of Turnitin in academia claim that this tool is, first and foremost, a commercial entity that "intrudes on privacy without getting permission to copy, reproduce or preserve the databases used." Also, many researchers and students complain that using Turnitin makes them guilty until proven otherwise; a 'feeling' that can hamper the progression of academic research and innovation. Consequently, some Canadian universities and others in the US, like Princeton, Harvard, Yale, and Stanford have decided not to use Turnitin to detect plagiarism [16]. It seems that universities that have a long-standing 'heritage' of academic-integrity awareness do not require their staff members and students to use this software.

Roll [17] quotes Morris and Stommel, of Middlebury College and the University of Mary Washington, respectively, who argue that universities should reconsider the use of Turnitin, questioning "…the control and use of people's data by corporations…" and "…Turnitin's entire business model, as well as the effects on academia brought on by its widespread popularity." They argue that the members of staff who use Turnitin "supplant good teaching with the use of inferior technology reducing the student-instructor relationship to one where suspicion and mistrust are at the forefront."

Roll [17] adds that Morris and Stommel are not the first to criticize Turnitin because it is a business-oriented tool since the IUP Writing Center tutors were amongst the first to recognize and investigate the problems resulting from the use of Turnitin [18]. Furthermore, Morris and Stommel believe that plagiarism software creates an "environment of hostility rather than promoting student learning". They emphasize that it is not the "job of teachers or the job of schools to detect students' plagiarism". Rather, the role of members of staff "should be to meet students on the playground and have conversations about their work … Certainly, if there's an obvious case of plagiarism — and I notice it, and usually I don't need Turnitin to help me notice it — having a conversation with students about where they're at (is) very important."

In addition, the Conference on College Composition and Communication in the USA does not support the use of Turnitin, and the disadvantages of using this software are clearly stated [18]:

1. "undermine students' authority" over their own work;
2. Place students in a role of needing to be "policed";
3. "create a hostile environment";
4. Supplant good teaching with the use of inferior technology;
5. Violate student privacy.

Rafoth [18] states that one of the main problems with Plagiarism Detection Services (PDSs) is that they "Do not differentiate between formulaic text that is necessarily used in the same way in many publications across a discipline, particularly in technical and applied fields, and text that is copied for no other reason than convenience or cheating such as commonly used terms and definitions" [18].

Although researchers are divided regarding the use of Turnitin, one cannot deny that the implementation of this plagiarism detection software has facilitated the publication of research and has resulted in the production of quality research.

Realizing that instances of academic dishonesty and plagiarism have increased due to a rise in the amount of research conducted worldwide, journal editors now rely more heavily on plagiarism-detection software packages in their preliminary decisions concerning the acceptance or rejection of papers and articles. Once the similarity detection index is considered 'acceptable', the work is sent to be peer-reviewed; therefore, these tools have become time-saving devices. Since journals automatically 'reject' papers and articles that exceed the specified similarity index set by the editorial board, these detection tools have greatly reduced the duplication of published work. This has played a positive role in enhancing the production of quality scientific work.

Tools, like Turnitin have made researchers more aware of the importance of academic honesty and the negative consequences of plagiarism. Consequently, researchers nowadays self-test their manuscripts with a plagiarism tool before they submit their work. This ‘activity’ has resulted in literature that is correctly cited and paraphrased, and hence avoids mere duplication of previous literature.

4 Conclusion

When writing a research paper, researchers revert to the work of their predecessors to confirm or refute a proposition. This approach is expected, and is considered acceptable, if the researchers acknowledge the work of others. However, if reference to previous work is not maintained, academic dishonesty or plagiarism takes place. This outcome might be intentional or unintentional, but in both cases, action needs to be taken to avoid this end-result. To overcome such a problem, plagiarism detection software, like Turnitin is used in academia.

Although Turnitin has helped in reducing the instances of plagiarism in academic institutions, it still has many flaws that need to be addressed. For this reason, researchers are divided into those who support the use of this tool and those who oppose it. Nevertheless, Turnitin, and other plagiarism detection tools, have played a positive role in facilitating the publication of quality original research. Such research is the foundation of innovation and the bedrock of entrepreneurship.

References

1. Fleming K, Somogyi P (2012) Student guide – Turnitin FAQ’s. my.navitas-professional http://currentstudents.acap.edu.au/assets/ITACAP
2. Batane T (2010) Turning to Turnitin to fight plagiarism among university students. Educ Technol Soc 13(2):1–11
3. Walker J (2010) Measuring plagiarism: researching what students do, not what they say they do. Stud High Educ 35(1):41–59
4. Ison D (2014) Does the online environment promote plagiarism. A comparative study of dissertations from Brick-and-Mortar versus online institutions. MERLOT J Online Learn Teach 10(2):272–282
5. East J (2006) The problem of plagiarism in academic culture. Int J Educ Integr 2(2):16–28
6. Ewing H, Mathieson K, Anast A, Roehling T (2016) Student and faculty perceptions of plagiarism in health sciences education. J Furth High Educ 43(1):79–88. https://doi.org/10.1080/0309877/2017.13569/
7. McCabe DL, Trevino L, Butterfield K (2010) Cheating in academic institutions: a decade of research. Ethics Behav 11(3):219–232

8. Owunwanne D, Rustagi N, Dada R (2010) Students' perceptions of cheating and plagiarism in higher institutions. J Coll Teach Learn 7(11):59–68
9. McCabe DL (2005) Cheating among college and university students. A North American perspective. Int J Educ Integr 1(11). http://www.ojs.unsa.edu.au/index.php/IJEI/article/download/14/9
10. Turnitin (2018) https://en.wikipedia.org/wiki/Turitin
11. Grand Canyon University (2011) Turnitin: making intelligent decisions about students' originality reports. https://iblog.iup.edu/ctebloggers/sample-page/
12. Fresen J (2007) Building bridges: supporting institutional processes and practice in academic writing, feedback and student assessment. Academic IT Services: University of Oxford. https://www.plagiarism.org/assets/Fresen_paper
13. University of Reading (2018) Academic integrity toolkit. https://libguides.reading.ac.uk/academicintegrity/turnitin
14. Universitatea de Vest din Timişoara (2018) Academic integrity core to university's success. https://www.turitin.com/stories/academic-integrity-core-to-university'ssuccess
15. Buckley E, Cowap L (2013) An evaluation of the use of Turnitin for electronic submission and marking and as a formative feedback tool from an educator's perspective. Br J Educ Technol 44(4):562–570
16. Aujla S (2005) Plagiarism detection service. Turnitin spreads to over 4,000 schools worldwide. The Brown Daily Herald. https://www.browndailyherald.com/2005/10/20/plagiarism
17. Roll N (2017). New salvo against Turnitin. https://www.insidehighered.com/news/2017/06/19/anti-turnitin-manifesto-calls-resistance-some-technology-digital-age
18. Center for Teaching Excellence blog IUP CTE (2018) A critical perspective on plagiarism detection services. https://www.iup/edu/teachingexcellence/faculty-cafe

Innovation and Entrepreneurship in Higher Education: Enhancing Achievement of the United Nations Sustainable Development Goals

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Abstract Axiomatically, advances in education, higher education, and information and communication technology are considered to be great achievements of human endeavor. Such advances are expected to enhance aspirations essential to meet a number of the 17 Sustainable Development Goals (SDG) set by the United Nations General Assembly in 2015, in particular SDG4: "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all". Needless to say, education is a fundamental goal that contributes to fulfillment of several other goals of equal importance. As such, higher education is a major factor in poverty alleviation, SDG1: "End poverty in all its forms everywhere", through enhancing job opportunities, SDG8: "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all". Indeed, it has been demonstrated that illiteracy and poverty are two major factors that produce poor health and poor social development, SDG3: "Ensure healthy lives and promote well-being for all at all ages". It is also known that low literacy impacts on mortality and quality of life.

In this chapter, fundamental changes in education and higher education are outlined, particularly in innovation and entrepreneurship that are needed in order to contribute to the achievement of the Sustainable Development Goals. In this context, some ethical considerations are discussed, and some exemplary SDG4 innovative projects are presented.

Keywords Innovation · Entrepreneurship · Higher education · Sustainable development goals · Ethical values

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1 Introduction

Advances in education, higher education, and information and communication technology (ICT) are regarded as major human achievements that will enable countries to meet a number of the Seventeen Goals of the United Nations 2030 Agenda for Sustainable Development [1].These advances should be characterized by innovation and entrepreneurship, not just at the academic level but also at the applied and technical levels that utilize up-to-date technological tools, benefiting at the same time from best practices at the international level [2].

In Sect. 2 of this chapter, fundamental changes that are needed in education and higher education, particularly in innovation and entrepreneurship, are considered Sect. 3 describes the role of education in enhancing the achievement of the SDGs. Section 4 discusses some ethical considerations arising from innovative scientific and technological advances. In Sect. 5, some exemplary SDG4 innovative projects are presented.

2 Innovation and Entrepreneurship

It is indeed a great step for humanity that advances in education and information and communication technology have resulted in significant improvement in existing education approaches. These include content, methodologies, environment and learning outcomes. As a result of such advances, significant increases in learners' capabilities in innovation and entrepreneurship have occurred compared with past generations, and there have been corresponding significant decrease in illiteracy [3].

In the twenty-first century, universities should adopt strategies that accelerate their transition into the knowledge, entrepreneurship, and innovation-based economy. Such a transition should be based on at least 12 fundamental changes:

(i) It is imperative to stress open-learning systems, using ICT as an effective approach for satisfying the educational noble aims of SDG4. In particular, blended-open higher education, which is locally and internationally accredited, guarantees the highest standard of total quality assurance. The target audience includes all individuals, with special emphasis on adults who became engaged in the business of life without having the opportunity to pursue higher education. In particular, the Arab Open University [4] provides opportunities to those living in rural areas away from traditional universities, especially women. As a result of such open-learning approaches, there are many success stories contributing to the enhancement of human rights, human dignity, and fundamental freedoms [5].

(ii) Most universities tend to offer similar specializations with the same degrees, same curricula, similar requirements, the same course content, and sometimes the same textbooks and references. These universities can be considered campuses of the same university but differ in the quality of their staff and students. There is need for universities to review their programs to introduce greater breadth and flexibility in their undergraduate curricula e.g. breadth requirements accounting for at least 25% of each curriculum.

(iii) Universities should conduct periodic labor-market surveys to assess the needs of the economies of the region for specialization in fields such as management, international finance, entrepreneurship, industrial engineering, maintenance engineering, and computer technology. Universities should develop curriculum to better equip students for work and life in a rapidly evolving globalized world. In effect, the aim is to nurture graduates who think critically, have a broad intellectual base and yet are able to go deeply and rigorously into specific issues.

(iv) Introduce requirements to raise the proficiency of students in a foreign language in line with the needs of an open economy. In addition, this will ensure that a large segment of the student population will be able to benefit from international sources of knowledge. Initiating programs of international staff and student exchange has the potential to promote quality. In effect, universities should provide diverse cross-cultural settings at both regional and international levels.

(v) Develop attitudes and outlook among students, staff, and the public that value quality in services and products; encourage and spread a culture promoting systematically quality attainment and quality control because they are essential for success in an increasingly competitive world economy.

(vi) Establish partnerships with top prominent international universities, through which students have access to the best academic programs and professors in renowned universities around the world. This is achievable either through blended open learning or student-exchange programs.

(vii) The issues of graduate study, research, and the quality of the faculty and therefore the quality of the university are highly interlinked. The research fund in the budget of most Arab Universities is relatively too small to have a positive impact [6]. Hence, universities should substantially increase investments in research funding based on competitively awarded grants to highly innovative projects.

(viii) Establish future-oriented interdisciplinary research areas by linking strengths in humanities and social science with the vast potential of the natural sciences such as engineering and medicine.

(ix) Elevate academic research to global standards through recruitment of top-class researchers and securing cutting-edge research and laboratory equipment and facilities with appropriate funding and other infrastructure vital for the development of the university.

(x) Operate a compensation system for faculty and staff to become performance-based and set at internationally competitive levels.

(xi) Develop very close interaction and collaboration with industry, and an intimate government support in the form of favorable policies and incentives to promote entrepreneurship and innovation projects. Appropriate entrepreneurial activities may include selling services of university professors, ventures in high-tech industries, and commercial utilization of non-essential university real estate.

(xii) Arab universities must secure institutional accreditation and program validation from renowned international accreditation agencies e.g. ABET for engineering and technology; NAAB for Architecture. This requires, as a first step, proper study and assessment of the standards adopted by such agencies. The second step shall require setting proper academic policies and hence taking actions to meet said standards.

3 Enhancing Achievement of the Sustainable Development Goals (SDGs)

The 2030 Agenda for Sustainable Development targets achievement of 17 goals (referred to as SDG 1 through to SDG 17). Needless to say, education at all levels plays a pivotal role in achieving a number of these SDGs. To this effect, the role of education, particularly higher education, will be enhanced by implementing specific innovation and entrepreneurship reform measures, as described in Sect. 2 above.

To start with, it is obvious that quality education will enhance achieving **SDG 4:** "**Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all**". In this regard, provision of innovative lifelong-learning opportunities requires that universities should adopt an open-learning approach and continuous education tracks to suit a wide range of individuals, particularly those with specific location and time restrictions. Moreover, advances in teacher-education, particularly aimed at education for early childhood, are essential for achieving SDG4.

The great value of early childhood education in the development of children's minds, skills, and attitudes is widely recognized. Such a positive impact is clearly demonstrated by sustainable improvement of both the physical and psychological health of children. Not just this, but also it has been concluded in a recent international study [7] that an investment of one US dollar on early childhood education produces a return of (6–17) US dollars. A recent similar study in Jordan [8] concluded that one Jordanian dinar investment in early childhood education is forecast to produce a return of nine Jordanian Dinars, as a result of significant improvement in school performance, and eventual impact on the labour market.

In addition to SDG4, education also plays an important role in achieving several other SDGs. As such, higher education is a major factor in poverty alleviation, **SDG1: "End poverty in all its forms everywhere**". Several studies that demonstrate the value of a university degree in enhancing higher income. Again, higher education enhances, job opportunities, **SDG8: "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all**". It has also been demonstrated that illiteracy and poverty are two major factors that produce poor health and poor social development, **SDG3:**

"Ensure healthy lives and promote well-being for all at all ages". Indeed, an educated prospective mother is less vulnerable to maternal mortality or death of newborns. Such mothers will also welcome access to sexual and reproductive-health services.

Innovation and entrepreneurship in agricultural research at higher-education institutions could also play a major role in achieving **SDG2: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture**". Such advances will certainly increase agricultural productivity and hence increase incomes of small-scale food producers, in particular women, indigenous people, pastoralists, and fishers. Advanced agricultural research is also essential for achieving **SDG 15: Sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.**

Providing quality education, particularly for girls and women in remote and rural areas also enhances attainment of **SDG 5: "Achieve gender equality and empower all women and girls**". Undoubtedly, ICT education for women will enhance the empowerment of women in all relevant fields of application. Higher education will also ensure women's full and effective participation and equal opportunities for leadership at all levels of decision making in political, economic, and public life. In addition, beyond just gender equality, education is essential for achieving **SDG 10: Reduce inequality within and among countries.**

Education is also effective in realizing **SDG 12: "Ensure sustainable consumption and production patterns".** Thus, education is essential for ensuring that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature, and also for supporting developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production. Moreover, **SDG 14: "Conserve and sustainably use the oceans, seas and marine resources"** explicitly calls for increasing scientific knowledge, developing research capacity and transferring marine technology in accordance with the intergovernmental Oceanographic Commission Criteria and Guidelines. Needless to say, higher education and scientific research are the major factors in this regard. Specialized studies and advanced research at the higher education level are also essential for achieving **SDG 6: Ensure availability and sustainable management of water and sanitation for all, SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all, SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable and SDG 13: Take urgent action to combat climate change and its impacts.**

Finally, **SDG 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation** calls for higher education and research through its specific target 5: "enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research development spending".

4 Some Ethical Considerations

It is unfortunate that the benefits of educational advances are not enjoyed equally throughout the world, thus violating the ethical principle that education is a fundamental human right. Such inequities stem generally from poverty conditions that deprive a wide range of human beings from enjoying the highest attainable standard of education. As a result, injustices befall vulnerable and disadvantaged populations, with limited access to educational means, compared with other privileged groups.

Thus, actions must be taken to reduce such educational injustices, though consideration of the most disadvantaged and helping them to improve their education standards.

In brief, it should be mentioned that our aspirations for global fulfillment of SDG4 on education as a fundamental human right depends on the satisfaction of a number of ethical principles. For example, in the area of medicine, life sciences, and associated technologies, such principles (as delineated in three UNESCO Declarations), include: Education and Social Responsibility, Sharing of Benefits, Solidarity and International Cooperation, Justice and Equality, Non-Discrimination and Non-Stigmatization, Respect for Cultural Diversity and Pluralism, Protecting Future Generations and Protection of the Environment and Biodiversity [9–11]. It is worthwhile noting that, in the context of sustainable development, a number of these ethical principles are generally included in **SDG 16: Promote just, peaceful and inclusive societies;** and **SDG 17: Revitalize the global partnership for sustainable development.**

Hence, innovation and entrepreneurship at the higher-education level should require the introduction of a general-requirement course on the Ethics of Science and Technology. In this regards UNESCO has developed such course on Bioethics intended for students majoring in medicine and allied health sciences [12].

The lack of observance of the ethical principles delineated above should not discourage efforts by relevant private and public higher-education institutions to reach out, in their community services role, for vulnerable and disadvantaged populations. This is demonstrated by a sample of five innovative international SDG4-relevant projects, which were submitted to Arab Gulf program for Development: 2017 AGFUND International Prize for Pioneering Human Development Projects. Needless to say, it is proposed that Arab Universities should include in their programs instruction and training on similar innovative community outreach programs.

4.1 Partners for Possibility [13]

This South Africa project aims at providing training for school principals, from under-resourced and consequently under-performing public schools, and who have received little or no management and leadership training. These principals lack some of the key leadership and management knowledge and skills that are required for such a demanding and critical role as theirs. Rather than paying expensive consultants to train school principals, the program taps into an abundant existing resource, namely business leaders who have been well equipped to assume leadership positions and manage change. Such partnership between school principals and business leaders proved to be innovative and very effective in benefiting both parties. While principals benefit from management and leadership training, their business partners gain valuable insight into the immense complexity, ambiguity, and challenges faced by school principals, in addition to the social issues that underlie education. The program includes monthly meetings of the Learning Process Facilitators in each region. To save time and cost of travel, several regular team meetings are conducted via Skype or other on-line platforms. Needless to say, the project has had a profoundly positive impact on participating schools. Clearly, their project addresses SDG4.

4.2 Rural Women's Empowerment Ensuring Lifelong Learning [13]

This project in India aims at empowering rural women on life-long learning, covering vocational training, community engagement, civil society capacity building, financial stability, and repair and maintenance of community-owned and -managed solar systems. The target is to train 200 women solar engineers from 30 of the least-developed countries to fully electrify 200 non-electrified villages, thus improving the quality life of over 200,000 men, women, and children. The innovative component of the project lies in the fact that it never happened before that rural woman from the most-inaccessible village anywhere in the world has been trained to be a solar engineer in 6 months using only sign language. The most significant project impact is that it has been adopted at the state level, and called "Solar Mamas' Project" (since they are selected from grandmothers between the ages of 35 and 50). This is a worthwhile project meeting several SDG's (including SDG4).

4.3 Special-Education-Needs School [13]

This project in Mauritius is remarkable in its effects to empower students with learning and physical disabilities, who would have otherwise not been able to attend school, resulting in enabling them to integrate better in their communities. As such, the project (SENS – Special Education Needs School) is very much in line with SDG's promoting quality education, gender equality, economic growth, and fighting poverty. Project SENS is innovative in its expanded components, including daycare centre and rehabilitation services for students and members of community.

Health professionals are recruited to work as part of unique multi-disciplinary team. Indeed, SENS follows a holistic approach that is not limited to education, but rather extends to the needy in the community. Besides, the project is highly efficient in its leadership, communication with parents, and financial management.

4.4 House of Education [13]

This project in Senegal aims to offer children in situations of vulnerability an educational setting where they will be able to benefit from better conditions to build their future. Such educational settings, including ICT skills, are realized in the "House of Education". In particular, the project targeted the empowerment of little girls, from the most disadvantaged families, to exit from labour market, by schooling them and giving them access to quality, inclusive, and connected education. Such girls originate from villages, or border countries, were driven to the city by the armed conflict which plagued the region for over 30 years, or else driven by great poverty of the countryside. The poverty often forces the little girls to leave school to work as street vendors, domestic servants, or fruit pickers. The positive outcome of the project resulted in having these girls leaving the labour market, attend school at House of Education, and integrate in their city, their country, and the world around them. It should be noted that although the economic situation affects both sexes equally, the phenomenon of child labour appears to be much more noticeable among girls: 13.8% of them compared to 1.8% of boys do more than 28 h work a week. This is definitely a worthwhile project consistent with several SDG's (including SDG4).

4.5 Fast-Track Transformational Teacher-Training Program [13]

This project in Ghana aims at improving the teaching methods and curriculum knowledge for student-teachers and in the following year as newly qualified teachers, and hence improving their professional well-being. The training program includes implementation of the new pedagogy and active play-based learning approach in their classrooms. A direct impact of the project is enhancing the learning outcomes of 4 and 5 years-old school children. The innovative aspects of the project are demonstrated in the new pedagogy for early childhood education, the effective training model, engaging parents and the monitoring and evaluation process. The project proved to be effective in working within the existing government system: colleges of education and Ghana Education Services. Training is delivered by college professors and tutors, in addition to teachers and officers of the Ghana Education Service. The project resulted in positive transformational impact on the early education of the youngest Ghanaian children. The program trained 247 practicing teachers and head teachers, 473 student teachers, and 50 Ghana Education Service officers. Additionally, the program improved learning outcomes of almost 8000 4 and 5 year-old children. The project rightly addresses SDG4.

5 Concluding Remarks

In conclusion, the discussion in the sections above on achievement of SDGs through higher education raises a number of questions.

Will Arab higher education deliver the desired SDGs? What are the main stumbling blocks to the SDGs? Are Arab governments facilitating delivery of the SDGs? In any case, how do you measure innovation and entrepreneurship? How do you establish the necessary changes in attitudes and culture? Can you prioritize the necessary changes? Will the SDGs be superseded and can they be improved?

Some of these questions call for specific targeted research projects. Hence, it is essential that sizable research efforts in higher education should concentrate on innovative approaches to achieve the SDGs. In the Arab Region, in particularly, universities should establish partnerships with incubation management, innovation-promoting agencies, technology transfer, and entrepreneurship support. Besides, governments are called upon to implement policy and measures that improve entrepreneurial environment and hence provide stable funding for innovation and entrepreneurship.

References

1. Hamdan MA (2018) How Education Contributes in Achieving 2030 Agenda. Sixth AGFUND Development Forum (2018). The role of education in achieving the 2030 Agenda for Sustainable Development, 1st March, 2018 Arab Open University, Riyadh, Saudi Arabia. http://agfund.org/sixth-development-forum-role-education-achieving-2030-agenda-sustainable-development/
2. Tan J, Gopinathan S (2000) Education reform in Singapore: towards greater creativity and innovation? NIRA Rev. 7(3): 5–10. https://repository.nie.edu.sg/bitstream/10497/14323/1/NIRA_Review-7-3-5.pdf
3. Engle PL et al (2011) Strategies for reducing inequalities and improving developmental outcomes for young children in low-income and middle-income countries. Lancet 378(9799):1339–1353
4. Hamdan MA (2014) Arab Open University: special experience in founding a regional non-traditional university. The 10th Annual Meeting of The World Academy of Sciences (TWAS_ARO), Alexandria, Egypt 29–30/12/2014 Bibliotheca Alexandrina. https://www.bibalex.org/en/default
5. Hamdan MA (2013) Simple analysis of the "Story" of Arab higher education system. The 9th annual meeting of The World Academy of Sciences (TWAS_ARO), Alexandria, Egypt, 29–30/12/2013 Bibliotheca Alexandrina. https://www.bibalex.org/en/default
6. UNESCO (2017) UNESCO study report on financing higher education in Arab states. http://www.unesco.org/new/fileadmin/MULTIMEDIA/FIELD/Beirut/video/Report.pdf

7. Lilan Foundation (2017) Enabling education: steps towards global disability-inclusive education. https://www.lilianefonds.nl/uploads/media/58c7e40d894ef/rapport-enabling-education.pdf
8. Fink GE et al (2017) Harvard University & Jordan University: economic implications of investing in early childhood care and education in Jordan. Working Paper, Queen Rania Foundation. https://www.qrf.org/sites/default/files/ECD%20Returns%20Brief%20English.pdf
9. UNESCO (1997) Universal declaration on the human genome and human rights. http://portal.unesco.org/en/ev.php-URL_ID=13177&URL_DO=DO_TOPIC&URL_SECTION=201.html
10. UNESCO (2003) International declaration on human genetic data. https://unesdoc.unesco.org/ark:/48223/pf0000136112
11. UNESCO (2005) Universal declaration on bioethics and human rights. https://unesdoc.unesco.org/ark:/48223/pf0000146180
12. UNESCO (2008) Bioethics core curriculum. https://unesdoc.unesco.org/ark:/48223/pf0000246885
13. Sixth AGFUND Development Forum (2018) The role of education in achieving the 2030 agenda for sustainable development, 1st March, 2018 Arab Open University, Riyadh, Saudi Arabia. http://agfund.org/sixth-development-forum-role-education-achieving-2030-agenda-sustainable-development/

Innovations in Creating Incentives for Academic Achievement and Growth: Developing a Compensation Model at the Faculty of Medicine of the American University of Beirut (AUBFM) 1999–2009

Nadim Cortas

Abstract The rapid pace of breakthroughs in discoveries and technology during the last half-century disrupted traditional medical-education systems. As of 1995 at AUBFM, a full strategic assessment defined clear goals and targets aligned to the missions of education, research and patient care focusing on human needs of all stakeholders with the objective of undertaking a major transformational restructuring that made each grow in a financially sustainable manner with a defined timeline. Recruiting the number of faculty members required for the changes implemented after 1991 would have necessitated an unsustainable increase of tuition fees by 1999. Tuition fees increased at the AUBFM from $700 per year in 1960, by 2.24-fold in 30 years, by 12-fold in the next 10 years (1990–2000), while as a result of intervention, by 1.30-fold in the following 10 years and 1.64-fold by 2019. A 55-fold increase in tuition occurred from 1960–2019 while the Lebanon GDP purchase power parity (GDP-PPP) increased by about twofold in the same period. This diminished greatly socioeconomic diversity, reduced significantly the potential pool of applicants to medicine, weeding off potential skill and talent, and changed the character of the profession.

A Medical Practice Plan (MPP) was adopted in 2002 as the centerpiece of Medicine's recovery plan to be the locomotive that drives growth and sets the foundations for growth and financial sustainability. The plan resulted in recruitment of professional change agents and physicians that increased patient workloads and revenues significantly per year as of 2002 and beyond, improving efficiency of the medical institutions.

This chapter focuses on the major transformational changes, 1999–2009, that built the foundations, made a quantum leap forward, set the stage and developed a trend that continues to date. The experience may be helpful to the plethora of emerging universities in the Arab world.

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1 Background

The creation of the first medical school in Lebanon and Syria in 1867, one year after the founding of The Syrian Protestant College (SPC) whose name was changed to the American University of Beirut (AUB) in 1920, was a unique and pioneering endeavor in this region. It reflected the foresight of the founders who realized from the outset the importance of medical education and health care to people, and as an essential ingredient to attract the best students and faculty members not only to medicine but also to the liberal arts undergraduate college.

The founders expressed excellence in building capacities and creating critical masses of people for excellence and growth. The founding medical faculty consisted of five members.[1] The first class of six students, graduated in 1871, studied in a small rented premise with an 8-bed infirmary in downtown Beirut. Practicing medicine initially was part of their missionary activities [1].

The school moved to its current campus when the first medical building finished in 1873. An affiliation agreement was made with the Johanniter Hospital,[2] whereby AUB doctors would provide medical care pro bono in lieu of having the hospital as a practical training and teaching facility for their students. This started a tradition of pro bono care for patients who cannot afford it that lasted for more than 120 years. Medicine then was almost totally physician-dependent with a negligible need for testing. Patients who could afford private care, paid in cash or in kind as shown in Fig. 1, in a photograph taken in 1897 by Franklin T. Moore [1, 2].

The faculty delivered quality medical education, provided exceptional patient care and engaged in research. It was during this period that George Post gave chloroform anesthesia for the first time in Beirut. He also published and edited the first medical journal in Lebanon, Al-Tabib (1874–1914) [1].

Students later came mainly from what is now Lebanon, Syria, Palestine, and Jordan and to a lesser extent from North Africa. Graduates spread practice all over the region, even to some remote villages.

Success attracted growing numbers of patients and practicing physicians to work at AUB, a new piece of property was purchased,[3] the big residence on it was used as a hospital. A nursing school was built in 1905, a women's pavilion in 1908, followed by an eye pavilion in 1909, and the children's hospital in 1910.

[1] Cornelius and William Van Dyck, George Post, John Wortabet, Edwin Lewis and Richard Brigstocke.

[2] A Prussian Hospital built by the Knights of the Order of St. John in Ras Beirut.

[3] From the Adhm (Azm) family.

Fig. 1 Eye clinic. Patients sometimes brought food (Zawwadeh) in basket as fees. November 1897 (Photograph and caption taken from The Moore Collection Franklin T. Moore Photographs (1892–1902), Published by American University of Beirut Press in 2006, Page 84. Note the eggs and olive oil in the baskets)

> *In this early period (1867–1910) excellence was expressed in setting the foundation and building a structure with a critical mass of people that allowed it to consolidate itself and grow. By 1910, a stable structure with human and physical capacities was in place to make a qualitative leap forward. This generation of our predecessors changed the face of medical education and health care in the region and prepared the ground for new opportunities and growth* [1].[4]

The period that followed, 1910–1975, was marked by growth in different directions. The admission requirements and curriculum followed the standards of the American Medical Association as of 1934. Networking with other institutions started through medical conferences as of 1913.

A pathology, clinical pathology, and microbiology building with an amphitheater and a morgue was opened in 1923. In addition to delivering teaching and service, it prepared smallpox, typhoid, and cholera vaccines for Lebanon.[5] An outpatient

[4] Taken from a commencement speech on the hundredth anniversary of the hospital (now AUBMC) given by the author.

[5] The vaccine was prepared at the Department of Microbiology and Parasitology of American University of Beirut.

department (OPD) building with clinics in all specialties was opened in 1932. In contradistinction to patients seen in private clinics or offices, the OPD patients, in the spirit of the Johanniter (Prussian) Hospital agreement, paid no professional fees and were not charged for complete blood counts, routine urinalysis, and stool tests done by students. Each physician gave 1 day a week to attend to patients at OPD assisted by students and later residents. Half a day was spent in general medicine and half a day in the physician's specialty. Admissions from OPD to hospital were cared-for free of professional fee. Inpatients paid 25 Lebanese Pounds[6] in the 1950s (US $8 then, present value in 2019 is approximately US $80) for all laboratory tests performed during their admission with an almost equivalent amount for radiology procedures available then, when needed. Philanthropy partially subsidized these relatively small amounts. Private to non-private hospital patient admission ratio was around one for decades. The physicians, particularly surgeons, gained significant experience and dexterity from the high patient load.

In 1946, full-time faculty appointments were introduced into the clinical medicine departments at AUB,[7] one year after the first formal postgraduate training (residency) program was established. A surgery building with well-equipped operating rooms was opened in 1954 making the total number of hospital beds at AUB 220 [1].

As of 1955, a large number of physicians who completed their residency and fellowship training in the USA returned to Lebanon, many to AUB. Many firsts in education, research, technology, and in various modalities of specialized medical care were thus introduced. The Departments started to grow and differentiate into specialty divisions.

Full occupancy of the of the 220-bed hospital needed 50–60 physicians at the prevailing patient's length of stay (LOS) of around 15 days then. The number would increase as the LOS decreased. Chairs of departments were appointed gradually as full time from 1946 on. The rest of the physicians were given admitting privileges to the hospital but ran their own outpatient clinics/offices. To attract back to AUB the best physicians after completing specialty training in the USA in an affordable manner, physicians were offered full-time salaries for 2–3 years during which time their patient load is built. During this period, their collected professional fees went to the faculty of medicine. Once the load became adequate, they maintained their hospital admission privileges but established their own outpatient practices outside AUB. In return, each physician gave contractually while on salary, 600 h per year at the discretion of the department chair for teaching, research, clinical practice at OPD and care of inpatients admitted from OPD, and 300 h per year when they became fully self-supported by their professional fee income. When on salary, the physician was given the faculty title of rank of clinical (specialty) e.g. assistant professor of clinical medicine, and when off salary it becomes clinical rank of

[6] From a written statement by Raif Nassif, former Director of Laboratory Medicine and the Hospital (AUBMC), on the 100th Anniversary of the AUB Hospital, taken from the Annual reports.

[7] By James O. Pinkston, Dean of the Medical Faculty at AUB, 1944–1950, taken from History Makers in the Health Sciences *from the American University of Beirut*, compiled and edited by Nabil Kronful, American University Press May 2017.

(specialty) e.g. clinical assistant professor of medicine. Since 600 h/year is equivalent to a full-time teaching load and 300 to a part-time load, the latter were also called part-time clinical faculty, vis-à-vis teaching, although all their patient care was at the institution. After 2–3 years, each relieved salary was applied to recruit a new physician. As capacities grew, the tradition that started with the Prussian Hospital extended into more service to the community. AUB physicians of all tracks worked in both government and private (NGO) hospitals on a pro-bono basis with students, residents and fellows. Medical students and residents participated in vaccination campaigns, the most successful in the 1950s that eradicated smallpox and in 1966–67 that almost eradicated polio in Lebanon. Outreach into the community was a primary objective, extending all support to newly established government and not-for-profit non-government hospitals and clinics.[8]

Soon thereafter, with new technological advances, separate charges were applied for various tests and radiological procedures. In the mid to late 1960s, a costing study utilizing the Relative Value Units (RVUs) was introduced,[9] starting with clinical pathology tests. A system that allocated overhead and general service costs, in this case, to laboratory medicine and to radiology was in place. A relative value unit (RVU) was determined for each test/procedure based on direct cost (personnel, supplies, machine cost, and time among others) to perform each test, with the least being assigned 1 RVU and the rest given an RVU value relative in cost to the least [3, 4]. Total cost (direct and allocated) and total RVUs performed were computed independently and the cost per RVU was determined. A cost for each test/procedure was calculated by multiplying the RVU value of the test by the cost/RVU. The costing study was extended to other areas of the hospital, in some cases by applying the cost-to-charge ratio [4]. Items on the cost description master list were billed for private patients at 3-times cost for 1st class patients (one bed/room), 2-times cost for 2nd class patients (two beds/room), and at quasi cost for "ward patients" (two or more beds/room). Ward patients are 3rd class and 4th class patients. 3rd class patients, whose number was small and negligible, paid a physician's professional fees while 4th class patients were cared for without professional fees. The margins levied for Class I and 2, partially subsidized the ward patients. The ratio of private-to-ward patients remained around 1 till the mid 1970s to be disrupted by the civil war in Lebanon and ultimately the growth of the private health-insurance industry in the 1990s, and the health-insurance component of the National Security Social Fund (NSSF). Private and public insurance eliminated this class-dependent charge to cost system by negotiating lower competitive billing prices with volume rebates for private insurances and by fixing the price to be paid for a charge item by NSSF [5].

[8] Such as the Sidon Government Hospital, and among the not-for-profit institutions: the Lebanon Hospital for the Mentally Diseased at Asfourieh, the Hamlin Sanatorium at Shebanieh, the Kennedy Memorial Hospital in Tripoli, the Karaguezian Maternity and Prenatal Clinic in Bourj Hammoud and the Mother and Child Social Center in Ras Beirut. Midwives and students were trained and went for home deliveries. Championed by John Wilson.

[9] By Raif Nassif MD, Chair of Clinical Pathology then and later Director of Faculty of Medicine and Hospital.

The large loads and mix of pathologies of patients attracted by the system prevailing up till the mid 1970s, provided physicians with adequate practice that allowed them to improve their skills and outcomes, produce and publish clinical and basic research, become internationally known, and have opportunity choices for career mobility, particularly to the USA, Canada, and Europe. The undergraduate teaching and postgraduate training programs became robust and successful, attracting top candidates and providing the desired placement choices for their graduates.

The hospital became the first in the region to receive full accreditation by the US Joint Commission on Accreditation of Healthcare Organizations (JCAHO) from 1956–1986 and a member in the American Association of Medical Colleges (AAMC) in 1957. It became a referral center for patients from the entire region and beyond. A new Medical Center (AUBMC) with a 425-bed hospital was inaugurated in 1970[10] and the Diana Tamari Sabbagh Building for the Faculty of Medicine was occupied in 1975. "During these 5 years, AUB medicine reached an impressive stage of development. Research activity increased. Full time faculty reached 89 and hospital bed capacity was held at 95% [6]". An incentive clinical faculty practice compensation plan was introduced in the early 1970s (see below).

In the period 1945–1975, the geographic and social mix of students and patients reached their widest range. Visiting faculty came in numbers from major US medical centers such as Columbia University, Harvard University, and Johns Hopkins University.[11] Medical education was significantly subsidized by clinical practice. All this was achieved by recruiting academicians, professionals, and medical staff that cherished excellence and by having a system that cared for all patients across the socioeconomic spectrum.

Private for-profit hospitals emerged as of the 1950s taking advantage of AUBMC's markups for private patients but they could not build patient loads that would attract the required critical mass of highly trained physicians. Expertise at different levels remained concentrated in the two university hospitals in Beirut, AUBMC and the Hotel Dieu de France complimented mainly by other not-for-profits such as the St. George (Greek Orthodox) hospital and government hospitals, some supported by FM/AUBMC.

The Lebanese civil war from 1975–1992 interrupted the momentum. The Medical Center, however, adapted quickly to war and took care of a large number of victims [6]. Patient care was affected most. The rapid change in the catchment pool, patient load, and mix, made some services downsize while others, such as orthopedic surgery, grow rapidly. The number of occupied beds gradually decreased from around 400 to approximately 170, with hospital floors having to be closed. This resulted in maldistribution of hospital employees, whose total number became relatively large. Significant variations, discrepancies, and inequity in remunerations of faculty members/physicians and employees of equivalent status, resulted from the stepwise and profound devaluation of the Lebanese pound (1984–1993). During this period, the hospital was reimbursed through Government (National Social

[10] Built by the United States Agency for International Development (USAID) funds.

[11] Exchange programs partially funded by the US based Rockefeller Foundation and the Commonwealth Fund.

Security Fund, NSSF and Ministry of Health, MOH) funds, direct contributions, or indirect through warring factions, non-government organizations (NGOs), and self-pay [5].

After the fighting stopped in 1991, financial contributions gradually decreased and after few years, NSSF and MOH funds started to deplete. In the meantime, the private medical insurance industry in Lebanon started to grow aggressively. They convinced self-paying patients that they would provide them with the same care if not better for less money at the same hospitals they go to and that they would have oversight for quality and efficiency of care. The shift of a significant number of self-payors to private insurance companies that negotiated better deals with hospitals, eliminated the subsidy for poor patients and diminished the capability of Faculty of Medicine and AUBMC to give physicians salaries and indirectly subsidize medical education. The NSSF and MOH with time could not keep up in providing poor patients with the same standard of care.

In the meantime, the rapid pace of breakthroughs in discoveries and technology during the last half-a-century resulted in major disruptions in the steady states of both patient care and traditional education systems. Methods involving process analysis, quality assurance, and performance improvement became too slow to incorporate rapidly generated relevant knowledge and new technology while eliminating the obsolete, a process of entrepreneurship and innovation had to be factored in. This produced redundancies and omissions in medical-education programs, which in addition to costs of new technology incorporation and decreased subsidy from clinical practice, resulted in a very high rate of increase in the cost of education. Tuition fees increased at the AUB Faculty of Medicine (AUB-FM) from $700 per year in 1962–63 to $1570 in 1990–91 (by 2.24-fold in 29 years), to $18,599 in 1999–2000 (by 12-fold in 10 years), and as a result of intervention, to 24,208 in 2008–09 (by 1.30-fold in 9 years) and to 39,755 ln 2018–19 (by 1.64-fold in 9 years). Tuition fees increased 55-fold from 1962–2018 while the per-capita gross domestic product (GDP) in Lebanon increased by about 2–3-fold and the GDP purchase power parity (GDP-PPP) by about twofold in that period. To attenuate the rate of rise of tuition fees, the number of students per class was increased from 40 students in the 1960s, to 60 students in the 1970s through the 1990s, to 80 students by 2008–09 and 112 students by 2018–19. Increasing the number of students per class to attenuate the rate of rise of tuition was only marginally effective, particularly through the 1990s. The resulting marked increase in tuition fees diminished if not eliminated, socioeconomic diversity and significantly reduced the potential pool of applicants to medicine. This also occurred in the USA [7]. In the US, where students have access to loans, the increased amount of debt at graduation, shifted specialization choices by necessity to money-generating fields resulting in shortages in highly needed less money-making specialties. The return on investment for specialties like family medicine and psychiatry became too low to pay loan debts and maintain one's standards of living [8, 9]. New York University (NYU), declared in 2018, that it built an endowment of $600 million (m), to generate at 4% annual utilization, the tuition fees for its 600 medical students as of next year [7], and the College of Physicians and Surgeons at Columbia University (P&S), built an endowment of $250 m to eliminate the need for prohibitive student loans.

2 Impact of Cost of Faculty Recruitment at AUBFM 1993–2000

At AUB-FM, recruiting, for example from 1993–2000, the number of faculty members required to meet teaching and patient-care demands increased significantly the cost of education. Total annual faculty salaries as shown in Fig. 2, increased from $4 m to $7.5 m and, plus benefits, from $5.2 m to $9.8 m. This would have necessitated an unsustainable increase of tuition fees to $34,000/year, unsustainable for Lebanon in 1999, to cover the cost of educating 280 medical students. Without such faculty recruitment, however, neither teaching nor patient care requirements will be satisfied.

The rate of increase in costs for both education and patient care, became significantly higher than the rate of revenue generation and the resultant structural deficit threatened the future of the medical enterprise at AUB. The Medical Institutions at AUB needed major restructuring to move away from a consolidated status quo that became unsustainable, and to engage in a process of sustainable growth that puts them at par with peer institutions in the USA.

3 Planning for Recovery

As of 1995, a process of observation, prototyping, sketching, and brainstorming was launched to define clear targets in all programs of education, research, and patient care focusing on human needs of all stakeholders. The objective of which is to achieve a plan for major restructuring in each area, aligning human needs with what is feasible and sustainable. The process started by identifying what needs to be done urgently while going through a process of self-assessment, reviewing the guiding statements followed by strategic planning and preparation for the various accreditations and reaccreditations sought.[12] The major functions studied for each program included the optimal number of people required with definition of peoples' excellence, the enabling facilities to be established, the state-of-the art technologies needed and to be transferred, the plan to become compliant with best practices of peer institutions and provide the best client services. A market analysis with surveys for satisfaction, institutional choice, awareness, and visibility had to be conducted. During all this process, the working groups for each program made sure to define the actions to be taken for each objective with defined goals and timeline for each of

[12] US Middle States Association for the Faculty of Medicine as part of the University, Joint Commission International (JCI) for the Hospital, Magnet for the Nursing Service, The College of American Pathologist (CAP) Accreditation and when available to foreign Medical schools, The Liaison Committee on Medical Education (LCME) accreditation or equivalent for the Faculty of Medicine and the American Council for Graduate Medical Education (ACGME), currently available as ACGME-i for international Faculties of medicine.

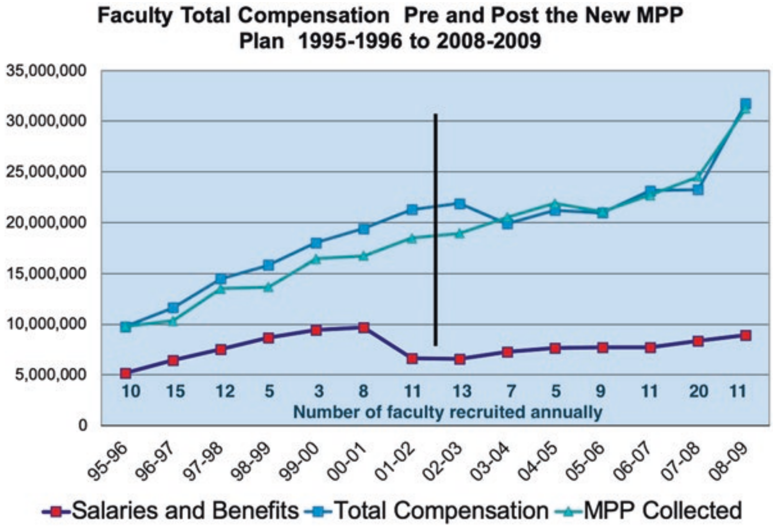

Fig. 2 Total faculty basic salaries paid by the Faculty of Medicine and take home (total compensation) increase with time and number of faculty. The additional faculty recruited each year is shown on the X-axis in orange from 1995–2009, before and after introduction of the Medical Practice Plan (MPP), marked by a vertical line. Change in total basic salary is shown in the bottom curve ─■─. The light blue intermediate line is the total professional fee (MPP) collected ─▲─ and the top darker blue line shows the total compensation ─■─ (take home) for physicians

the targets to be achieved, measured by key indicators. The objectives include achieving compliance with standards of the desired accreditations.

The process was facilitated by two teams funded by the Ford Foundation[13] invited by President of AUB, John Waterbury: an international health care consulting group, the Joint Commission Worldwide (JCW)[14] for the hospital and an Academic Review Team chaired by Paul Griner, M.D., and included Torsten Wiesel, M.D., a Nobel Prize Laureate.[15] The Academic Review team reviewed critically and analyzed the strengths, weaknesses, opportunities, and threats (SWOT analyses) presented by heads of departments and programs, interviewed stakeholders (students, faculty, trainees, and leadership), reviewed programs and presented their report in 1999. The JCW Report presented in 1998, included in section one a proposed timeline for actions, shown in Fig. 3.

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[13] Funded by the Ford Foundation.

[14] The Joint Commission Worldwide (JCW) and Health Care Consultants, USA, were invited by AUB President John Waterbury in 1997 to review the AUBMC, and concluded their work in 1998 by an extensive report entitled “AUBMC, Strategic and Operational Assessment.”

[15] The Academic Review Team included. Paul Griner, M.D., Chair, J. Robert Buchanan, M.D. Ramsey Cotran, M.D. Linda Lewis, M.D. George Thibault, M.D. Torsten Wiesel, M.D. Their Report was submitted to AUB in 1999.

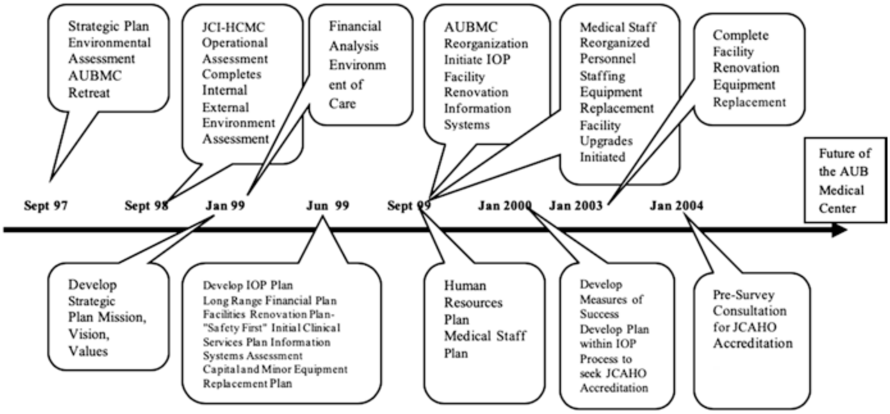

Fig. 3 Actions and timeline to achieve JCI accreditation presented in the JCW Report in 1998

The self-study was followed by a strategic planning process that involved 23 strategic planning groups with 189 members/106 individuals. Members of the different groups included physicians, nurses, basic scientists/researchers, non-academic employees, and students among other stakeholders for some groups, worked together to come up with innovative and sustainable ways to grow and chart the future of education, research, and patient care at the Faculty of Medicine and the Medical Center. The following accreditations were obtained by 2009: US Middle States Association for the Faculty of Medicine as part of the University, Joint Commission International (JCI) for the Hospital, Magnet for the Nursing Service, and that of the College of the American Pathologist (CAP). A significant investment and effort was made during this planning process with the help of visiting teams from Johns Hopkins University, to make the postgraduate program compliant with ACGME guidelines and received ACGME-i accreditation in 2014. The medical education program is largely compliant with the Liaison Committee on Medical Education (LCME) guidelines that does not accredit non-USA faculties of medicine. Recent US legislation requires an equivalent accreditation for non-US medical schools whose graduates wish to pursue their training in the USA. This is provided by the Association for Evaluation and Accreditation of Medical Education Programs based in Turkey with a Turkish acronym, TEPDAD and accreditation was obtained by AUB FM in 2018.

In addition, a US consulting firm, MGT of America, supported the working groups in documenting the programmatic elements of the plans and assisted in establishing projection methodologies. These plans were the basis on which Sasaki, Machado and Silvetti Associates Inc.,[16] established the University Facility Master Plan, including that for the medical campus.

[16] Sasaki, Machado and Silvetti Associates Inc. an Architecture and Engineering firm, registered in Boston MA assisted by MGT of America Inc., a US consulting firm for documenting program requirements with future projections were invited by President John Waterbury to establish a com-

A comprehensive Strategic Plan was submitted to the President of the University and the Board of Trustees in 2007, with a 20-year horizon, updated in 2009. A short version, the Medicine Strategic Plan overview was circulated to all members of the Faculty of Medicine.

4 Urgent Issues: Establishing an Equitable Compensation Plan

The most imminent urgent matter turned out to be the very wide range of renumeration for individuals that are of equivalent status, merit, and seniority. The major identified cause for the differences was the value of the Lebanese Lira (pound) vis-à-vis the US dollar at the time of appointment. The Lira devalued, with significant fluctuations, as of 1984 from around 5LL[17] to the dollar to a nadir of 2500 LL to the dollar in 1992 (500-fold drop) and was pegged to the $ USA at around 1500 LL/USD since the end of 1997.[18] Adjustment to salaries by the institution during this period could not but lag from being totally corrective in both directions. The devaluation also affected the clinical compensation plans for physicians.

The first clinical-compensation plan, “Incentive Plan” was introduced in the early 1970s to supplement the full salaries given to full-time practicing physicians.[19] The initial plan allowed physicians to retain up to 40% of professional fee revenue to a ceiling equivalent to doubling one’s salary. The plan succeeded in increasing significantly the workload of physicians but the rate of increase plateaued once the ceiling was reached. The increased workload also generated higher income to the hospital with the net being greater than before the plan. Ceilings were reached, however, within the first 6 months of the year for a significant number of physicians in surgical specialties whose work then slowed down and with some, the overall return to the hospital as compared to pre-plan diminished. This made the Incentive Plan Committee modify the plan to one that started with a 70% take-home pay to the physician and went down by 10% for each successive 20,000 LL bracket and remained at 10% for professional fee income above 100,000 LL. i.e. no ceiling. In addition, to provide further incentive for high earners, a carrot was placed at 180,000 LL professional fee earnings, at which and above, take-home pay will go up from 10% to 30% of the professional fee revenue continuously thereafter. This plan increased the workload per physician and the utilization of the hospital and its services significantly.

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prehensive facility master plan for the whole university. The campus plan is published at www.sasaki.com/project/163/amercan-university-of-beirut-campus-master-plan/

[17] For decades before, the rate was quasi stable at about 3 Lebanese Lira (LL) to a US dollar.

[18] Banque du Liban (BDL) history of the Lebanese Lira (pound) exchange rate with the US dollar, published on the web.

[19] All physicians that are appointed as full time by the Faculty of Medicine have an academic title and given practice privileges at AUBMC.

The Lebanese civil war, 1976–1991 however, changed the patient mix and with the marked devaluation of the Lebanese Lira, the set brackets for the 'Incentive Plan' lost their significance. The plan was dollarized after the fighting stopped in 1991 as follows: in the first bracket of $20,000, 70% will go to the physician and 30% to the institution, in the second bracket of $20,000, 60% will go to the physician and 40% to the institution, thereafter and above $40,000 of professional fee earnings, the amount will be split at 50% for each. An end of service (pension) of 12.5% of the physician's earnings was taken from the institution's share and placed in a provident fund. This yielded around 40% to the institution at the early 1990s, during the relatively lower professional-fee income periods, and increased to 46% with the higher professional fee yields i.e. from an average of around 60% down to an average of 54% to physicians, respectively.

In 1999–2000, for example, total professional fee collected was $16,112,750 of which $8,723,630 (54.1%) was distributed as supplemental compensation to physicians and $7,389,120 (45.9%) went to the FM/AUBMC of which, $1,090,453[20] was deposited in a provident fund for end-of-service indemnity (pension) and the remaining $6,298,667 (39% of total collected) was used to cover the total cost of the private outpatient clinics (offices) amounting to $1,600,000/year, and part of the physician's fringe benefits amounting to $1,030,000/year.[21] The balance of $2,630,000 was used to cover the cost of around 34 FTEs for FM/AUBMC with a remaining balance of $268,667 going for miscellaneous costs.[22]

The self-study and work on the strategic plan showed by 1999 that the curriculum leading to the MD degree including the graduate program in basic sciences leading to an MS degree require 60 FTEs and the hospital requires 21 FTEs for various functions described in the JCW Report (1998), amounting to a total of 81 FTEs for FM/AUBMC. In 2000–2001 as shown for Table 1, the FM was paying for 97 FTEs and AUBMC 34 FTEs, and therefore, in addition to the 81 FTEs required for the various academic and hospital functions, FM/AUBMC were paying for 50 FTEs of practicing physicians who by 1999 were not making their money, while retaining them on board however, was extremely important to achieve a turnaround at AUBMC. The rate of increase in costs of patient care and medical education became higher than the rate of increase in patient revenues and student tuitions. The number of open beds at AUBMC had dropped gradually to 170 beds from 400–425 as of the 1980s. Patient referral from private insurance, NSSF, and MOH attenuated billing rates and with the latter two, very large receivable accounts had accumulated by 1999.

The annual structural deficits of the medical enterprise at AUB were increasing rapidly. A number of options for recovery floated around ranging from shifting all clinical faculty to part-time status, relieving the University from all salary and

[20] End of service indemnity is 12.5% of physicians take home from the plan and is given, with its appreciation, as a lumpsum upon retirement as per policy.

[21] Trips to conferences for faculty members $ 500,000 in 1999–2000 and Education allowances to children of faculty amounting to $ 530,000 in 1999–2000.

[22] Registration fees in the Order of Physicians as an example.

benefit liabilities and, as in the past, each faculty member would provide a certain number of hours of teaching and administrative duties to the institution in return for admission privileges, and downsizing the Faculty of Medicine. The hospital will then expand by giving privileges to a growing number of self-supporting part time physicians as it opens more beds.

Another option was to spin off the medical center with its liabilities to be run independently by its stakeholders with an independent board of governors/trustees. None of these became serious options because the cost of implementation of any of these options to the University would be much greater than making the investment through absorbing deficits for a period of time, and pursuing the conjecture and projections of the emerging strategic plan. The plan that was initiated in 1994 by re-establishing the research enterprise and later on facilitated by the JCW and Academic Review Committee Reports of 1998 and 1999. The resulting strategic Plan was presented to the BOT in 2007.

The center piece of this strategic plan, was to radically transform the existing "Incentive Plan," run by the University that owns the professional fees, determines the proportion that would be distributed to physicians, decides on how the remaining money is spent and assumes all liabilities including those for fringe benefits and end of service indemnity, into a comprehensive Medical Practice Plan (MPP) whose participants, the full-time active physicians with Faculty of Medicine appointments, collectively called "MPP Participants," assume all practice costs and liabilities. These costs include the physician's practice costs, fringe benefits, essential professional career development support for each physician contributing to the plan, and provoding support towards the mission of the Faculty of Medicine and the AUBMC. In return, the University gives the MPP participants, represented by an MPP committee, through the Dean of the Faculty of Medicine, the authority to run the MPP according to approved Rules and Regulations with the oversight of the President of the University and its Board of Trustees. The growth of the practicing clinical faculty as per the mission and strategic plan of FM/AUBMC becomes dependent on the growth of the MPP. The first step was to shift 50 practicing FTEs to the MPP. The projected time frame is shown in Table 1.

Table 1 Projected number of FTEs to be shifted to the Medical Practice Plan (MPP) to become self-supporting, to decrease the support of the Faculty of Medicine to satisfy the 60 FTE requirement for acdemic functions and AUBMC to 21 FTEs for clinical functios while providing the opprtunity for increasing practicing physicians in different specialties by growth of the MPP. For projection purposes, the total number was kept at 131. Projections made in 1999–2000 for 2000–01 until 2004–05. The desired planned distribution is projected to be achieved by 2003–04

	FM	AUBMC	Self-supporting (MPP)	Total
00–01	97	34	0	131
01–02	60	28	43	131
02–03	60	22	49	131
03–04	60	21	50	131
04–05	60	21	50	131

After extensive financial analysis, legal preparation of all documents, consensus building among physicians and approval of the BOT, the plan was implemented in 2002–03 for clinical departments and in 2003–04 for clinical support departments,[23] preceded by a trial "mock" year for each during which the current and new scenarios were presented in parallel.[24]

A condition for the successful establishment of the MPP was that it would initially neither favour the physicians nor FM/AUBMC but be for the good of all. This was satisfied by transferring the expenses that were paid by FM/AUBMC from its share of the collected "Incentive Plan" revenue to the MPP (MPP participants) together with the transfer of the total collected professional fee revenue to the MPP participants as shown in a scenario in Table 2.[25] The left column shows the current "Incentive Plan" collected revenue distribution, and how the portion ($7,389,120) going to FM/AUBMC is spent. The cost of the clinical facility refers to the total cost of the outpatient private clinics operation including manpower and equipment as per JCI standards. Children Educational Allowances refers to the K-12 tuitions paid as a benefit for faculty members at AUB and, conferences abroad, refer to travel and registration expense paid by the institution for one conference per faculty member per year. The right column shows the scenario for the new MPP. All collected professional fee revenue (in this case $16,112,750) will be transferred to the MPP participant's as per its rules and regulations. The end of service indemnity is deposited in a provident fund and the children's K-12 support allowance and support for conferences are placed in a Medical Dean's Development Fund. The end of service indemnity will be administered by the University and the rest, by the FM Dean's office. The cost of the private outpatient clinical facility ($1,600,000 in Table 2) will be divided by the total number of half days available in the facility to determine cost of utilization of half a day per week for a whole year. Deductions will be made on a monthly basis from each physician's earnings for the time of committed use during the year. The cost of facility is paid to AUBMC.[26]

To satisfy this condition further, it was determined as show in Table 1, that the 60 FTE requirement for the teaching enterprise is fairly stable since the number of students is a quasi-controlled fixed variable and the ratio of students to teachers does not vary much over time, the same is true for the 21 FTE requirement for the running of up to a 425 bed hospital within AUBMC. In contrast, at a targeted patient's length of stay (LOS) of 3.6 days, on average, one physician is needed to keep one bed fully occupied during 1 year. The average outpatient load per physician at AUBMC is around 1000 outpatients per year with a mean admission rate of 10%. To open the 425 beds at AUBMC, a gradual increase of recruitment to reach

[23] Pathology and Laboratory Medicine, Radiology, Radiotherapy and Anesthesiology.

[24] About 90% of full time clinical faculty members signed the documents in the trial mock year and the rest by the second year. The trial year in effectively became the initiation year.

[25] The scenario that shifted the authority and liability of professional fee revenue from FM/AUBMC to the MPP participants.

[26] Each physician had to commit usage for a year e.g. 3 half days per week for a year but may change the commitment for each coming year as a function of anticipated loads.

Table 2 Distribution of collected incentive plan revenues in 1999–2000 compared to the projected scenario of distribution of the same amount by the new MPP

Distribution of collected "Incentive Plan" revenue in USD 1999–2000					
	Incentive plan USD	% of collected		New MPP USD	% of collected
Total collected	16,112,750		Total collected	16,112,750	
Distributed to physicians	8,723,630	54.2%	Distributed to physicians		
Distributed to FM/ AUBMC	7,389,120	45.8%	Distributed to FM/ AUBMC		
End of service indemnity	(1,090,453)		End of service indemnity	(1,090,453)	
Balance 1	**6,298,667**	**39.0%**	**Balance 1**	**15,022,297**	
Cost of clinical facility	(1,600,000)		Cost of clinical facility	(1,600,000)	
Children's education allowance	(530,000)		Children's education allowance	(530,000)	
Conferences abroad	(500,000)		Conferences abroad	(500,000)	
Balance 2	**3,668,667**		**Balance 2**	**12,392,297**	
Salaries and benefits for 34 FTEs	(3,400,000)		Distribution to physicians	(8,723,630)	
Balance 3	**268,667**		Medical dean's development fund MDDF	(1,611,275)	10%
Registration fees and other misc expenses	(268,667)		Departmental operating fund DOF	(805,638)	5%
Balance 4	**0**		**Balance 3**	**1,251,755**	
			Adjustments for transfers with FM/ AUBMC	(1,251,755)	
			Balance 4	**0**	

around 425 physicians, will be in line with the mission and the strategic plan, to establish the envisaged patient focused centers of excellence and develop group practices to improve skills. This clinical growth will be driven by the MPP and will parallel its growth. Growth will initially fill newly opened beds but ultimately primarily drives the growing outpatient and same day ambulatory loads. The support services within AUBMC will be expected to grow fast with ambulatory practice expansion. With the establishment of the new MPP, the Faculty of Medicine paid each physicians for the proportion of her/his effort in teaching and academic administration,[27] this showed a projected drop in the teaching and academic

[27] Full teaching load per academic year is considered as 12 credits. The number of credits a faculty member teaches will determine the % teaching effort and the hours spent on administrative academic committees will determine the % effort in academic administration.

Table 3 Projections made in 1999–2000 for the assumptions in FTE transfers to 60 FTE for teaching, paid for by FM (from student tuition), 21 FTE for AUBMC and the rest as self-supporting through MPP with a planned annual growth in 000 USD

	99–00	00–01	01–02	02–03	03–04	04–05
FM	7171	3077	3077	3077	3077	3077
AUBMC		2088	1719	1351	1290	1290
Self supporting (MPP)		2994	3376	3758	4141	4523
Total	7171	8159	8172	8186	8508	8890
Total (FM/AUBMC)	*7171*	*5165*	*4796*	*4428*	4367	4367

Actual salaries may increase by merit and cost of living determinants

administration payroll from around $7,171,000 to $3,077,000 as shown in Table 3. The hospital (AUBMC) paid ultimately for 21 FTEs, distributed to physicians in proportion to the effort of each in clinical administration. An effort analysis tool was developed for this purpose [5].

5 Medical Practice Plan Income Distribution

Collected professional revenue (inpatient and outpatient) will be distributed as shown in Fig. 4. Collections are pooled and up to 30% are set aside for deductions for Indemnity provision, cost of use of outpatient facility, malpractice insurance, deductions of benefits,[28] the Medical Dean's Development Fund (MDDF), and the Department Operating fund (DOF). The MDDF consists of 10% of the collected professional fee revenue, under the discretion of the Dean, that supports the physician/faculty career development, research, trips to conferences, the guaranteed initial income of new practicing faculty recruits, and supports the academic mission of the FM. The Department Operating fund (DOF) consists of 5% of the collected professional fee, supports new recruits for the first 2–3 years until they make their income and pay it back later indirectly, and the academic mission of the department. The remaining 70% balance is pooled in Fund A, to be distributed to physicians labeled the department MPP Fund (A in Fig. 4). All of Fund A goes to physicians within the year, to be paid monthly, partly as MPP on account (D), part of the guaranteed floor income (F) and the variable income (B), keeping 15% labeled as the Departmental Reserve Fund (G) to be paid to Physicians by the end of the year. The floor income includes in addition to the MPP on account, the portion from FM for teaching, research and academic administration effort (B) and the portion from the hospital for clinical administration effort (C). All revenues, shown in Funds F, E and G, in Fig. 4 below are distributed to each physician through a clear, transparent, and contractually binding distribution plan from which taxes and other payroll deductions are made. It is important to note that with this plan, the direct take-home

[28] As defined in the Statement of Policies on Benefits and Allowances for Academic Personnel.

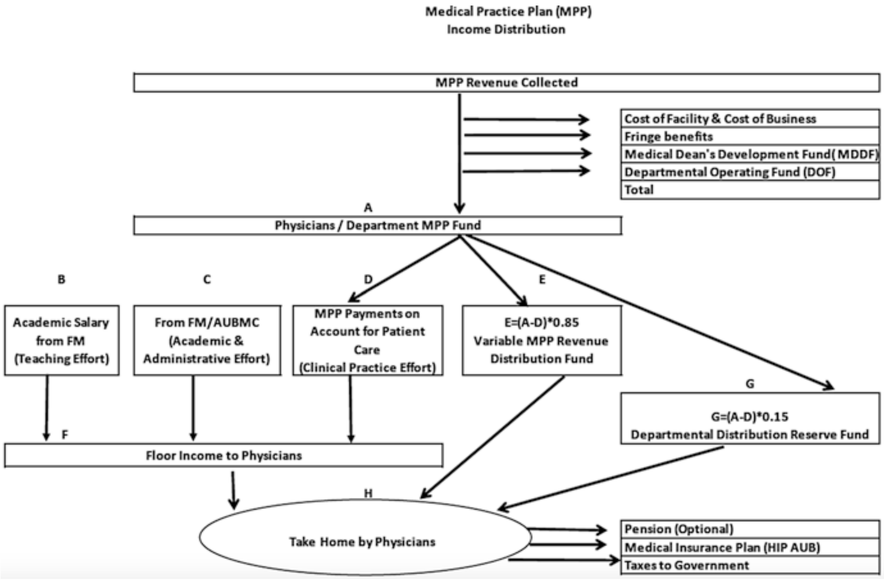

Fig. 4 MPP distribution plan described in the text above. *MPP* Medical Practice Plan, *MDDF* Medical Dean's Development Fund, *DOF* Departmental Operating Fund

distribution to physicians is around 70% as compared to about 55% in the previous "Incentive Plan" and the rest go as 10% to the MDDF, 5% to the DOF, the cost of use of the clinic (the overall average turned out to be close to 10% of collected professional fee revenue) and the rest for other expenses and benefits not covered by the MDDF and DOF.

6 Achieving Equity in Salaries

To rectify the very wide range of renumeration for individuals that are of equivalent status, merit, and seniority, created over time by the fluctuating large devaluations of the Lebanese Lira among other factors, the average salaries and standard deviations were calculated for each rank for 1999–2000. The minimum salary for each rank was considered as 2 standard deviations below the mean and were found to be US $50,000 for assistant professors, $60,000 for associate professors, and $70,000 for professors, rounded to the nearest $10,000. There was significant overlap among ranks, and the average annual increase ranged from $1000–1500, differing between ranks. The equitable basic salaries for each faculty member was re-calculated on the basis of these numbers e.g. an associate professor with 3 years in the rank will be assigned $63,000. The non-practicing basic science individual will receive the same amount as salaries, paid primarily from student tuition fee revenue and other FM resources, and the practicing faculty from the 3 sources, student tuition fee revenue

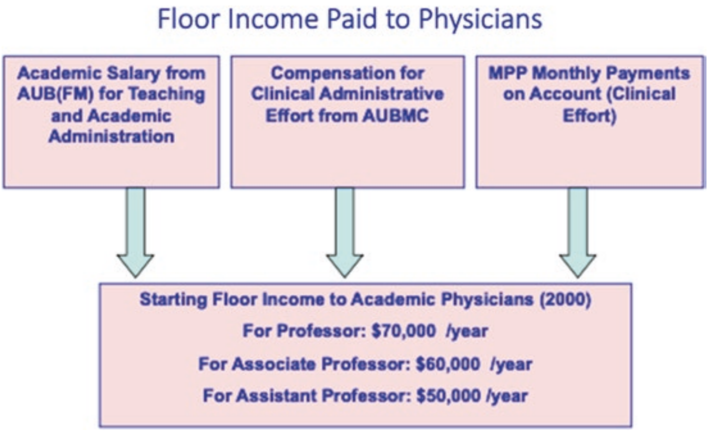

Fig. 5 Components of the floor income and starting floor incomes as of 2000

for academic effort, hospital patient revenue for clinical administrative effort and the balance will be paid as MPP payment on account, shown in Fig. 5. The few that did not make up their MPP on account from their practice during the year, were supported initially by the DOF and/or the MDDF, as if they were new recruits. All physicians made their floor income by 2–3 years. The basic salary for practicing faculty was called floor income since it is a guaranteed income that came from multiple sources and may be complemented by the variable income earned through practice. The floor income is a guaranteed monthly income regardless of practice earnings and from which the indemnity provision for each faculty member is calculated. The floor income from there on will increase as per the determinants of salary increases for faculties across the University. The floor income and its clinical practice components are illustrated in Figs. 5 and 6.

7 Beyond Equity: Recruitment of Excellence and Change Agents

The post-war re-adaptation to peace and building desired services in education, patient care and research, required the recruitment of excellence and change agents for all three. Recruited primarily from the USA, such individuals require an environment in which they can thrive, grow and keep their choices for career mobility, particularly to the US. They expected being given the opportunity to achieve a competitive post-tax take-home compensation equivalent to what they would have made per the regularly published American Association of Medical College (AAMC) scales. In turn, they will utilize and grow AUBMC's inpatient and outpatient services to satisfy the needs of all stakeholders, including research, teaching, and training programs, and achieve financial sustainability. The feasibility of recruiting such

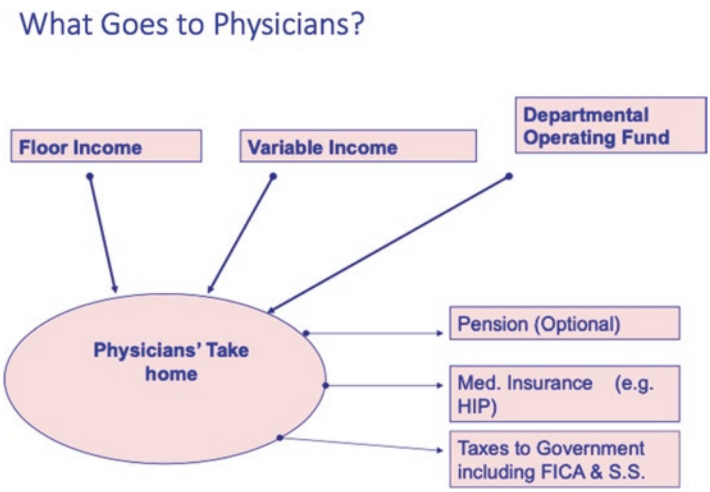

Fig. 6 Components of the total annual physician's compensation from clinical practice sources

individuals depended on the growth of services they would achieve. The total compensation of current active clinical faculty was within the range of AAMC scales, with some, however, being closer to the lower percentile range while others, closer to the upper, notwithstanding the fairly equivalent floor income. In support departments, primarily radiology and laboratory medicine, each procedure and test has a professional-fee component (PFC) that is dependent on the effort physicians put in establishing, maintaining, performing, and interpreting the procedure or test. The total professional-fee component collected is then distributed to the various faculty members in the department. The formula used in 1999–2000 in one department at AUBMC gave the instructor 4%, the assistant professor 8%, the associate professor 16%, professor 20%, and Chair 25% of the collected professional fee, with take-home pay ranging from 15th – 90th percentile of each rank as per the AAMC US National scale. If all would receive at the same percentile amount for their ranks, the formula would have to change as shown in Table 4 as take home projected. This indicates that the department shown in 4 at AUBMC is in the 60th percentile of departments in the AAMC national USA scale and will grow with projected growth. Note that at the same percentile the ratio of a Chair's take-home pay to an assistant professor is more than twice, preserving equity for seniority.

Having established an MPP plan that transferred administration of clinical practice to the MPP participants through the Dean of the FM or his designee,[29] a plan that allowed physicians to retain more money to be distributed as compensation, pay their costs, create funds that support their career development, the academic mission of the FM and grow as per a strategic 5-year rolling plan with 10-year and 20-year

[29] For example, the Chief Medical Officer, also referred to at AUB as the Associate Dean for Clinical Affairs.

Table 4 Distribution of collected Professional fee component (PFC) in a clinical service department at AUBMC by a formula that gave the instructor 4%, going up to 25% to the Chair of the collected PFC, resulting in a range being rom the 15th percentile to the 75th percentile

SERVICE DEPARTMENT - EXAMPLE		Instructor	Assistant Professor	Associate Professor	Professor	Chair
FM (AUB)	Total Takehome (Old Plan)	4%	8%	16%	20%	25%
	Total Takehome (Projected)	9%	12%	15%	17%	25%
US Medical Schools (National)	Mean	N/A	176	208	239	358
	20th Percentile	N/A	144	169	198	285
	50th Percentile	N/A	171	202	234	339
	80th Percentile	N/A	208	243	276	419
Comparison	00-01 Takehome FM (AUB) vs. US (National)		15th Percentile	90th Percentile	90th Percentile	75th Percentile
	Projected Total Takehome FM (AUB) vs. US (National)		60th Percentile	60th Percentile	60th Percentile	60th Percentile

The projected formula to distribute the PFC collected equitably, will change the distribution formula to a range from 9% to 25%, with all having a take home at 60th percentile of US National compensation as per AAMC publications

horizons, it became important to find out the feasibility of the rate of growth and its impact on the AUBMC and the FM.

The strategic plan was starting to define objectives and goals for both the FM and the AUBMC. For the former, it was realized that the capacities[30] of the medical school building[31] were built for a class of 90 students or 360 students for the 4-year program leading to the MD degree. The number of students in 1998–99 was 279 and by adding students to the entering class, gradually increased to 300 in 2002–03 and from 2007 on as shown in Table 5. The maximum number to be reached was 360 for a class of 90 students or 284 for a class of 96 students. This will maintain the quality of entering students.[32] The increase from 279 students up to 284 did not change the requirement for 60 FTEs to teach the curriculum, including teaching the MS program in basic medical sciences. The number of residents and fellows were clamped at a number that provides each with the requirements of the American Council of Graduate Medical Education (ACGME).

As for AUBMC, the greatest challenge was to open the closed beds; this requires recruiting physicians (clinically active faculty FTEs) to increase the number from around 190 in 1999–2000 to a final goal of 425. This was necessary to re-establish the required clinical offerings at AUBMC and to increase bed occupancy to the target of 425 beds. The different floors of the hospital went through a renovation

[30] Lecture rooms, discussion spaces, laboratories and lounge spaces.

[31] The Diana Tamari Sabbagh Building.

[32] It is hoped that as tensions ease in Lebanon and qualified students from the region or outside will be attracted to apply to AUBFM, expanding the pool of applicants.

Table 5 Estimated number of students MD, MS & PhD, Residents and Fellows, in upper panel, projected as per Strategic Plan 2007 version till 2017–18 and in lower panel, the estimated total faculty members projected in the different categories

Undergraduate Programs	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13		2017-18
MD Programs	318	325	340	345	356	360		360
Graduate - Masters	42	52	57	62	66	70		70
PhD Programs *			5	10	15	20		20
Residents	237	246	236	236	236	236		236
Fellows	36	37	38	37	37	37		37

		Estimated Total Faculty Member (FTE)						
Basic Science	21	25	21	21	21	21		21
MPP-Participants	158	174	186	198	210	222		300
Non MPP-Participants (Clinical)	70	71	69	67	66	65		55
Total Faculty Members	249	270	276	286	297	308		376
Teaching FTEs	60	60	60	60	60	60		60

The MPP participants are projected to continue to increase most, at around an average of 12 FTEs/year. The practicing non-participants consist of the part time faculty members, recruited before 1999 whose privileges were kept until retirement, increase the number of practicing physicians as they decrease in number while the full time MPP participants increase

program, one area closed at a time to be renovated to the new target function, not to interfere with the rest of the hospital operation.

Open-bed capacity went up from 170 beds through the 1990s to 273 beds in 2008–09 as shown in Table 6 and an additional 92 beds under construction to open in 2009–2010, including a full floor for adult cancer patients,[33] an expanded and up-to-date neonatal unit, a 24 bed women's floor,[34] a 4-bed neuro-ICU,[35] a bone-marrow transplant suite to make a total of 4 bone marrow units.[36] The emergency department facility was significantly enlarged, re-built in compliance with international standards, and opened in 2004. An independent Emergency Medicine

[33] The Basile adult cancer program floor of around 44 beds. I am greatful to Drs. Ali Bazarbachi and Marwan Sabban for developing the proposal for stablishig a multidisciplinary cancer center with the author for Naef K. Basile.

[34] That was occupied by a makeshift nursery and neonatal unit while the new one was being built.

[35] Within the Mounir Abuhaydar multidisciplinary neuroscience program.

[36] Three were completed in 1983, built through a USAID donation the last finished in 2010, built in the name of Mr. Jirji Bachir, funded by him and a group of his friends. Dr. Ali Bazarbachi became pivotal in the growth of a successful and growing Bone marrow Transpalnt Service at AUBMC.

Table 6 Required bed capacity, number of physicians and private clinic (office space) readjusted from MGT of America/Campus Master Plan to reflect implementation of the strategic plan

	2008–2009	March 2010	Target 5 years (2014–2015)	Target 10 years (2019–2020)
Beds	273	365	385	425
Faculty/physicians	245	252	312	372
Clinic space requirements[a]	85		123	220 + 15 (in Satellites)

[a]The capacity within the AUBMC vicinity is limited by traffic impact assessment to 220 clinics and the additional will be in satellites to which for the convenience of patients, physicians go

Department was established to take over its operation.[37] The ultimate total number of 425 beds will consist of approximately 375 beds in the current hospital and 50 beds in an adjacent building identified as building 56 in Fig. 9, that include a 20-bed children cancer center, a 12-bed psychiatry unit, expandable to 20 beds and around 25 same-day chemotherapy beds. This was designed to provide AUBMC with enough beds while the renovation and expansion program, primarily in same-day and ambulatory services is finally designed within patient-focused multidisciplinary centers of excellence. The strategic plan projections and data with that of MGT of America and the Master Plan are summarized in Tables 5 and 6.

8 Assumptions and Projections for Growth

The JCW Report indicated that AUBMC was receiving a small proportion of its catchment pool in Beirut and its suburbs because of the change in its operation (1976–1993), and the slow post-war re-adaptation to peace needs. The load was there. An exercise assuming an increase of 6 clinically active FTEs and their impact on total collected professional fees and on hospital revenues revealed, as shown in Tables 7, 8 and 9 below, a significant annual increase in both revenue streams. The projected revenues from the outpatient and inpatient services calculated from expected first-year loads for new physicians, shown in Table 7 and 8 respectively, started, as shown in Table 9, with a projected increase of $5,287,000 for 6 FTEs added in 2001–02 and with 6 FTEs added each year thereafter, the number increases to $8,387,000 in 2004–05. The details of component services from which such increases occur are shown in Tables 7 and 8 for outpatient and inpatients services respectively.

The estimated increase in collected professional fee revenue was calculated from the same assumptions, shown in Table 9, in amount, as proportion of total professional fee collected, and in the right column, as the resulting projected revenue increase for AUBMC.

[37] Prior to that each clinical department took care of their patients.

Table 7 Sources of projected increases in AUBMC revenues resulting from a hypothetical recruitment of 6 FTEs that will care for an average first year load of outpatients and inpatients

Expected increased gross revenue to AUBMC resulting from increased patient load (Sum from Tables 7 and 8)					
		01–02	02–03	03–04	04–05
Expected increased gross revenue to AUBMC resulting from increased patient load		5287	6931	7622	8387
Sources of projected increased revenue to AUBMC					
I. Out-patient (32%) of AUBMC Revenues					
		01–02	02–03	03–04	04–05
Drugs	6%	102	133	146	161
Supplies	2%	34	44	49	54
OR	0%	0	0	0	0
Patient services	8%	135	177	195	215
Professional fees	32%	541	710	781	859
X-Ray	18%	305	399	439	483
Lab. Med.	28%	474	621	683	751
Others	6%	102	133	146	161
Total	100%	1692	2218	2439	2684

The upper panel shows total outpatient and inpatient increases. The lower panel shows the details of projected increases in each of the relevant services and their total for each year. All figures are in US $ 000

Table 8 Sources of projected increases in AUBMC revenues resulting from a hypothetical recruitment of 6 FTEs that will care for an average first year load of outpatients and inpatients

Sources of projected increased revenue to AUBMC					
		01–02	02–03	03–04	04–05
II. In-patient (68%)		3595	4713	5183	5703
Solutions	2%	72	94	104	114
Drugs	13%	467	613	674	741
Supplies	21%	755	990	1088	1198
OR	9%	324	424	466	513
Room and services	15%	539	707	777	855
Patient services	5%	180	236	259	285
Anesthesia	4%	144	189	207	228
Professional fees	13%	467	613	674	741
X-Ray	6%	216	283	311	342
Lab. Med.	15%	539	707	777	855
Adjustments	−3%	−108	−141	−155	−171
Total	100%	3595	4713	5183	5703

The details of projected increases are tabulated in each of the relevant services and their total for each year. Totals from inpatient servces are added to totals from the outpatient services shown in Table 7 above. All figures are in US $ 000

Table 9 Projected total collected professional fee revenue and AUBMC revenue increses with the hypothetical addition of 6 clinically active FTEs caring for average loads of patients during their first year from 2000–2005 with the amounts and rates of increase for each year

	Prof. fee revenue collected	Additional self-supporting faculty	Resulting increase in prof. fee revenue	Annual % increase of collected fees (workload)	Resulting increase in AUBMC revenue
00–01	16,687	0			
01–02	18,178	6	1,491	9%	5,287
02–03	20,133	6	1,955	11%	6,931
03–04	22,283	6	2,150	11%	7,622
04–05	24,648	6	2,365	11%	8,387
Average				10%	

The last column to the right shows the projected resulting increase to AUBMC revenues in USD 000, with an average increase of USD 7,056,000 per year

9 Role of the Medical Practice Plan in Recruiting New vPhysicians

Analyzing the proportion of collected professional-fee revenues deposited into the MDDF and DOF, it was realized that an additional 12 FTEs each year may be supported by both funds (DOF and MDDF) after all the other obligatory expenses are deducted. The challenge was to determine priorities and preparing the necessary facility to attract accomplished change agents. The establishment of the research enterprise necessary for attracting such individuals from the USA was previously described [5]. The rest was part of the Strategic and Master plans for which a recruitment plan was made with gradual additions until the target of 425 physicians is reached in 2019–20. Reviewing the 5-year plan on a one year rolling basis, needless to say, may change the targets, particularly for the 10-year and 20-year horizons. A physician-recruitment plan was established to add on an average 10–12 clinically active physicians a year as shown in Table 10 below and hence, various projections were made assuming the addition of 12 FTEs a year for a horizon of 10 years as of 2007 and at times, beyond. Adjustments to projections are made during each annual budget cycle to correct for delays or new and unforseen realities to preserve sustainability of all desired finctions at the FM and the AUBMC.

The evolution of the cancer multidisciplinary program at AUB as of 1998 is an example of evolution of an existing solo practice to a group practice through a patient-focused center of excellence that was propelled by the MPP for physician support and recruitment. An analysis of cancer practice at AUBMC revealed that many physicians in different specialties take care of cancer patients in different proportions within their solo practices e.g. a surgeon may have 20% of her/his practice caring for patients with colon cancer and 10% in resection of other cancers, an ENT specialist may have 25% of her/his practice in caring for head and neck tumors and so on for hematologists/oncologists, gastroenterologists, pulmonologists etcetera.

Table 10 Actual and planned recruitment of clinically active faculty and the net remaining

Year	Recruited	Retained	Left
2000–03 (3 years)	34	30	4
2003–04	7	5	2
2004–05	5	5	0
2005–06	9	6	3
2006–07	11	5	6
2007–08	20	12	8
2008–09	11	9	2
2009–10	18		
2010–11	12 (planned)		
2011–12	12 (planned)		

Some of those who left were old timers that retired. A larger number left after the July 2006 Israeli invasion of Lebanon. As of 2012 the projections reflect an addition of 12 FTEs per year

Adding all percentages, established that of a larger number of physicians, a sum total of 17 FTEs practice cancer at AUBMC i.e. as if having 17 full-time cancer specialists. Rather than the patient going to the different physicians, a multidisciplinary cancer program with an outpatient facility was planned with clinics, shared by the various practitioners, that include all the trained support staff and a number of chemotherapy stations serviced by a special pharmacy unit. A new linear accelerator was installed and 3 bone-marrow transplant (BMT) units were planned and built by 2003, a 4th BMT unit was added in 2009–10. The increased loads of patients pointed to the need for a dedicated floor of around 40 beds in addition to the BMT units. A full proposal with a feasibility plan for an outpatient and inpatient cancer center was developed by all stakeholders[38] and implemented as the Naef K. Basile adult cancer center as of 2002. At the same time, members of the American Lebanese Syrian Associated Charities (ALSAC) that founded and run the St. Jude Children's Research Hospital[39] in the USA, were looking for a partner in Beirut. The readiness at AUB made their choice easy. The Children's Cancer Center of Lebanon (CCCL) was opened at AUB in 2002 in partnership with the St. Jude Children Research Hospital. This completed the children and the adult patient-focused multidisciplinary cancer center at AUB. The same story led to the establishment of the Abuhaydar[40] Neuroscience center with a floor in the hospital that includes a

[38] Sent initially to Ms. Mamdouha Bobst in 1999 who connected AUBMC with the American Cancer Society and the Memorial Sloan Kettering Cancer Center who made very valuable comments. She supported a breast cancer program for poor patients and funded the establishment of the Breast Cancer unit. She funded the purchase of two linear accelerators in 2009 and pledged for a large donation in her will for cancer at AUBMC and a satellite in Tripoli. The establishment of the Adult cancer center, through the same proposal was funded by Naef K Basile that included significant upgrade of the outpatient facility in 2002 and renovating a complete inpatient floor for adult cancer patients that was opened by the end of 2009.

[39] In Memphis Tennessee, USA.

[40] Funded through a donation by Mounir Abuhaydar.

neuro-ICU and the first bona fide independent psychiatry program at AUBMC with a 12-bed expandable inpatient unit.

Each service in the Emergency Room (Facility) (ER) was administered by the respective clinical department for that service e.g. the Department of Surgery administered the ER surgery service and so on. This created conflict of interest. By 2004, an expanded and totally renovated emergency facility was opened which attracted board certified Emergency Medicine specialists and an independent Emergency Department (ED) was established[41] for which more ED specialists would be recruited. As a stopgap and until a critical mass of ED specialists are recruited, physicians at AUBMC may commit themselves to the ED but may not admit the patient they see at the ED to their service. The ED grew steadily with ED physicians growing in number.

The increased patient loads to all services partly as a result of reputation, a growing ED and as importantly, through referrals from a growing mass of physicians totally committed to AUBMC, improved through a growing collected MPP revenue, the compensation per physician and the capability to recruit the desired physicians (Figs. 12 and 13).

These were examples of achieving goals and targets of the unfolding strategic plan fuelled by growing MPP support for the recruitment of highly credentialled motivated change agents. The growth and success attracted big philanthropy support.

10 Preparing the Outpatient Facilities

It became apparent that a plan for outpatient facilities needs to be established to meet the recruitment plan. The outpatient visits per year were followed from 1996–2001, by MGT of America making projections as of 2001 through 2020 to include the projected annual new recruits, shown in Fig. 7 below as the green bars.

These projections were made on the assumption that, on average, 12 physicians will be recruited each year. The expected number of outpatient visits per physician for a particular year shown in Fig. 8 were then multiplied by the number of physicians including the new potential 12 recruits. The blue line in Fig. 8 connects the diamonds that represent the actual number of outpatient visits per physician 2001–2009, showing an increasing trend, the point representing patients per physician for each coming year per linear regression was multiplied by the number of current physicians plus 12. The red line connects the squares showing the projected calculated outpatient visits/physician from 2009–2020. The blue diamond in 2015–2016 shows that the actual number of outpatient visits/physician is in line with the projected (slightly less). The variance of actual outpatient visits from projected visits is due to lesser oupatient visits/physician than predicted as of 2013–2014 (Fig. 8).[42]

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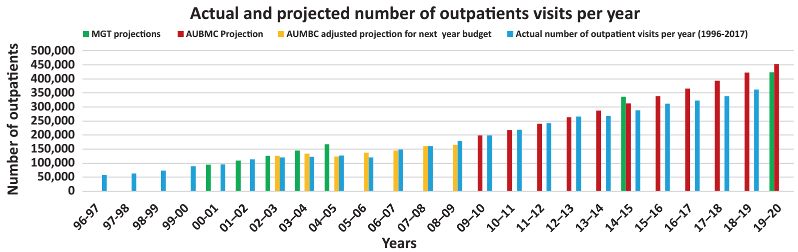
[41] Dr. Amine Kazzi was the founding Chair.

[42] The number of clinic visits was taken from a special report of the Dean to the BOT and through courtesy of Deputy VP Ziyad Ghazzal.



	96-97	97-98	98-99	99-00	00-01	01–02	02–03	03–04	04–05	05–06	06–07	07–08
MGT projections					94,128	108,991	125,835	145,321	166,789			
AUBMC Projection												
AUMBC adjusted projection for next year budget							125,505	133,761	123,853	137,064	145,321	160,514
Actual number of outpatient visits per year (1996-2017)	57,798	62,752	72,661	89,174	95,780	113,945	120,550	122,202	127,156	120,550	148,624	160,183

	08–09	09–10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18	18–19	19–20
MGT projections							336,468					424,117
AUBMC Projection		198,847	217,656	239,875	263,058	287,204	312,314	338,388	365,425	393,426	422,390	452,318
AUMBC adjusted projection for next year budget	165,329											
Actual number of outpatient visits per year (1996-2017)	178,651	198,415	218,369	242,341	265,414	268,509	288,535	311,680	323,437	339,041	361,868	

Fig. 7 Actual number of outpatient visits each year (Blue Bars) and projected number by MGT of America (Green Bars), adjusted by AUBMC each year as projections for building the budget for the coming year (orange bars), and extended from the 2004–2009 actuals by AUBMC using the same MGT formula (Red Bars)

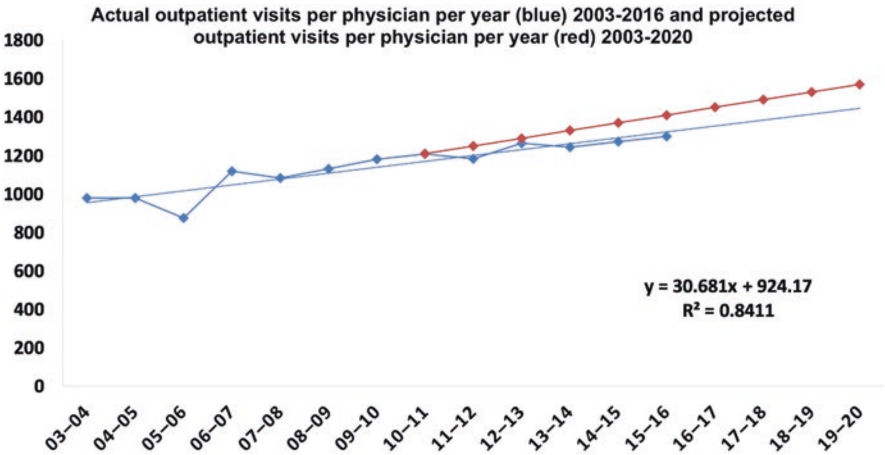


Fig. 8 Actual and projected average number of outpatient visits per physician each year from 2003–2020. The blue diamond points represent the actual average number of outpatient visits per physician for that year. The red square points represent the projected number increasing from a 1000 to 1572 visits per year over the entire period ending in 2020

Using the same methodology, the orange bars in Fig. 7 were produced for budgeting purposes, taking into consideration the actual number of recruits for that year and other factors.[43] The red bars in Fig. 7 are projections from the 5 years of actuals 2004–2009 assuming the addition of 12 FTEs/year. Based on this data, the number of outpatient clinic spaces were then determined by MGT of America as per the evolving strategic plan, shown in Table 6 above and the number of outpatient spaces were included in the facility Master Plan. A traffic impact study recommended that

[43] Such as renovation and construction during that year and the political environment.

no more than 220 outpatient clinic facility should be built within the AUBMC complex and the additional 15 should be in satellite facilities.

11 The Master Plan

As the strategic plan was unfolding and MGT of America documenting the programmatic requirements with the necessary projections, a facility Master Plan was developed[44] in alignment with the strategic plan. This took into consideration the major transformations, over a horizon of 20 years, presented in the strategic plan for education, research, and patient care, notably the establishment of multiple patient-focused centers of excellence such as cancer, neuroscience, cardiovascular, women's health, diabetes, obesity and metabolic disease, Emergency Medicine and different areas within pediatrics among others. Significant expansion in ambulatory and same-day services including an increase in operating-room capacities were envisaged and planned for. The establishment of the core research facility and the research enterprise are previously described [5].

Work started by rehabilitating the main AUBMC Phase II building floor by floor followed by building 56[45] shown in Fig. 9 of the AUBMC buildings footprint. The ground floor of building 56, with a garden and an independent entrance, was renovated to become the Children Cancer (CCCL) outpatient facility; the first floor, at the level of the main hospital entrance, into a patient admission (PA) unit for surgical patients and the family medicine clinics. The second floor was renovated to become the outpatient facility of the Basile adult cancer center and included same-day chemotherapy beds, the 3rd floor was renovated to include an expandable 12-bed inpatient psychiatry unit with all its amenities and an adjoining outpatient psychiatry facility. The 4th floor became the CCCL's 20-bed children inpatient cancer unit. All this was made possible by an MPP-propelled adequate recruitment of physicians for optimal operation.

The number of private-outpatient clinics in 2001 were 49 located in the AUBMC Phase I building and those for family medicine in Dale Home, a building not shown in Fig. 9 since it will be demolished and be replaced by the Medical Center expansion building. The Abou Khater Medical Arts Facility was totally renovated and opened in 2006 to ultimately have 73 clinics[46] and a Wound Center in its basement that had an independent access with the necessary ramps for patient transportation. Fifty private[47] clinics were planned to be within the Phase I and II AUB buildings (see Fig. 9), as part of the multidisciplinary centers of excellence, to be built at different times,

[44] In 2002, by Sasaki Machado and Silvetti Associates Inc. an Architecture and Engineering firm, registered in Boston MA. Viewed on the web at www.sasaki.com/project/163/american-university-of-beirut-campus-master-plan/

[45] Built in 1954 as a building with 4 ORs for surgical patients.

[46] Funded by Pierre (Fahd) Abou Khater, 45 clinics were ready in 2006 and the rest deferred till 2014.

[47] Around 40 existed in 2009.

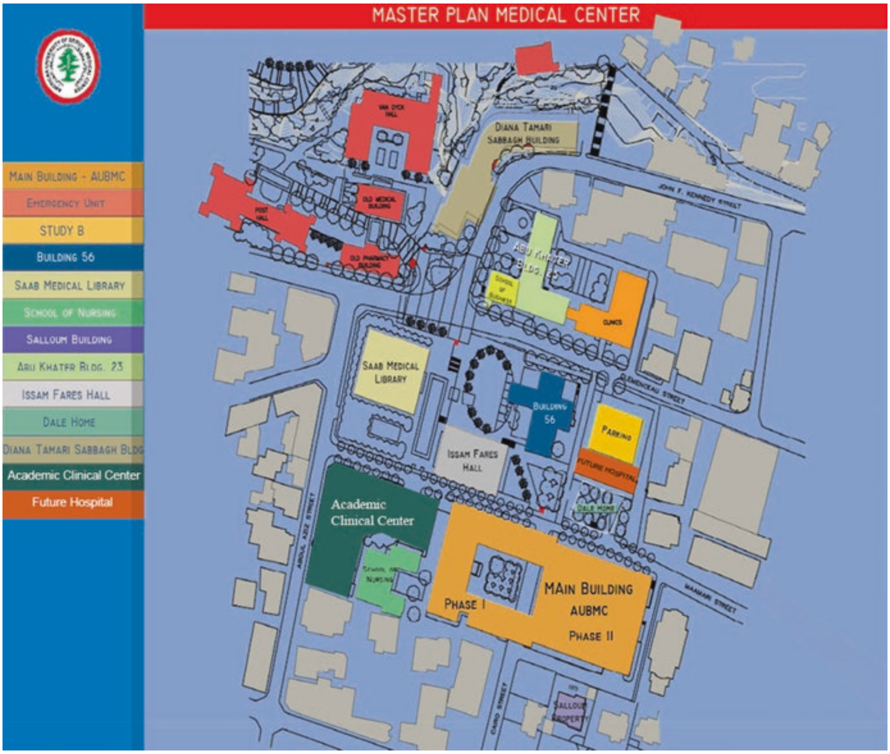


Fig. 9 Footprint of the AUBMC building complex taken from the Master Plan. The medical complex buildings start with the Diana Tamari Faculty of Medicine Building, light greenish grey at top of picture, the T-shaped pale green Pierre Abou Khater (Fahd) Medical Arts Facility (MAF) and its annex (orange to be built and independently named as the pateint load grows), the Saab Medical library (SML) building (The Saab Medical building in addition to a big multifloored Library, includes the Dean's office facilities and a 4-floor underground garage), the Issam fares Post graduate Medical Education (PGME) Hall in grey, building 56 in dark blue, site of future expansion of the medical center, brown and yellow, the Academic Clinical Center building (ACC), dark green to be built last, the Hariri School of Nursing (Renovation Funded by HE Saad Hariri and opened in 2009), the phase I and II Main AUBMC building (Opened in 1970, built by a USAID donation. Phase I has the outpatient clinics and houses the academic clinical departments and Phase II is the Hospital), and the Salloum Property, violet, purchased to become the Medical Administration Building (MAB). The MAB houses the Medical and Nursing Administration, including biomedical engineering (replacing 5 Operating Rooms planned in the basement of this building), renovation of MAB started in 2009)

such as cardiopulmonary, women's health, neuroscience, general surgery and orthopedics[48] among others, the total including those in building 56[49] will make up to 150

[48] Orthopedics planned close to the physiotherapy department.

[49] In the Children Cancer Center of Lebanon (CCCL), Family Medicine, Adult Cancer and Psychiatry.

Fig. 10 A perspective of the AUBMC complex as the master plan unfolds, produced by Sasaki, Machado and Silvetti (see Fig. 9 for foot print)

clinics, the rest of around 70 clinics will be built within the centers of excellence in the new buildings including the MAF Annex building. A perspective of the medical center complex with connecting tunnels is shown in Fig. 10.

A stacking diagram for all buildings except for the ACC, that became the Halim and Aida ACC, the Med Café[50] and the new medical center expansion, building was developed by NTD Stichler Architects, Tucson, AZ. The Medical Administration Building (MAB) was commissioned in 2009. The strategic and master plans provided significant flexibility for the implementation and execution of the ACC, Medical Center Expansion buildings and the MAF Annex building (Fig. 9).

After 2010, the MAF annex was built as shown in Fig. 11 above, as the Wassef and Souad Sawwaf Building,[51] to house the PET-CT facility, the Family Medicine and University Health facilities, offices and clinics. The ACC as the Halim and Aida Daniel building was built by 2016 to house a number of ambulatory and same-day centers including surgical facilities and three academic floors. The breaking-ground ceremony for the medical center expansion to house a cancer hospital, pediatric floors and add 275 beds, shown in Fig. 11, took place in June 2019. The early renovation of Building 56, opening beds at the outset of recovery, minimized the decrease in bed capacity during closure of units in the main hospital for renovation and made the implementation of the Master Plan timely and easier. Its final replacement may occur closer to 2030.

[50] Not in the original plans.

[51] Funded by Wassef and Souad Sawwaf, philanthropists.

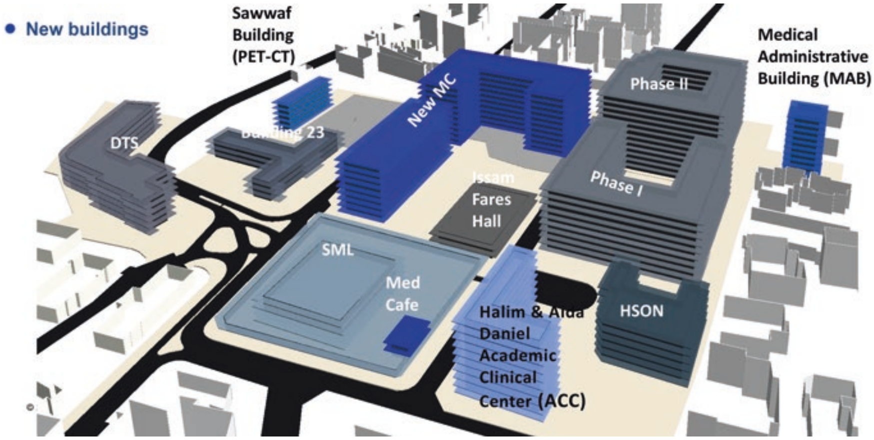


Fig. 11 Perspective of the AUBMC medical complex distributed in 2019 during the breaking ground ceremony for the new medical center expansion building. (Taken from the AUBMC website, AUBMC 2020 Vision: The story; path 5 slide 39)

12 Impact of the Medical Practice Plan

12.1 Education

Faculty recruitment from 1993–1999 as shown in Fig. 2, in addition to the introduction of required new technology, rapidly increased the tuition fees at the Faculty of medicine, going up from $1570 in 1990–91 to $18,599 in 1999–2000 (by 12-fold in 10 years and, to cover the resultant deficit, tuition fees would have had to go to $34,000, an unsustainable level for Lebanon. By reducing the number of FTEs supported by the FM to the required number for teaching, and shifting about 6 million USD of salaries and benefits annually through MPP to clinical and service departments as shown in Table 11, the increase in tuition fees was markedly attenuated. After implementation of the MPP, part of the salaries for teaching and administration were transferred to the MPP as 'MPP on account' forming part of the floor income for both, the clinical departments and, 1 year later, the support departments (see Figs. 4 and 5). Similar transfers were effected for benefits. The total sum transferred to the MPP amounted to $27,802,204 by 2006–07 as shown in Table 11.

In addition to creating efficiencies in the teaching program, limiting the laibility of the FM to the 60 FTEs required for acdemic functions among other measures, attenuated the increase in tuition, going from $18,599 in 1999–2000 to $24,208 in 2008–09 (by 1.30-fold in 9 years) and to $39,755 ln 2018–19 (by 1.64-fold in 9 years). An education unit was established at the Dean's office that

Table 11 The Upper panel shows University (FM) contributions transferred to the MPP after implementation of MPP as mock in 2001–2002 and formally as of 2002–2003 in the clinical departments followed by 1 year in the support service departments. (lower panel) Part of the salaries for teaching and administration were transferred to the MPP as 'MPP on account' forming part of the floor income. Similar transfers were done for benefits

Contribution of the University and MPP to salaries and benefits (2000–2007)-clinical departments	**MPP fully implemented**							
	Pre-MPP 2000–2001	**MPP mock YEAR 2001–2002**	**2002–2003**	**2003–2004**	**2004–2005**	**2005–2006**	**Forecast 2006–2007**	**University contribution transferred to the MPP**
Salaries/teaching and administration	4,341,039	2,207,769	2,358,767	3,014,454	3,300,472	3,594,869	3,488,715	
MPP on account		2,564,208	2,692,178	2,905,814	3,149,009	3,721,244	3,924,081	**16,392,326**
Floor income	4,341,039	4,771,977	5,050,945	5,920,268	6,449,481	7,316,113	7,412,797	
Benefits paid by AUB	1,215,491	1,336,154	660,455	860,010	838,808	830,067	806,765	
Benefits paid by MPP	Not applicable	356,952	377,802	776,057	817,298	942,621	972,395	**3,886,173**
Contribution of the University and MPP to salaries and benefits (2000–2007)-service departments	**MPP fully implemented**							
	Pre-MPP 2000–2001	**Pre-MPP 2001–2002**	**Pre-MPP 2002–2003**	**2003–2004**	**2004–2005**	**2005–2006**	**Forecast 2006–2007**	**University contribution transferred to the MPP**
Salaries/teaching and administration	1,706,822	1,657,773	1,657,773	880,574	915,645	909,252	905,213	
MPP on account				1,388,061	1,529,588	1,581,319	1,603,858	**6,102,826**

Floor income	1,706,822	1,657,773	1,657,773	2,268,635	2,445,233	2,490,571	2,509,071	
Benefits paid by AUB	477,910	464,176	464,176	339,143	290,087	288,703	253,619	
Benefits Paid by MPP				343,644	356,748	362,380	358,108	**1,420,879**
								27,802,204

Note: Benefits were averaged at a rate of 28% over the years, as the actual percentages are not available, and based on actual percentages as of 2003–2004
Note: Benefits paid by MPP equal to 12.5% on the MPP on account portion plus aprx 55% of cost of education paid by physicians

developed an effort analysis tool[52] [5]. An Assistant Dean for education was appointed[53] to lead the curriculum and teaching committees in developing a new curriculum with significant reduction in didactic lectures, developing and/or identifying on-line presentations to replace the lectures and giving time to students to learn from them, supported by a significant increase in interactive evidence-based education through team-based learning, research paper, case discussions, and by introducing simulation[54] technology for education and training purposes while emphasizing all other aspects of medicine from the ethical and humane through legal and technical. As the enterprise grows, a significant increase in the number of qualified physician scientists and educators will make the teaching load per physician fall within the percent of time to be given to the institution in return to the privilege to practice within it. This will cut further the cost of education. With the growth of collected professional-fee revenue, the MDDF and DOF will grow providing more support to the academic mission of the FM. The growth rate of the practicing faculty should not surpass what is affordable by the growth rate of the MDDF and DOF.

12.2 Professional Practice

Using the same projection technique as for the number of outpatient visits shown in Figs. 7 and 8, and building on the assumption of adding, on average, 12 FTEs/per year and the calculated average rate of increase in collected professional fee revenue per physician per year in the past 5 years (the 1st period being 1999–2003), the projected total professional fee collected for each successive year was obtained by multiplying the calculated average rate of increase over 5 years e.g. 1.04 (or 4%) by the expected number of physicians in the next year including the additional newly recruited physicians. The next set of 5 years used to determine the average rate of increase per physician came from the actuals (blue bars), from 2004–2009 from which projections were made through 2017–2018. Data shows that growth was in line with projections and plans (Fig. 12) with small variance.

With the establishment of centers of excellence and the growing mass of physicians, AUBMC attracted larger patient loads that were referred to the appropriate physician within the system. This increased the average load per physician and alleviated the fear that recruiting physicians would decrease the load per physician. In fact, with increasing number of physicians per year represented by the blue line in Fig. 13, the average take-home remuneration per physician, represented by the red

[52] With the help of KPMG, one of the big four international auditing firms.

[53] Ramzi Sabra who was supported to receive an Master's degree in medical education from the University of Illinois.

[54] A simulation training program was initiated for training staff nurses and to be expanded to include all aspects of education and training.

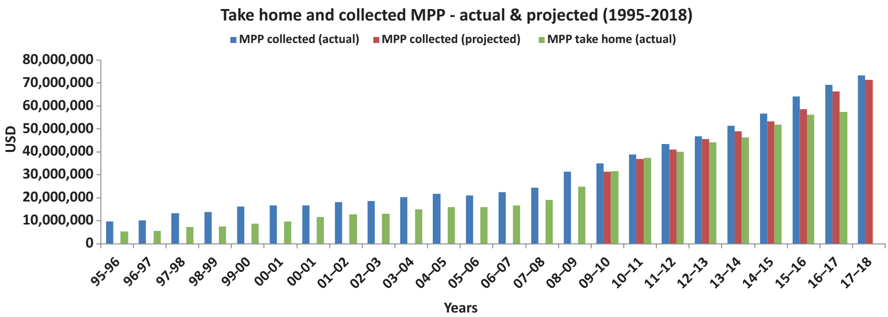


Fig. 12 Actual collected professional fee revenue 1995–2018 represented by blue bars, compared to the projected professional fee collections represented by red bars. The year 2000–2001 is shown twice, the left representing the "Incentive Plan distribution" and on the right the new MPP collection. The green bars represent the physician's take home. Looking at the two scenarios in 2001–2002, take home is higher with the new MPP

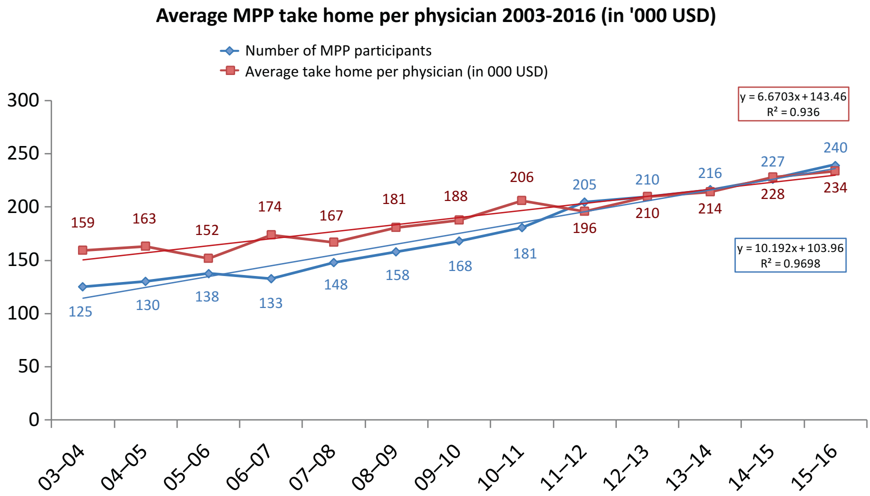


Fig. 13 Average take-home remuneration per physician from collected professional-fee revenues 2003–2016. The blue line represents the number of physicians (MPP participants) and the red line, the take home per physician (in '000 USD). The trend line for average take home per physician y = 67,000x + 143,000 with $R^2 = 0.936$

line, also increased. Again both the increase in the number of physicians and take home by physician fit the strategic plan projected linear growth of around, on average, 12 physicians per year.

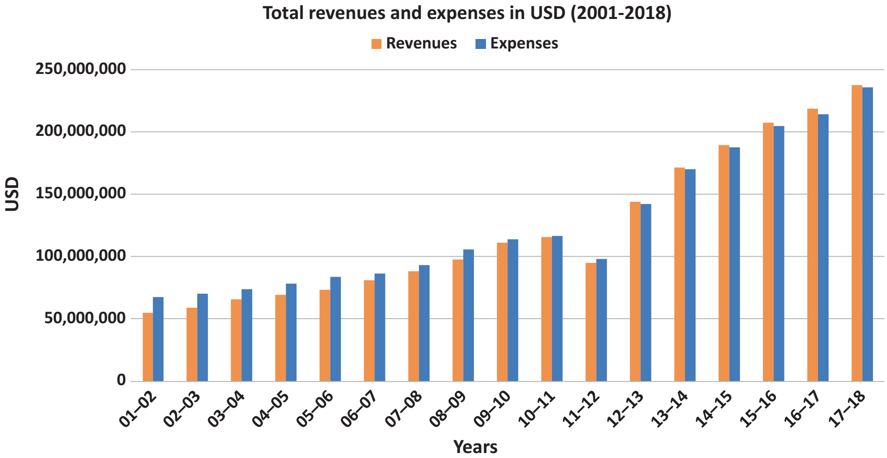


Fig. 14 Total revenues of AUBMC represented in orange bars and expenses in blue bars, from 2001–2018. The decrease seen in 2011–2012 represent data of 9 months resulting from change of the fiscal year adopted by the University year from January 1 – December 31 to July 1 – June 30 for subsequent years

12.3 Patient Care

Total AUBMC revenues shown in Fig. 14 as orange bars and expenses as blue bars,[55] show a steady increase in AUBMC revenue.

During 2011–2012, the University fiscal year was changed from Jan 1–Dec 31 of each year to July 1–June 30 of each year. As explained in the Office of Institutional Research and Assessment at AUB (OIRA) annual reports, the Revenue before 2012 was reported after certain deductions for expenses were made but after 2012, all expenses were reported together and separately from the revenues segment of the balance sheet and hence both revenues and expenses appeared slightly higher after that date except for the 9-month reporting in 2011-2012. This same issue affected slightly calculation of revenues per physician, shown in Fig. 15 but did not affect the net revenues less expenses figures. The important realization, however, was that there was steady increase in both, AUBMC revenues and the average contribution per physician to AUBMC over time.

These amounts will continue to increase by the same trend through the period of dynamic growth, for the period it takes for physicians to maximize their practices, in particular the new comers, and for the newly established services to reach their optimal steady states. In the USA, the average amount generated per year to hospitals has fluctuated but reached in 2019 a range of 1.6–3.5 million USD per physician

[55] Obtained from reports to the BOT, 2001–2009 and from 2009–2018 from the website of the Office of Institutional Research and Assessment (OIRA) through guidance of Dr. Karma El Hasan, its Director.

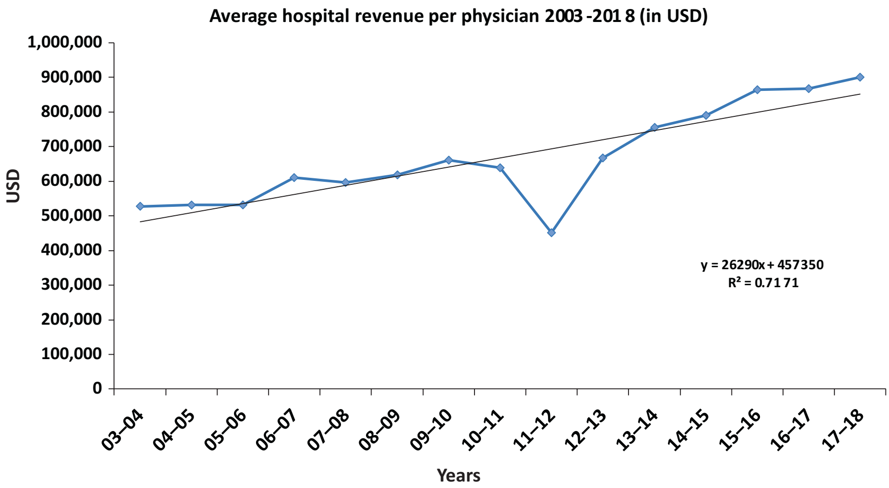


Fig. 15 Average revenue generated per physician, excluding professional fees, to AUBMC per year 2003–2018. The university fiscal year was changed in 2011–2012 and the 2011–2012 reported value is for 9 months only

depending on the specialty with an average 2.4 million USD per physician per year [10, 11].

Examining the AUBMC annual balances, total revenues less total expenses, from 2001–2018, shown in Fig. 16, reveals a bumpy recovery from a deficit of $12,521,963 in 2001–2002 to a surplus of $1,720,285 in 2017–2018 with a peak surplus of US $4,265,819 in 2016–2017.

The fluctuations during the transitional recovery period (2001–2011) were due to multiple causes among which, corrections across the university for provident funds, post-war restructuring of university support departments with allocations to AUBMC, closing sections of the hospital for renovation and reconstruction, establishing centers of excellence and other programs with start-up lay outs, loss of business resulting from political events[56] among others. It was important to keep a balance between rate of recovery and set-backs, sometimes by slowing change, to maintain a steady reduction of the deficit and to achieve breakeven by 2010–2011 as projected in the strategic plan.[57] The university absorbed a decreasing deficit, on average of $7,000,000 a year for 10 years to achieve recovery. After breakeven, more aggressive growth may be pursued as long as a positive balance and determinants of sustainability are maintained as shown in Fig. 17.

As the ratio of new recruits to total number of physicians decreases and the rapid recovery and growth phase of establishing the centers of excellence, programs and

[56] Assassination of Prime Minister Rafic Hariri in 2005 and the Israeli invasion of Lebanon through July 2006.

[57] The new construction and renovation plan will result in a 30% increase in bed capacity in 2010 as compared to 2008–2009.

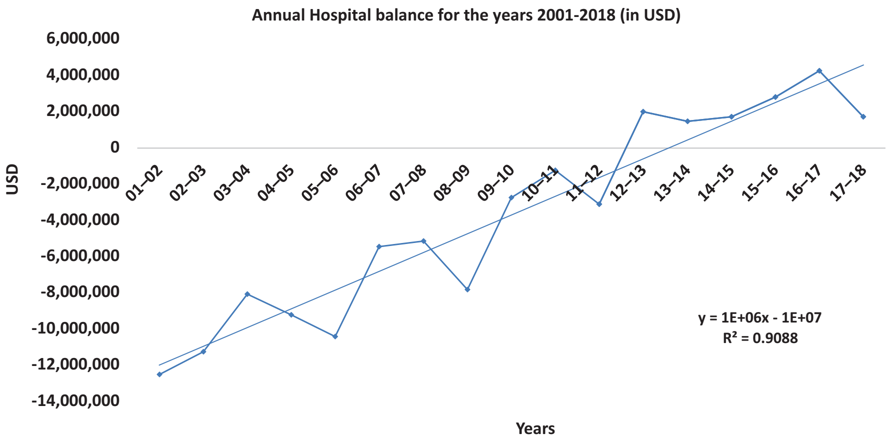


Fig. 16 Revenue less expense balances at AUBMC 2001–2018, going from a deficit of \$12,521,963 in 2001–2002 to a surplus of \$1,720,285 in 2017–2018 and peak surplus of \$4,265,819 in 2016–2017. All points fit a straight recovery line as projected in the strategic plan, with almost breakeven by 2010–2011

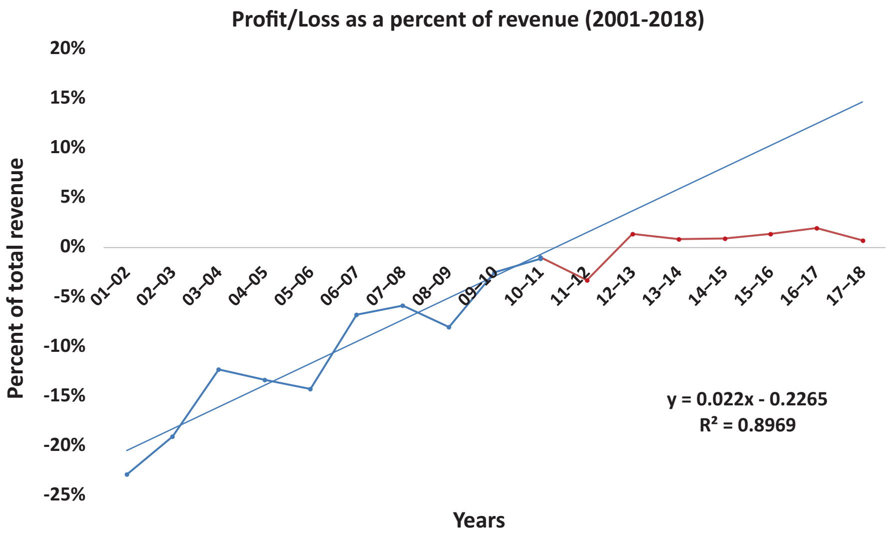


Fig. 17 AUBMC deficit/surplus as percentage of total revenue for each year from 2001–2002 to 2017–2018. The percent deficit decreased until breakeven in 2010–2011, representing transformational and foundational growth. After breakeven, linear regression of data from 2001–2011, would have predicted significant increase in the surplus ratio. The reported ratio remained fairly constant because of significantly more aggressive rate of growth in that period. The 2001–2011 period is shown in blue and the 2012–2018 period in red

facilities, defined by the strategic and master plans, nears its end, the rate of increase in expenses is expected to diminish while the rate of revenue increase is expected to remain much the same if not better.

12.4 University Budget

[58]"In 1998 and for some years thereafter, AUB faced substantial operating deficits. One of the biggest challenges facing the vice president for medical affairs (appointed in 1999), was to reduce the deficit in the operations of the hospital. Dean Cortas did this largely through the introduction of a new medical practice plan that in part shifted the salary burden to the clinical faculty. From 2003 on, we brought the trustees balanced budgets [12]."

12.5 Overall Impact

The medical practice plan was designed in line with the historical evolution of the process of compensation at the AUBFM. Recruitment of full-time physicians at AUB started as of 1946, with a fixed salary while collected professional fees went to the institution. Affordable recruitment of physicians was too slow to meet the expanding clinical load and to accommodate highly trained and credentialled physicians returning from the USA. A system was developed[59] to support new recruits by a salary for 2–3 years until their practice grows and then each would move into solo practices but give the FM and hospital 300–600[60] h at the discretion of the chair of the department, for teaching, patient care,[61] research, and administration. This resulted in significant growth of all services as well as for the residency-training program. After the new 425-bed hospital was opened and the first specialty fellowship program was launched in 1970, the institution needed to retain more of the full-time physicians, particularly those who demonstrated excellence in specialized patient care, teaching, and research and to provide them with competitive compensations. There was greater need for administrative time with expansion of the departments and the Chief of Staff office. An 'incentive plan' was established in the

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[58] Quotation from Restoring Excellence: AUB 1998–2008 by John Waterbury in Lead Innovate Serve: A Visual History of the American University of Beirut's First One Hundred and Fifty Years; First edition 2016, Section 5, A New Millennium 1997–2016 pp. 219–224; published by American University of Beirut Press; Page 222.

[59] By Deans Joseph McDonald (1953–67) and John Wilson, (Chair of Surgery 1953–1966 and Dean 1966–1968) who made most use of this system to build the department of surgery. Other departments followed suite.

[60] 600 h per year when on salary and 300 h per year when off salary.

[61] As a continuation of the legacy that started with the Prussian Hospital.

early 1970s, to supplement the salary of full time physicians with a take-home ceiling at twice the salary. This did not provide enough incentive for physicians to go on seeing patients after the ceiling was reached. The plan was modified to start with a higher percentage of take-home remuneration at low professional-fee earnings that gradually decreased to a minimum of 10% at high-earning brackets, with no ceiling. After a certain level of earnings, however, a carrot was placed, at which level and above, the physician retained 30% as explained in Sect. 4 above. This period, 1970–75, was reported as the most prosperous period for AUBMC [6]. After inauguration of the new 425-bed hospital, the rapid demand for recruiting physicians for filling the hospital beds, utilization of support services, and making most-efficient use of the newly built private clinics, could not be met with university money and hence a new category of appointees, similar to that of the 1960s was introduced, labelled Geographic Full Time (GFT),[62] to which physicians with clinical efforts of 80% or more were transferred and new highly specialized clinicians were recruited. A GFT recruit would have effectively a low basic salary plus benefits but uses the newly-built AUBMC private clinics, have all the practice at AUBMC, pay a collection fee and minor expenses amounting to 5–10% of professional fee collected, and give the institution 600 h at the discretion of the chair for academic functions. This was a favourite choice at that time of prosperity for both, the FM and the GFT physicians, since it did not cost the university much for the academic services rendered and more importantly left the physician with a higher compensation relative to others. This unfortunately turned out to be the most vulnerable form of appointment in unstable countries or countries in a steady state of unrest like Lebanon. As loads dwindled down during the early stages of the fighting in 1976, the GFT physicians lost significant income and their basic salaries were too low for sustenance. They became a liability to the university since cost of the clinic and their academic contribution were higher than the revenues from services they rendered. Most of the appointees in this category left by the early 1980s. The 'Incentive plan which helped bring about prosperity (1970–75) was disrupted after 1984. The 'Incentive Plan' was later dollarized after the fighting stopped, as described in Sect. 4 above, and started to yield around 40% of the collected professional fees to the institution during the early 1990s. This increased to 46% with higher professional fee yields. As for physicians, their share went down from an average of around 60% to an average of 54% as incomes increased and they moved to higher brackets.

By the late 1990s, the share of the University from the Incentive plan plus tuition fees and medicine's share of the endowment could not sustain the rapidity of recruitment required to build the hospital's capacity and achieve an acceptable operation. The university would not take greater liabilities and risks without a clear plan that shows light at the end of the tunnel. A transformational plan was presented that separated, through mission-based budgeting, the academic, the hospital, and professional practice enterprises. The areas of interaction were clearly defined. The main

[62] Had effectively low basic salaries with benefits for teaching but took about 90–95% of their patient care earnings.

revenue stream (a) for the academic enterprise would include the tuition fees, the revenue from the endowment either restricted or allocated to the faculty of medicine and dedicated contributions, (b) for the AUBMC, from patient-care revenue in addition to revenue from the endowments and philanthropic contributions, and (c) for physicians, from the professional fee revenues. Each enterprise would pay for all its costs. The relative growth in the academic enterprise is expected to be slower than that of the medical center which would grow in parallel with the growth of the professional-practice enterprise, the inpatient growth rate will attenuate and reach a certain quasi steady state as same-day medicine for surgery, chemotherapy and other procedures develop and grows with ambulatory medicine. Ambulatory growth will result in significant growth in support services such as laboratory medicine, radiology, and anaesthesia.

This separation of the enterprises, allowed for a major restructuring of the full-time status at FM/AUBMC. As in the past, all physicians had to qualify for academic titles and be appointed by the FM as full-time physicians with academic ranks. All collected professional-fee revenue, however, after deduction of the MDDF, the DOF, and other defined costs will be under the control of the physicians, administered by the MPP participants/committee through the Dean of the FM as per the MPP's Rules and Regulations. The amounts earmarked for take home may be distributed as take-home pay to each physician as in Fig. 4 (H), or pooled within a multidisciplinary program or group practice to be distributed by a defined, approved, and auditable take-home formula. In the previous 'Incentive Plan' physicians' share would have gone down approaching 50% as professional-fee revenue increases, with the MPP after deducting a fixed percentages for the MDDF and DOF and paying cost of business, the deducted amount will range from 25% to 30% and the take home from 70% to 75% of collected professional fee revenue. With the increase in 20–25% take-home remuneration and control of growth of professional practice, the MPP participants assumed the liability for the generation of the costs, including benefits and of linking growth to professional fee generation. Each dollar of professional fee generated translates into a certain amount of dollars for AUBMC as shown in Tables 7, 8, 9 and Fig. 15. It was shown that the projected increase in collected professional-fee revenue will allow for recruitment of 10–12 FTEs/year and the resultant increase in revenue will partially be used to decrease the deficit and partly to effect growth. This allowed for the completion of a strategic plan and facility master plan that ultimately results in gradually opening all beds of the hospital, renovate, equip, and expand AUBMC and start establishing multidisciplinary centers of excellence with group practices such as cancer, neuroscience including psychiatry, women's health, emergency medicine among others, and needless to say, plan to greatly enlarge the support services; in addition, restructure the teaching and research programs [5]. An effort analysis tool dependant on time spent in clinical practice, clinical administration, teaching, academic administration, and research determined the percentage effort each faculty member devoted to each. Clinical practice effort is compensated for by the professional fee take-home pay, clinical administration effort from AUBMC's patient revenue, and teaching, academic administration and research efforts from FM revenues and resources including tuition fees.

13 The Medical Practice Plan and Methods of Compensation in the USA

The MPP evolved from the history of compensation at FM AUBMC and not by a 'cut and paste' process. The fundamental transformational goals included its separation from both the academic and non-physician components of professional care by mission-based budgeting. With the authority given to the MPP committee through the dean, the MPP participants became responsible for the risks and liabilities of growth. Through shared governance, the three entities, FM, AUBMC, and MPP participants agreed on strategic plans for education, research, and patient care with 5 years rolling plans, 10 and 20 year horizons that allow for transparent assessment and oversight at multiple levels. Being the determinant of professional recruitment, the MPP drove the process forward. The plan provided a fixed percentage of the professional fee revenue for recruitment, research initiation, and maintenance, faculty's career development and wellbeing, thus supports the mission of the University. The take-home remuneration of each physician, in most instances, is supplemented by other forms of compensation for teaching, academic administration, clinical administration, and research. The initial distribution plan was kept simple[63] with the clinical take home in clinical (practice) departments being patient volume-dependent while in support departments in addition, it is rank-sensitive.[64] The academic and administrative supplements are similarly rank-sensitive in all departments. The protection of the MDDF and DOF were the hallmarks for growth. The rate of recruitment and growth should follow and not exceed the rate of growth of the DOF and MDDF.

Compared to evolving compensation plans in the USA [13–19], which include: a) revenue less (allocated) expense plans, not common in academic centers, b) base pay plans that may or may not be tiered by volume and/or rank, plus or minus a component of non-practice, i.e. other pay e.g. for teaching, administration etcetera. For such plans, the introduction of greater sophistication (other than time and volume) in measuring production include quality and/or efficiency indicators with the idea of providing awareness of and incentives for both. The indicators for quality and efficiency are measured by relative value units, RVUs [14, 17, 20] with an ending that indicates its purpose e.g. RVUe is an RVU for education, RVUr for research, and RVUi for insurance cost. The system was popularized by Medicare. c) The Capitation Plans with or without productivity components are dependent on predetermining cost of service, and paid for as a lump sum, went into disfavor because of changing costs and cutting corners. d) Straight salary/minimum-income (floor income) guarantees plus bonus/incentive; adopted most commonly in academic centers in the USA, are excellent for young new recruits but competitive practices overgrowth in this model will stifle group practices and decrease the quality of care.

[63] In line with historical compensation at FM AUBMC and to facilitate implementation.

[64] Ratios for rank differentials are taken from the annual AAMC compensation surveys across the USA.

The introduction of the various RVU systems is thought to attenuate the overgrowth in clinical practice and encourage physicians to partially shift their efforts into other income generating areas such as the quickly emerging areas of digitization, developing teaching/case materials and extending practice beyond a confined geographic area among others. The MPP introduced at AUBMC in 2002, consisted of a floor income linked to the effort analysis and after deducting costs from professional revenue, each physician paid fixed percentages to the MDDF and DOF. Low income earners paid the same percentages as high income earners. The latter may reach their take home targets to be comrable to peers in the USA as per AAMC compensation scales to attenuate practice overgrowth while low income earners are given subsidies for up to 3 years from the DOF and MDDF, after which they will take what they earn minus the required contributions. This gives them an incentive to reach the target. To avoid failure, recruitment is made when the actual or projected rate of increase of patient laod in the particular area of the recrutee is adequate to support recruitment. Quality and efficiency indicators were contemplated and are being defined.

As these plans evolve, what seems to be happening within group practices is a tendency for achieving more compensation equity within members of a particular discipline and greater focus for each physician to build skills in a specified area of practice. Members of a discipline's take-home remuneration are becoming closer to each other in percentile rankings published by the AAMC annual survey. Will this new reality move the process back to square one as is done at Mayo and Cleveland clinics, where the total revenue pool less mission-aligned expenses[65] determines through a mission based-formula of distribution, the average percentile ranking of the available take-home compensation kitty and hence compenstes each individual at that percentile for her/his discipline e.g. at 75th percentile of the compensations reported in the AAMC annual surveys? Distribution to physicians across the institution becoes aligned with this percentile, each in their own discipline. In addition to this compensation, Mayo and Cleveland Clinics offer a good benefit-and-pension package deducted from pooled revenues. The practice and all other efforts, education, research, administration etcetera, however, in this model, become totally institutionally driven.

The scope of this chapter does not extend to a detailed description of each compensation method with its pros and cons. The MPP was tried successfully at AUBMC from 2002 till now. Minor changes in distribution were introduced in 2013. Compensation plans need to be customized to each institution and regularly reviewed with tie. Cut-and-paste approaches result in encountering major problems after the fact rather than working them out through customization. To be successful, the plan should not initially deviate much from current practice, the academic (FM), administrative (AUBMC) and professional (MPP) enterprises need to shift to new steady states initially with a zero sum for all. Growth may then occur at a different pace for each, in a complimentary manner that benefits all.

[65] As determined by the strategic plan timeline.

14 Conclusions

The Medical Practice Plan (MPP) implemented as mock in 2001–02 and adopted in 2002–03 proved to be the locomotive that drove growth by fueling the recruitment of change agents with the needed clinical skills at a rate of 10–14 per year and hence became the centerpiece of the Faculty of Medicine and Medical Center's (FM/AUBMC) recovery plan and future sustainability. As presented, it succeeded to: (a) attract and retain qualified physicians; (b) indemnify equitably all faculty members; (c) form group practices to improve patient care and physicians' skills; (d) make academic physicians assume ownership of medical practice, and bear its costs; (e) link clinical growth to revenue generation, and thus diminish the university's liabilities for salaries, fringe benefits, and professional-fee receivables; (f) support the academic mission of the Faculty of Medicine by continuing to make each physician contribute 300–600 h per year for teaching, research and administration among other things; and (g) by markedly enhancing shared governance at the institution.

The plan provided incentives for physicians to increase collected professional-fee revenue while increasing their compensation as shown Figs. 12 and 13. The plan, for illustration, reduced the liability of the university for salaries and benefits significantly as shown in Table 11 by $27,802,204 from 2002–2007 while annual savings continue thereafter. It contributed about $6.9 million to support the operation of the FM/AUBMC, $1.5 million for research, and $2 million for faculty development and conference travel in the same period. The MPP generated money to recruit on an average 10–14 faculty members per year each of whom made their costs within 2–3 years. In 2009, there were 270 FTEs of faculty members, up from 190 in 2000–01, 25 in basic science, 170 MPP participants, and 71 practicing non-MPP participants.[66] This increased in 2018–19 to 323 FTEs of full time faculty, 35 in basic sciences, 288 full timers in clinical departments, (52 non-practicing faculty, 236 practicing MPP participants), and 48 practicing non-MPP participants.[67]

The increased patient loads generated to AUBMC significant additional revenue per year that contributed to the gradual reduction of the FM/AUBMC deficit while rebuilding finances. A careful balance was kept between the reduction of the operation deficit and keeping up the momentum of required growth, particularly in the MPPs early stages (2002–2010). The teaching and academic administration compensation was held at 60 full-time equivalents (FTEs), required for teaching the medical and Master of Science curricula and this contributed to control the increase in tuition to about 3% per year. A critical mass of MPP participants in different specialties evolved that made it possible to establish multidisciplinary centers of

[66] Carried through from the old academic part time, clinically full time faculty with clinics outside AUBMC.

[67] The author is grateful to Provost Mohammad Harajli for authorizing HR to provide him the faculty number data and to Deputy VP Ziyad Ghazzal for authorizing Nabil Mansour (HR/FM) to provide me with required data for FM and AUBMC.

excellence, revive the research enterprise, develop a critical mass of investigators to unfreeze the PhD program in biomedical sciences, and achieve the required accreditations for all programs. Further modifications of the curricula may further decrease costs and ultimately, with growth of the faculty, more of the 300–600 h given by each member may go to teaching.

As a result, the following were achieved: a system for effort analysis of faculty members was developed. The quality of achievement for each faculty member in each component of effort: research, teaching, and service were determined for each faculty member through defined indicators. This provided standards for recruitment, promotion, and equitable compensation that were gradually improved [5]. The strategic and master plans started to unfold with renovation of hospital floors resulting in the gradual increase in bed capacity.

The Facility Upgrades in 1996–2010 (see Fig. 9) included renovation of the 10 operating rooms and making plans for the addition of an extra five. The Pediatric ICU, PICU (6th floor) was renovated, and the Neonatal Intensive Care Unit (NICU) was upgraded, expanded, and built with skylights on the 7th floor starting as of 2007 and inaugurated in 2010. Four hospital floors were renovated, each with around 44 beds (4th, 6th, 7th and 8th), including the Idriss Delivery suite on the 7th**,** the 8th floor to become a cancer floor by 2009 and half of 10th floor. All of building 56[68] was renovated to include the ambulatory and inpatient unit for the CCCL on floor 1 and 5 respectively, family-medicine clinics, academic offices, and the surgery pre-admission unit on Floor 2, the Naef K. Basile ambulatory care facility on floor 3, and the psychiatry (part of AHNI)[69] inpatient and ambulatory units on floor 4. In addition to rebuilding an expanded emergency facility and establishing an Emergency (ED) department, the outpatient facility was markedly expanded by building the Pierre (Fahd) Abou Khater Medical Ars Facility in building 23 and renovating building 56 (multipurpose). The Rafic Hariri School of Nursing was totally renovated and inaugurated in 2009. Most AUBMC departments were significantly re-equipped from 1993–2009.

The active recruitment and facility renovation led the establishment of multidisciplinary programs of excellence. The multidisciplinary Cancer Program consisted, in addition to the academic component, of the Children Cancer Center of Lebanon (CCCL) and the Naef K. Basile (adult) Cancer Institute (NKBI). The CCCL, affiliated with St Jude's in the US, was operational in 2002 and takes care, free of charge (supported by donations and the Ministry of Health) of 100 children newly diagnosed with cancer per year, about 40% of the load in Lebanon. The Naef K. Basile (adult) Cancer Institute (NKBI) started in 2004 with ambulatory facility in building 56 an inpatient facility comprising the 8th floor of the hospital including the first 3 Bone Marrow Transplant Units in Lebanon, established in 2003 by USAID[70] support. The cancer load increased from around 900 patients/year to 1450 patients/year

[68] See Fig. 9.

[69] AHNI stands for the Abuhaydar Neuroscience Institute.

[70] USAID is the United States Agency for International Development.

after the NKBI was established and jumped to 1770 after the cancer floor was inaugurated in 2009, to range between 1800 to 2350 patients/year from 2010–2015. The Abuhaidar Neuroscience Institute (AHNI) was inaugurated in 2007 including the a state of the art 12-bed psychiatry unit in building 56 and neuro-ICU, with an inpatient unit on the 4th floor of Phase II building of the main hospital. The Abou Khater (Fahed) Medical Arts Facility was inaugurated in 2004. The Women's Health Program facility and the Bopst Breast Cancer suite were inaugurated in 2009 and 2010 respectively. The first Academic Department of Emergency Medicine in Lebanon with US Board certified emergency physicians was established with a completely newly built emergency facility was inaugurated in 2006. The Tabourian orthodentistry residency program was established in October 2001.

AUBMC achieved the required standards and became accredited by the Joint Commission International (JCI in 2007) so did its nursing service by the American Nurses Credentialing Center (ANCC) and achieved the prestigious Magnet Status (2009), the latter held then by only 5–6% of hospitals in the USA. The Rafic Hariri School of Nursing achieved accreditation by the Commission on Collegiate Nursing Education (CCNE) and the FM by the Middle States Association of Schools and Colleges. The College of American Pathologists (CAP) accredited the Department of Laboratory Medicine in 2008.[71]

The foundation for restructuring the curriculum, to include a significant component of interactive, problem-based, and team-based learning, were put in place. An education unit reporting was established. The assistant dean for education, Ramzi Sabra was supported to receive a Master's degree in Medical Education from the University of Illinois. A critical mass of about 15–20 FTEs of established and productive researchers were needed to be on board, as advised by the Academic Review Team in its 1999 Report to re-start the PhD and establish the MD PhD programs at AUBFM. They were being gradually recruited and had reached around 15 FTEs by 2009. The foundations for revamping the clinical curriculum were also built. All these were taking place as the number of full time faculty members was increasing and new facilities were renovated and/or built. A full plan for the DTS medical school building was completed by NTD Stickler (USA) early in 2009.

The energy of growth fostered partnerships with the Cleveland Clinic,[72] St. Jude, Sloane Kettering and MD Anderson. With the latter, AUB became a sister institution and a fortnightly clinical videoconference is held during which cancer cases from both institutions are discussed. Exchange programs with many prominent academic centers abroad are ongoing. A joint AUB and MUSC (Medical University of South Carolina) MD/PhD program had a number of graduate students enrolled in and graduated. A graduate of this program, Yusif Zeidan, completed his training and became Board Certified in Radiotherapy, joined the Department at AUB in 2016. The MD PhD is granted jointly by MUSC and AUB.

[71] All accreditations were successfully renewed on time since.

[72] Mainly for the annual Middle East Medical Assembly (MEMA).

Strategic Plan: the State of the University address of the President John Waterbury in 2004 guided the work on completion of the Strategic Plan. The Medicine plan was developed by 123 strategic plan groups with 189 faculty members, staff, and students among other stakeholders participating. The first draft was presented in 2007 and updated in 2009. It described the current status and what was achieved in each area: education (FM and SoN[73]), research (FM and SoN), and patient care (all AUBMC departments and services). It defines the strategic direction of each Department and service with projections towards the future, including actions, goals, and targets with a timeline and key indicators as measures of achievements. The 5-year rolling plan with its 10- and 20-year horizons formed the basis of the facility Master plan. It spells out the need for future development of incubator projects/Centers in Molecular Basis of Disease, Genetically Inherited Disease, Embryonic Stem Cell Research, Natural and Synthetic new drugs and Biomechanical and Biomedical Engineering.

The period beyond 2009, a period of execution and implementation of the plan, was marked by aggressive growth in establishing the rest of the infrastructure for teaching, research, and patient care. With the energy of growth, fund raising allowed for almost completion of the master plan as described earlier in this chapter. Significant effort was put in developing the designs and stacking diagrams for all buildings and undertaking a significant part of the renovation and construction by 2009, except for the Waasef and Souad Sawwaf, ACC and Medical Center Expansion buildings whose designs were developrd later, completing construction of the first two and placing the corner stone for the last in June 2019 (Figs. 9–11).

This chapter focuses on the major transformational changes, 1994–2009 that built the foundations, made a quantum leap forward, set the stage and developed a trend that continues to date. The experience may be helpful to the plethora of emerging universities in the Arab world.

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References

1. Kronfol N (ed) (2017) History makers in the health sciences from the American University of Beirut, compiled and edited by N. Kronfol. IBSN: 978-9953-0-4014-1. https://books.google.com.lb/books/about/History_Makers_in_the_Health_Sciences.html?id=RfYatAEACAAJ&redir_esc=y
2. The Moore Collection (2006) Franklin T. Moore photographs (1892–1902). American University of Beirut Press, p 84. https://www.aub.edu.lb/aubpress/pages/moorebook.aspx
3. Baadh A, Peterkin Y, Wegener M, Flug J, Katz D, Hoffmann JC (2016) The relative value unit: history, current use, and controversies. Curr Probl Diagn Radiol 45(2):128–132

[73] SoN is School of Nursing.

4. Becker's Hospital Review (2019) Healthcare cost accounting: 8 strategies to streamline implementation and quickly achieve measurable results. ASC Communications. https://www.beckershospitalreview.com/finance/healthcare-cost-accounting-8-strategies-to-streamline-implementation-and-quickly-achieve-measurable-results.html
5. Cortas N, Rahal BL (2019) Role and impact of bibliometric analysis of research productivity in faculty evaluation, recruitment, promotion, reappointment, benchmarking, and in Mission-Based Management (MBM): experience of the faculty of medicine at the American University of Beirut AUB (1997–2007). In: Badran et al (eds) Major challenges facing higher education in the Arab world: quality assurance and relevance. Springer, Cham, pp 289–324
6. Khuri RN (1983) The summer of 1982. Middle East J Anesthesiol (Spec Issue, Lebanese War) 7(1):1–8
7. Thomas B (2019) Free medical school tuition: will it accomplish its goals? JAMA 321(2):143–144
8. Asch DA, Nicholson S, Vujicic M (2013) Are we in a medical education bubble market? N Engl J Med 369(21):1973–1975
9. Verduin ML, Balon R, Coverdale JH, Louie AK, Beresin EV, Roberts LW (2014) The rising cost of medical education and its significance for (not only) psychiatry. Acad Psychiatry 38(3):305–308. https://doi.org/10.1007/s40596-014-0118-7
10. Merritt Hawkins (2019) Report: demand for specialist physicians driving physician recruitment. https://www.prnewswire.com/news-releases/report-demand-for-specialist-physicians-driving-physician-recruitment-300879065.html
11. Merritt Hawkins (2019) Survey: physicians generate an average $2.4 million a year per hospital. https://www.prnewswire.com/news-releases/survey-physicians-generate-an-average-2-4-million-a-year-per-hospital-300799621.html
12. Restoring Excellence: AUB 1998–2008 by John Waterbury in Lead innovate serve: a visual history of the American University of Beirut's first one hundred and fifty years; First edition 2016, Section 5, A new millennium 1997–2016. American University of Beirut Press, p 222. http://www.aub.edu.lb/aubpress/Pages/LeadInnovateServe.aspx
13. Seabury SA, Jena AB, Chandra A (2012) Trends in the earnings of health care professionals in the United States, 1987–2010. JAMA 308(20):2083–2085
14. Reich DL, Galati M, Krol M, Bodian CA, Kahn RA (2008) A mission-based productivity compensation model for an academic anesthesiology department. Anesth Analg 107(6):1981–1988
15. Andreae MC, Blad K, Cabana MD (2006) Physician compensation programs in academic medical centers. Health Care Manag Rev 31(3):251–258
16. Chung JH, Paushter DM, Katzman GL (2017) Impact of an incentive compensation plan on academic productivity. J Am Coll Radiol 14(4):558–560
17. Lee TH, Bothe A, Steele GD (2012) How Geisinger structures its physicians compensation to support improvements in quality, efficiency, and volume. Health Aff 31(9):2068–2073
18. Gordon L (2001) Basic models for physician compensation with corresponding contract provisions. Group Pract J 50(2):17–23
19. Merritt Hawkins on behalf of The Physicians Foundation (2016) 2016 Survey of America's physicians practice patterns and perspectives. https://www.merritthawkins.com/uploadedFiles/Physicians%20Foundation%202016%20Survey%20of%20Americas%20Physicians.pdf
20. Hamory B, Douglas S (2016) Physician compensation plans in value based world. http://health.oliverwyman.com/2016/08/making_sense_of_macr.html

Illinois Institute of Technology (IIT)'s Experience in Building a Culture of Entrepreneurship in Its Engineering Curricula

Robert F. Anderson and Sohail Murad

Abstract Competing in the modern world will not look like it did when the major manufacturing industries were shipbuilding, steel mills, oil refineries, and automobile manufacturers. What will the oil-exporting countries do when their wells go dry? What happens when your new industries must compete against the American, German, Korean, Chinese, and Japanese companies long established with strong balance sheets, global customers, and attractive income statements? It is not too late to begin a major cultural change in your universities. While this chapter addresses engineering applications, similar issues must be faced in law schools, medical schools, and business schools.

Keywords Innovation · Entrepreneurship · Technology Transfer · Teaching · Economic Development

1 Introduction

1.1 Problem Statement

Traditional fundamental technical courses will always be an important part of the foundation of an engineering education [1]. But in today's world they do not go far enough. Employers in the United States expect all of our graduates to be technically competent. What they are also looking for is curiosity, creativity, financial acumen, communication skills, problem solving, project management, and teamwork. As the world shifts from heavy industries to computers, social media, medical devices, new

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transportation systems, artificial intelligence, and big data management, opportunities abound for a university that commits to responsiveness and rapid change [2].

2 Management of Change

All change is difficult – and cultural change is the most difficult. Institutions are typically built upon a foundation of rock. Over the years, policies and procedures, reward and recognition systems, staff selection and promotion, tradition, and leadership styles reinforce "the way things are done around here" [3]. Change agents grow frustrated at the lack of progress and eventually give up.

Why is cultural change so hard? It involves a lot of hard work and change in attitudes. People fear that stepping out of their comfort zones creates a high risk of failure. As a result of massive change, some people are winners and some are losers who will do anything to protect the status quo. Fear and defensiveness harden their attitudes and commitment to resisting the new ideas. Ultimately change affects power, which few want to give up. But change can happen under strong, committed leadership and application of a rational change management process. Each step of the model explained below must be completed before moving on to the next. Failure to address all of them will stop any well-intentioned change process. The variables are multiplied to indicate that poor performance in one will pull down the effectiveness of the entire process.

2.1 Change Model

- $D \times V \times F > R = C$ [4]
  - **D**issatisfaction with the status quo
  - **V**ision of something better
  - **F**irst steps (detailed project management with clear roles and responsibilities)
  - **R**esistance
  - **C**hange

It takes time and hard work to document what is wrong with the status quo. Involvement of people working in the process at all levels of the organization must contribute. The resulting document should be shared across the organization with senior management leading the communication process. The message needs to be "Here are the problems we have identified that stand in the way of growth and continued success. I am committed to changing the way I do my job and ask for your commitment to help me achieve significant improvement in our performance."

The vision must be motivating, stretching, and challenging – but not impossible. It must be quantifiable and externally focused, emphasizing the impact on the customer audience. "We will introduce two new commercial products to the global marketplace per year. We will improve our customer satisfaction scores by 10% per year until we consistently satisfy more than 95% of their expectations. We will cut the cycle time from basic research to commercial introduction by 50% within three years."

The first step is a focus on implementation. What needs to be done? Who will do it? When? With what resources? With what impact? How will it be measured and monitored?

Resistance must be discovered and overcome. Senior management sets the tone and puts the organization on notice that standing in the way of progress will not be tolerated. Resisters often have legitimate concerns. Getting them involved to address their concerns turns a barrier into an enabler.

Such organizational or cultural change typically takes 5 years. Even minor improvement need to be celebrated to maintain the momentum. As change agents are identified and rewarded the organization realizes that this is serious business [5].

3 Historic Versus Future Focus of Universities

Universities have historically focused on basic science, fundamental research, publications, and open sharing across the scientific community. If the mission of the university becomes innovation and entrepreneurship, the culture must embrace making things, breaking things, taking crazy risks, and following illogical processes toward massive improvement and then protecting the resulting intellectual property before publication. A strong technology-transfer function is essential to achieving balance between the old and the new [6].

3.1 Academic Culture of Openness

Moving to a culture supporting innovation and entrepreneurship runs into a barrier that has prevailed in universities for decades if not centuries. Most professors are collegial, not competitive. They want to publish their work, debate with colleagues around the world, and attend research conferences such as the Gordon Conference [7]. Their scientific progress involves standing on the shoulders of giants.

3.2 Entrepreneurship

Entrepreneurship is the best model for fast, significant change [8]. The staff must be protected from the risk-averse culture of the typical large organization. A small self-standing group has no history, no rules, no sunk costs, no "we've always done it this way", and an opportunity to build a better culture focused on massive improvements to products, processes, and operating procedures. Absence of a command-and-control management structure, close working relationships among the entire team, commitment to a set of stretch goals, open communication, and tolerance of risks and failure are key to a new level of organizational effectiveness. Reward and recognition systems will create a problem with traditional bureaucratic human resource systems. Key players need to get a big payoff when they are successful.

4 Technology-Transfer Process

Technology transfer is the process of transferring scientific findings from one organization to another for the purpose of further development and commercialization [9]. This requires diverse business skills, familiarity with patent and licensing law, broad-based technology background, and industrial experience. Practitioners must be bilingual (university and business languages) to serve as the interface between academicians and business people. For a real-world example, we offer the experiences of co-author Anderson.

4.1 Background of an Illinois Tech-Technology-Transfer Expert

- Chemical engineering degree from Illinois Tech
- MBA degree from Northwestern University
- 37 years with UOP LLC, a Honeywell company, world's largest source of technology to the oil-refining and petrochemical industries
  - Technology development
  - Commercialization
  - Licensing
  - Marketing
  - Strategic planning
  - General management
- 14 years at Illinois Tech in tech transfer/entrepreneurship and 18 years teaching

4.2 What Does a Technology-Transfer Expert Do?

The expert manages all aspects of generating and protecting intellectual property, starting with counseling the faculty inventor on patent law, assisting with generation of the patent disclosure, engaging a patent attorney to offer an opinion on patentability, coordinating communication between the inventor and the patent attorney, deciding on making a formal patent application, and managing the relationship with the United States Patent and Trademark Office (USPTO). After a patent is issued, the tech-transfer person is responsible for monetizing the invention. This can involve licensing, selling the patent, or assisting with formation of a company to commercialize the technology.

The technology-transfer process can include development of relationships with industries, assisting a startup company with management issues, and collaboration with other universities and government laboratories. Marketing, strategic planning, sales, and negotiating experience are part of the job requirements.

5 University Mission

Illinois Tech's Mission includes teaching, research, community service, and economic development. Having a strong, clear mission statement is an essential part of designing the university of the future [10].

5.1 Evolution in Teaching

The foundation of an effective program in support of innovation and entrepreneurship continues to be the traditional science disciplines, engineering specialties, and a mix of undergraduate and graduate degree programs. While most engineering and science curricula are already providing the basics, it is possible to interweave experience with team-based projects, creativity, project management, business skills, and entrepreneurship. In some cases, a formal business minor involving finance, accounting, marketing, business law, strategic planning, and similar topics can be offered. While most students want to finish their undergraduate programs in 4 years, it may be necessary to add a fifth year to cover all of the relevant material needed for a career in technology-oriented business.

5.2 University Impact on Economic Development

Technology-based startup businesses can provide jobs for students or community residents. When technology is adopted by established businesses, their profitability and their workforce can grow. Local government can collect higher tax revenue. Universities can participate in workforce development: education, training, and retraining of employees to be able to contribute to high tech manufacturing. Everyone benefits from providing new products and services to the community.

5.3 Sponsored Research in the United States

Research is expensive. Total research budget of US universities is greater than $40 billion/year.

Government agencies such as the National Institute of Health, National Science Foundation, Department of Defense, Department of Energy, and others provide about 90% of the funds while industrial organizations provide the remaining 10%. The major targets of sponsored research are biotechnology, energy, information technology, and materials science.

5.4 Comparing Startup Companies (Entrepreneurs) with Large Established Companies

Existing private-sector companies have advantages and disadvantages. They typically have a lot of money available for research and development, manufacturing facilities, and market access. They have well-known brands and solid reputations. At the same time, they can be bureaucratic, slow to react to changes in technology and markets, and risk-averse.

A typical new startup company based on technology must be focused, ambitious, fast-moving, agile, and non-bureaucratic. They thrive not on taking risks, but on managing risks.

6 Why Support the Entrepreneurship?

6.1 Qualitative Benefits to the University

As students and young professionals become more interested in the entrepreneurship career path, the university's ability to attract and retain entrepreneurial faculty becomes critical. Globalization of industries makes it essential to attract outstanding graduate students from around the world. Successful product or process introductions contribute to the university's reputation for innovation. Building successful collaborative research programs with industry opens the doors to wider opportunities for both parties, providing highly trained students for the industrial workforce and giving the university access to equipment and talent they would normally lack.

6.2 University Reputation and Recognition

Public relations are an important function as universities compete with each other. Successful technology commercialization leads to recognition for the university and its faculty, which leads to attraction of additional faculty and students. Capturing value from innovation contributes to the university's budget to support growth, purchase of expensive equipment, and recruitment of high-quality staff. Good corporate relations based on how universities can help industry solve its problems opens the door to additional sponsored research and other cooperative ventures.

6.3 Attraction of Faculty and Students

Some faculty want to see their research commercialized and several of them want to participate in the process. Participation in product and process development and commercialization makes them more effective educators for entrepreneurial students. Faculty and students both want to work with the best people in the field and they want to have a positive influence on society. Students want their education grounded in economic reality and they want to work on problem with high visibility.

6.4 Measuring Benefits to Society

It is difficult to identify and quantify the proper metrics for monitoring societal benefits. Some that have been used include patents filed and issued, license agreements signed, revenues from licenses, new companies formed earnings from equity investments, number of new products introduced, capital investment, jobs created, taxes collected, less disease, environmental quality improvement, and longer life span.

7 Transformation from Manufacturing to a Knowledge-Based Economy

Hard physical facilities such as steel mills, automobile manufacturing, oil refineries, petrochemical plants, and textile mills used to be the basis for economic competitiveness. With advances in information technology, artificial intelligence, big data exploitation, and social-media businesses based on intellectual assets have taken over industry leadership. Examples include e-commerce, education, pharmaceuticals, medical imaging, music, electronic games, and telecommunications. Solutions to global problems in energy generation, environmental cleanup, food and water supply, and transportation will require integration of the “hard” and “soft” sciences.

7.1 Biggest Challenges in Technology Commercialization

- Basic invention can be quick and inexpensive
  - Computer simulation
  - Back of the envelope calculations
  - Test tube experiment
- Reduction to practice is neither quick nor inexpensive
  - Risk mitigation
  - Performance details
  - Economic details
  - Many practical issues

7.2 Research vs Development

Nearly every university does research but very few do development. A rule of thumb estimates that $1 million of laboratory research will require $10+ million of development effort preparing for commercialization. An example from oil refining or petrochemical technology development illustrates the scope of the development phase.

- Evaluating feedstock sources and impurities
- Catalyst development – formulation, manufacturing procedures, performance, life, deactivation mechanisms, regeneration

- Materials of construction
- Product yields and specifications
- Optimization of operating variables

7.3 Marketing

Most new ventures fail because of poor marketing. Absence of a significant customer base with a clearly defined problem and unsatisfactory current solutions suggests an unsuccessful future. It is natural for a scientist or engineer to become enamored with their technology whether or not there is a commercial opportunity. It is also easy to overestimate a potential customer's propensity to try new ideas. For this reason, time spent preparing a detailed problem statement is essential before investing time and money on a "solution". If you are unable to clearly and quantitatively explain the value proposition from the customer's perspective you should look elsewhere. On the good-news side, new computer tools make it easy to reach many prospective customers via websites and social media to confirm potential demand before spending a lot of resources.

7.4 Example of Successful Technology Transfer

A new drug for neuropathic pain was discovered by chemistry professor Richard Silverman after 15 years of research at Northwestern University. The patent was licensed to Pfizer for $700 million. Under Northwestern's policy of sharing income Professor Silverman received ~$175 million [11]. Pfizer was not interested in ongoing collaboration with the professor, they just wanted the patents. The professor continues to do research for the love of science.

8 Conclusion

Technology transfer is a complicated process that is essential to creating economic development in the Arab world. Best practices are understood and well documented, although challenging to implement. Nevertheless, universities have an important role to play in solving global issues of energy, food, environment, public health, water, and housing. The secret of success is close cooperation between faculty and technology-transfer staff.

References

1. Mccowan JD, Knapper CK (2002) An integrated and comprehensive approach to engineering curricula, part one: objectives and general approach. Int J Eng 18:633–637. https://www.ijee.ie/articles/Vol18-6/IJEE1331A.pdf
2. Goltz SM, Hietapelto AB, Reinsch RW, Tyrel SK (2008) Teaching teamwork and problem solving concurrently. J Manag Educ 32:541–562. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.840.8668&rep=rep1&type=pdf
3. Venables M (2019) Change of culture reaps rewards for BP's digital transformation. Forbes. Jan 31, 2019. https://www.forbes.com/sites/markvenables/2019/01/31/change-of-culture-reaps-rewards-for-bps-digital-transformation/#7d0184c6199c
4. Beckhard R (1975) Strategies for large system change. Sloan Manag Rev 16:43–55. https://search.proquest.com/openview/8f6502b8f7f98c54842f4b673eb676f0/1?cbl=35193&pq-origsite=gscholar
5. Dannemiller KD, Jacobs RW (1992) Changing the way organizations change: a revolution of common sense. J Appl Behav Sci 28:480–498. https://journals.sagepub.com/doi/abs/10.1177/0021886392284003
6. Rasmussena EA, Sørheim R (2006) Action-based entrepreneurship education. Technovation 26:185–194. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.462.6998&rep=rep1&type=pdf
7. Panda S, Santosh S (2017) Faculty perception of openness and attitude to open sharing at the Indian National Open University. Int Rev Res Open Distrib Learn 18(7):89–111. http://www.irrodl.org/index.php/irrodl/article/view/2942/4463
8. Patzelt HP, Shepherd DA (2017) Strategic entrepreneurship at universities: academic entrepreneurs' assessment of policy programs. Entrep Theory Pract 33:319–340. https://journals.sagepub.com/doi/abs/10.1111/j.1540-6520.2008.00291.x?journalCode=etpb
9. Bradley SR, Hayter CS, Link AN (2013) Models and methods of university technology transfer. Found Trends Entrep 9:571–650. file:///C:/Users/Sohail/Downloads/9781601986696-summary%20(3).pdf
10. Stark K (2018) At Illinois Tech, energy innovation and entrepreneurship have new home. Energy News, December 5. https://energynews.us/2018/12/05/midwest/at-illinois-tech-energy-innovation-and-entrepreneurship-have-new-home/
11. Technology Transfer Works: 100 innovations from academic research to real-world application. https://www.immagic.com/eLibrary/ARCHIVES/GENERAL/AUTM.../A070216T.pdf

The Role of Faculty Members in Building an Entrepreneurship Culture in Higher Education: The Case of the Australian College of Kuwait

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Abstract The field of entrepreneurship education has witnessed accelerated advancements in the last two decades with a trend towards a university-wide education. This chapter investigates the role of faculty members in building a culture of entrepreneurship in higher education. It takes the Australian College of Kuwait (ACK) as a case study and a role model in applied education and Project-Based Learning (PBL). Then it explores the involvement of faculty members in college activities and teaching methodologies that promote a culture of entrepreneurship. Finally, it sheds the light on the personal attributes and qualities of instructors that promote entrepreneurial behavior among the students in the college.

Keywords Australian College of Kuwait (ACK) · Entrepreneurship and intrapreneurship · Entrepreneurial mindset · Innovation · Applied education · CDIO · Project-based learning (PBL) · Internship · SMEs

1 Introduction

There is a global augmented trend of encouraging and developing entrepreneurship in the education sector. The goal is to prepare college graduates to gain commercialization skills and ability to introduce new business ideas and create small and medium enterprises (SMEs).

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Generating entrepreneurs means increasing the number of business leaders and change makers who drive new business ideas to successful enterprises. These enterprises have distinctive contributions to the development and diversification of the national economy. Many of them were able to create a global presence and impact many aspects of our lives. To name a few, Google, Facebook, Apple, and Amazon were all launched by young entrepreneurs that had learned the entrepreneurial process and applied it well. They all started as small business ideas and witnessed exponential growth. In the USA, fast-growing technology-based businesses flourished while in Europe and China the development of SMEs and startup approach for small businesses was observable [1].

It is self-evident that entrepreneurship has been the single most important component of long-term economic growth. In 2000, the U.S. economy required 21 million jobs for people entering the work force for the first time. It turned out that 23.5 million new jobs were created. Small businesses and the entrepreneurs who run them accounted for more than two thirds of those new jobs [2].

The emergence of an economy that relies on SMEs triggers the need to educate and prepare college graduates to become entrepreneurs after graduation [3]. Entrepreneurship education has become increasingly important worldwide and is given high priority in many countries. For example, entrepreneurship education in China is driven by grassroots innovations and government policies.

For the last two decades, entrepreneurship education in China received special attention from the government on a national level. Table 1 summarizes the development of entrepreneurship education in China since 1997 [1].

In the Middle East, due to varying political, economic, social, and legal factors, entrepreneurship education has been progressing with relatively good advancements in some countries compared with others. Most startup businesses are based on new business ideas, which require an inductive and encouraging environment that supports critical and creative thinking. Such an education environment is lacking in many universities and colleges in the Middle East. Consequently, the intellectual capital and property in the Middle East is very low in comparison to U.S. and Western countries.

Table 1 History of entrepreneurship education in China in the last two decades

Year	Achievement
1997	Student competitions on new business ideas were encouraged
2002	Launch of National Entrepreneurship Education Pilot Program (NEEPP) by nine different institutions
2005	Know About Business (KAB) program developed by UNESCO is introduced in China and made available in six different universities (cultivating innovation and entrepreneurship)
2008	Entrepreneurship and science parks are introduced in different universities
2012	Ministry of Education made entrepreneurship education compulsory at the tertiary level Universities have startup incubators on campus
2015	Online entrepreneurship education through MOOCs (Massive Open Online Course) encouraging peer-to-peer learning

Despite the above challenges in the Middle East, many universities and colleges have introduced world-class programs for entrepreneurship education. In this chapter, we present the Australian College of Kuwait (ACK) as a role model for applied education and Project-Based Learning (PBL) that graduated many entrepreneurs who started successful ventures in the last 15 years.

In order to investigate the role of faculty members in building a culture of entrepreneurship among their students, we need first to define entrepreneurship and understand its elements and characteristics. Then we need to find out how it is educated and what common characteristics and attributes successful entrepreneurs have.

2 Entrepreneurship & Innovation

"Entrepreneurship" comes from the French word *entreprendre* meaning "to undertake or to take in one's own hands". During the industrial revolution, the term "entrepreneur" was used to describe the person who had formulated a business or venture idea, developed it, and assembled different resources in order to create a new business venture. Generally, entrepreneurs are risk-taking people who react to opportunities and bear uncertainty. They do things that are not generally done in the ordinary business routine. Entrepreneurs are critical contributors to economic growth through their leadership, innovation, job creation, competitiveness, and formation of new industry. It is widely accepted that entrepreneurship provides the seedbed of new projects and wealth creation. It brings benefits both at the macro level of economic development and also at the micro level of personal achievement and creating new employment opportunities [4].

Entrepreneurship definition indicates "initiating a behavior" to accomplish a task, a process, a system, or project from start to completion. Consequently, entrepreneurship can be defined as the process of identifying opportunities and converting them into marketable products or services. The field of entrepreneurship involves defining, evaluating, and exploiting opportunities. Entrepreneurship is a dynamic process of vision, change, and creation. It requires the application of energy and passion towards the creation and implementation of new ideas and creative solutions. Essential ingredients include: (a) vision to recognize opportunity, (b) willingness to take calculated risks, (c) ability to formulate an effective venture team, and (d) skill to build a solid business plan and marshal needed resources [5].

On the other hand, entrepreneurship is viewed as a progressive process that occurs over time [6]. Therefore, entrepreneurial intentions would be the first step in the evolving process of business venture creation. Over time, these intentions will be converted to entrepreneurial behaviors [7].

However, there are antecedents that influence this process such as self-efficacy which reflects one's belief in his/her ability to accomplish a task. It plays a major role in how a person approaches goals, tasks, and challenges [8]. Furthermore, the personal attitude refers to the degree to which the individual holds a positive or negative personal valuation about being a successful entrepreneur [9, 10]. Finally, subjective norms could influence entrepreneurial intentions as they measure the perceived cultural influence and social pressure to encourage or discourage entrepreneurial behaviors [9]. Therefore, entrepreneurial intentions are influenced by the perceived behavioral control of the individual as well as the perception of the ease or difficulty of becoming an entrepreneur.

Entrepreneurship is often fueled by innovation. Innovation is the critical dimension of economic change [11]. Schumpeter argued that economic change revolves around innovation, entrepreneurial activities, and market power. In other words, product or process innovations are the practical implementation of inventions that have measurable values and can make meaningful impacts in society.

Innovation and entrepreneurship go hand in hand [12]. For example, Apple Inc. which started as an entrepreneurial company did not invent the MP3 but they "innovated" the iPOD line of portable media players. In fact, the German research organization Fraunhofer developed the first, however, unsuccessful MP3 player in 1989. In 1999, portable MP3 players were introduced in the market while the Apple iPOD was introduced in 2001 followed by a series of innovative product lines (iPod Shuffle, iPod Nano, iPod Touch) that provided measurable values to people all over the globe. The market shares of iPod grew to 31% in 2004 but it jumped to 65% in 2005 reaching a plateau.

3 The Entrepreneurial Process

The entrepreneurial process is dynamic and requires a self-motivated person to drive it to the end. The entrepreneur who captures the opportunity must have a strong passion and perseverance to develop innovative solutions, to exploit them, and organize the resources needed to successfully turn it to a profitable business.

In his encyclopedia of entrepreneurship, John Hornaday listed characteristics often attributed to entrepreneurs [13]. Table 2 lists a selection of these characteristics. It should be noted that not all of these characteristics and attributes are teachable and learnable. Some people possess certain innate traits and personality characteristics that are not teachable or learnable.

Table 2 Common characteristics often attributed to entrepreneurs

Passion, commitment	Confidence
Perseverance, determination	Creativity
Ability to take initiatives and make decisions	Energy, diligence
Risk taking – not afraid to fail	Resourcefulness
Self-leadership and dynamism	Courage
Orientation to clear goals and results	Honesty and maturity
Able to take challenges and manage change	Independence
Optimism and sense of humor	Ability to influence others

The entrepreneurial process consists of two dynamic processes:

1. Formation of the entrepreneurial mindset
2. Progression in the entrepreneurial journey

3.1 Entrepreneurial Mindset

A mindset is a mental attitude and set of assumptions, methods, or notations held in a person's mind that describes their mental attitude, view of the world and philosophy of life. It represents one's own interpretation and response to different situations and opportunities in life. Building the mindset process is a cultivation process that influences intentions/behaviors.

3.2 Entrepreneurial Journey

Successful commercialization of new business ideas is initiated by starting business ventures and taking calculated risks. It includes defining, evaluating, and exploiting opportunities then working effectively on creating business solutions for these opportunities. The venture journey process is the real exposure of the market, managing challenges and changes as a result of the commercialization process. The entrepreneurial journey is triggered and influenced by many factors as shown in Fig. 1.

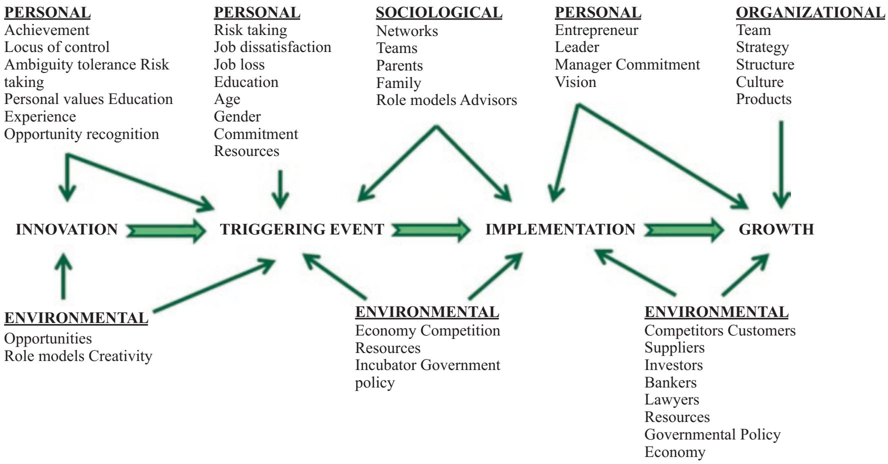

Fig. 1 The entrepreneurial process [2]

The main factors that shape and influence an entrepreneur are personal attributes and environmental factors [2]. Personal attributes are mostly learnt or gained as a result of the entrepreneurial culture or environment. These attributes include the following:

- Higher internal locus of control
- Desire for financial success
- Desire to achieve self-realization
- Desire for recognition
- Joy of innovation
- Risk tolerance

Environmental factors also play an important role in influencing an entrepreneur. It is more likely for someone to be innovative and entrepreneurial in a region that promotes and support entrepreneurship. These environmental factors include the following:

- Local, regional, or national attitudes
- Social and cultural pressures for or against risk taking
- Access to entrepreneurial role models
- Responsibilities to family and community

4 Entrepreneurship & Innovation Education

The field of entrepreneurship education has witnessed accelerated advancements in the last two decades with a trend towards a university-wide entrepreneurship education. According to Ewing Kauffman Foundation, there are more than 5000 entrepreneurship courses and programs offered in 2600 schools worldwide [14]. These courses focus on capturing opportunities and turning ideas to successful realities. Students who received education in entrepreneurship and product innovation were more likely to be self-employed and launch either business startups or social enterprises. The education of entrepreneurship was emphasized in a UNESCO World Conference in 1998 as it became an essential element of any entrepreneurship ecosystem [15]. However, this requires a paradigm shift from conventional education to entrepreneurial education that is made available for all university students. Many conventional business schools still teach business from the perspective of working for somebody in an organization.

Entrepreneurship education focuses on cultivating the entrepreneurial mindset of students which is teachable and learnable. Such mindsets influence behaviors and actions. Students practice the process of capturing opportunities and creating value based on active hands-on experimental approach [16]. This approach influences their attitudes to lead businesses and start new ventures. Research indicated that entrepreneurial behaviors are positively associated to entrepreneurial education [17].

There are scholastic difficulties in teaching entrepreneurship simply because it is an active process rather than static. It is a creative and challenging journey to establish a small business or to commercialize a new idea. It must be exercised practically overtime. Hence, conventional college or university education only glimpses a snapshot of it [18]. It is plausible to state that teaching entrepreneurship involves both the “knowledge” (i.e. science) and “skills” (i.e. ability and tactics). These skills are fundamental to implement the acquired knowledge and transform ideas to real enterprises. Obviously, this hinders the use of the more traditional approaches to teaching and learning.

To some extent, the underpinning knowledge of entrepreneurship can be taught with conventional pedagogy but students will still lack the entrepreneurial experience. This is described as the art of applying entrepreneurship skills in the real world [19]. An area which needs to be addressed is “tying academic learning to the real world”, linking pedagogical theories to actual business methods [20]. They proposed that mentoring by professional educators and successful entrepreneurs may be one such avenue.

Henceforth, there is a paradox or tension between enterprise creation as a “creative role” and startup business management as a “functional role”. New business creation is viewed to be inductive; it requires the ability to see things in a different way and involves leaps of perception and trials. Skills such as critical thinking, problem solving, and emotional intelligence are needed to prosper in this creative role.

There are pedagogical challenges of transmitting, informing, and developing entrepreneurial skills. However, these challenges can be overcome by providing the students with the opportunity to work with entrepreneurs who started real businesses and obtain experiential learning. Students who work with entrepreneurs will encounter the risks and ambiguity of the unstructured situations experienced by most entrepreneurs [21]. After all, true entrepreneurial learning should encompass both concept and procedure, so people should be encouraged to use their own initiative to secure their economic future [20].

Education can serve as a preparatory function to understand new venture initiation and business start-ups, whereby the transfer of practical knowledge and the acquisition and development of relevant skills would be expected to increase the self-efficacy and effectiveness of entrepreneurs [22].

Finland has a unique experience in taking an extra mile towards involving the practical experience in the education process. Entrepreneurship education in Finland is a broad concept that covers all levels of education from primary schools to colleges and universities. Entrepreneurship is linked to citizenship in Finland, in other words, entrepreneurs are viewed as active members in building their nation through their positive contribution to their society and national economy. Projects such as “Me and My City” are addressed to school students to build their entrepreneurial behavior, while university students are invited to be involved in real life businesses and team with real entrepreneurs. “Team Academy, Tiimakatemia” is an exemplar Finnish model for entrepreneurship education where teaching is replaced with proactive learning and teachers become coaches. No business simulation is taught but real business interaction. Young entrepreneurs learn from each other and from more experienced entrepreneurs. They reinforce their own learning and share a similar discourse, allowing for greater understanding [14].

5 Entrepreneurship & Innovation at ACK

The area of innovation and entrepreneurship is of great interest for the Australian College of Kuwait because of two parallel motives: (a) from the business perspective, innovation is a route to new markets, better economy and a more robust future; (b) from the perspective of the government, reducing reliance on oil is essential and it can be achieved through innovation and entrepreneurship, which are the sources of economic health and competitiveness. Given the vision of the country to be a financial hub, this goal can be achieved by pursuing and promoting entrepreneurship. Since the inception of the Innovation and Entrepreneurship Center, every semester, ACK has produced entrepreneurs that secured funding either through the Kuwait National Funds or through private investors.

5.1 The Case of the Australian College of Kuwait (ACK)

Founded in 2004, ACK was one of the frontier private colleges in the Gulf region, which adopted a pedagogy-based applied education, and hands-on experience that has strong links with industry. The "two plus two" system adopted by the college enables students to earn a diploma after finishing the first 2 years then a bachelor's degree after finishing a total of 4 years. The college has four schools: The School of Engineering, School of Business, School of Aviation, and School of Maritime.

ACK has an applied education system using Project-Based Learning (PBL) and CDIO (Conceive, Design, Implement, Operate) methods. In addition, it is reinforced by many supporting activities and strong links to the industry. Assessments are designed based on real problems and in many cases connected to real clients. Students are required to apply the acquired knowledge in class (i.e. theoretical part) in a real context. This involves the utilization of various important skills such as team work, critical thinking, problem solving, and decision making. In many cases, students working in groups face different views and learn to solve their intellectual conflicts and reach the optimum solution.

ACK has implemented tools to monitor and enhance the students' capabilities on a regular basis. These tools provide students the opportunity to meet real clients and present to them their proposed solutions for selected problems based on the underpinning knowledge and skills acquired in the college.

5.2 The ACK Strategy on Innovation and Entrepreneurship Education

Entrepreneurs have the simultaneous tasks of innovation, that is, bringing the first product to market, and of building and financing a new organization. Entrepreneurship is a significant source of new jobs creation and economic growth, and is being strongly incentivized by governments and universities. From the perspective of the entrepreneur, entrepreneurship is a high-risk, high-potential reward activity. The role model of many successful high-tech entrepreneurs has particularly excited young graduates in many nations. Other than the scarcity of resources, lack of established process and the extreme need to succeed quickly on the first product, the fundamental nature of work in an entrepreneurial firm is not very different. There are many things that are different about entrepreneurial ventures, including creating an organization and raising capital. There's a growing consensus that it is feasible and desirable to engage students in experiences that develop an entrepreneurial mindset, and that doing so will better prepare them for success.

ACK considers its applied education model based on PBL and CDIO as an enabling foundation for the development of entrepreneurship education. In its five-year strategic plan 2015–2020, ACK set a strategy for innovation and entrepreneurship in order to be projected in all schools.

The strategy covers five main areas of focus that are detailed in Table 3. Namely (1) curricular and extracurricular education; (2) promotion of activities that foster a culture of innovation and entrepreneurship; (3) strategic partnership through outreach and networking in industry; (4) encouraging academic research in entrepreneurship and business model innovation; and (5) provision of special services needed for new startup businesses such as intellectual property legal services, startup incubation, as well as the conduction of feasibility studies, business plans, and market research studies.

5.3 ACK Look at Education That Creates Innovators and Entrepreneurs

ACK is committed to nurturing all-round students to create students' values. When students graduate, they will contribute to society and create society's values, which conversely can realize the values related to Innovation and Entrepreneurship Education Development. In addition to PBL, ACK has adopted and implemented the CDIO teaching method. The CDIO has four phases and the four phases representing the abbreviation in the word CDIO are as shown in Table 4.

Table 5 summarizes the CDIO initiative, where each phase has a list of actions that lead to the process.

The CDIO Syllabus used at ACK is as follows:

Table 3 Elements of ACK strategy on innovation and entrepreneurship (2015–2020 ACK-Strategic Plan)

	Strategic goals	Objectives
1	Curricular and extra-curricular education	Curriculum development: Develop curriculums that support innovation and entrepreneurship. Supplement each curriculum with graduation projects that can be converted to startups and SMEs. Training: Design, facilitate and provide special training courses that support beginning entrepreneurs. Deliver boot-camp intensive training when needed
2	Promoting activities and functions	Guest Speakers program: invite experts and successful business owners to share their experiences with students on campus. Student startups competitions: organize and participate in annual student startup competitions in order to support progressing good business ideas to real ventures Other activities: Such as attending seminars, watching documentaries, participation in specialized workshops and forming student clubs
3	Outreach	Strategic Partnership: Focus on academic and financial partnerships (1) ACK-Academic partners: Reinforce partnership in knowledge and sharing expertise with universities such as CQU: Central Queensland University, Ryerson University & Cape Breton University in Canada. (2) ACK-Financial partners: Reinforce partnership with Kuwait National Fund for SMEs, Kuwait Banking Association as well as private and angel investors. Networking: Establish links in the industry that supports the development of innovation and entrepreneurship in ACK. Examples are: KFAS, INJAZ, API
4	Research	Promote research in the areas of entrepreneurship, product and process innovation Participate in reputed international conferences about entrepreneurship and innovation
5	Entrepreneurship services	Studies: feasibility studies, business plans and market research studies Mentoring services: provide supervision and advice on new startups Intellectual property and legal services: IP and copyright Business Incubation: provide an environment to incubate new startup businesses for specified periods before full launch in the market

Table 4 CDIO four phases [23]

The conceive phase	Defining customer needs; considering technology, enterprise strategy, and regulations; developing concepts, techniques and business plans.
The design phase	Creating the design; the plans, drawings, and algorithms that describe what will be implemented
The implement phase	The transformation of the design into the product, including manufacturing, coding, testing and validation
The operate phase	Using the implemented product to deliver the intended value, including maintaining, evolving and retiring the system

Table 5 The CDIO initiative [23]

Conceive		Design		Implement		Operate	
Mission	Conceptual design	Preliminary design	Detailed design	Element creation	Systems' integration & test	Lifecycle support	Evolution
Business strategy Technology strategy Customer needs Goals Competitors Program plan Business plan	Requirements Function Concepts Technology Architecture Platform plan Market positioning Regulation Supplier plan Commitment	Requirements allocation Model development System analysis System decomposition Interface specifications	Element design Requirements verification Failure & contingency analysis Validated design	Hardware manufacturing Software coding Sourcing Element testing Element refinement	System integration System test Refinement Certification Implementation ramp-up Delivery	Sales & distribution Operations Logistics Customer support Maintenance & repair Recycling Upgrading	System improvement Product family expansion Retirement

1. TECHNICAL KNOWLEDGE AND REASONING
    A. Knowledge of underlying science
    B. Core fundamental knowledge
    C. Advanced fundamental knowledge
2. PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES
    A. Analytic reasoning and problem solving
    B. Experimentation, investigation and knowledge discovery
    C. System thinking
        - Holistic Thinking: A system, its behavior, and its elements. Transdisciplinary approaches that ensure the system is understood from all relevant perspectives. The societal, enterprise and technical context of the system. The interactions external to the system, and the behavioral impact of the system.
        - Emergence and Interactions in Systems: The abstractions necessary to define and model system. The behavioral and functional properties (intended and unintended) which emerge from the system. The important interfaces among elements. Evolutionary adaptation over time.
        - Prioritization and Focus: All factors relevant to the system in the whole. The driving factors from among the whole. Energy and resource allocations to resolve the driving issues.
        - Trade-offs, Judgment and Balance in Resolution. Tensions and factors to resolve through trade-offs. Solutions that balance various factors, resolve tensions and optimize the system as a whole. Flexible vs. optimal solutions over the system lifetime.
    D. Attitudes, thoughts and learning
    E. Ethics, quality and other responsibilities
3. INTERPERSONAL SKILLS: TEAMWORK AND COMMUNICATION
    A. Multi-disciplinary teamwork
    B. Communications
    C. Communications in foreign languages
4. CONCEIVING, DESIGNING, IMPLEMENTING, AND OPERATING SYSTEMS IN THE ENTERPRISE AND SOCIETAL CONTEXT, THE INNOVATION PROCESS
    A. External, societal and environmental context
    B. Enterprise and business context
    C. Conceiving, system engineering and management
    D. Designing
    E. Implementing
    F. Operating
    G. Leading engineering endeavors
    H. Engineering entrepreneurship

5.4 Assessment Methods

ACK applies two assessment methods, direct and indirect methods. The two assessments methods are summarized in Table 6.

The details of the assessment criteria of the entrepreneurial personal skills and attitudes are shown in Table 7. A score of 1 indicates that the student has some experience or has been exposed to them. A score of 2 points to being able to participate in and contribute. A score of 3, which is an average score demonstrates that the student is able to understand and explain. If the student is skilled in the practice or implementation, then the appropriate score would be 4. Finally, a score of 5, which is the highest that can be achieved, indicates that the student can lead or innovate.

Table 6 Assessment methods [23]

Direct assessment methods	Indirect assessment methods
Course-related assessment Capstone course (assignments/projects) Case studies Classroom assessment Content analysis Course-embedded questions and assignments Portfolios Essays Theses, research and projects, publications Awards/grants received **Standardized assessments** **Other** Transcript analysis Placement record of graduates	**Institutional and program surveys** Alumni surveys Employer surveys Graduating seniors and graduates surveys Student satisfaction surveys **Other** Focus groups Interviews (faculty members, graduating students, alumni)

Table 7 Assessment criteria [23]

2.4. PERSONAL SKILLS AND ATTITUDES	1	2	3	4	5
2.4.1. Initiative and Willingness to Take Risks					
2.4.2. Perseverance and Flexibility					
2.4.3. Creative Thinking					
2.4.4. Critical Thinking					
2.4.5. Awareness of One's Personal Knowledge, Skills, and Attitudes					
2.4.6. Curiosity and Lifelong Learning					
2.4.7. Time and Resource Management					
2.5. PROFESSIONAL SKILLS AND ATTITUDES					
2.5.1. Professional Ethics, Integrity, Responsibility and Accountability					
2.5.2. Professional Behavior					
2.5.3. Proactively Planning for One's Career					
2.5.4. Staying Current on World of profession					

5.5 CDIO Standards

There are 12 CDIO standards that ACK follows and stated below (Table 8).

Table 8 Assessment criteria [23]

Standard	Title	Description
1	The context	Adoption of the principle that product, process, and system lifecycle development and deployment – conceiving, designing, implementing and operating – are the context for education
2	Learning outcomes	Specific, detailed learning outcomes for personal and interpersonal skills, and product, process, and system building skills, as well as disciplinary knowledge, consistent with program goals and validated by program stakeholders
3	Integrated curriculum	A curriculum designed with mutually supporting disciplinary courses, with an explicit plan to integrate personal and interpersonal skills, and product, process, and system building skills
4	Introduction to engineering	An introductory course that provides the framework for engineering practice in product, process, and system building, and introduces essential personal and interpersonal skills
5	Design-implement	Experiences; a curriculum that includes two or more design-implement experiences, including one at a basic level and one at an advanced level
6	Workspaces	Engineering workspaces and laboratories that support and encourage hands-on learning of product, process, and system building, disciplinary knowledge, and social learning
7	Integrated learning experiences	Integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal and interpersonal skills, and product, process, and system building skills
8	Active learning	Teaching and learning based on active experiential learning methods
9	Enhancement of faculty competence	Actions that enhance faculty competence in personal and interpersonal skills, and product, process, and system building skills
10	Enhancement of faculty teaching competence	Actions that enhance faculty competence in providing integrated learning experiences, in using active experiential learning methods, and in assessing student learning
11	Learning assessment	Assessment of student learning in personal and interpersonal skills, and product, process, and system building skills, as well as in disciplinary knowledge
12	Program evaluation	A system that evaluates programs against these 12 standards, and provides feedback to students, faculty, and other stakeholders for the purposes of continuous improvement

5.6 Faculty Development Program at ACK

The development at ACK is not just limited to the students only; faculty members go through a development program. Below is a list of the faculty development program [24]:

1. Ability to apply CDIO philosophy adopting the principle that product, process, and system lifecycle development and deployment – Conceiving, Designing, Implementing and Operating are the context for engineering education (Standard 1 CDIO);
2. Ability to plan specific, detailed learning outcomes for personal and interpersonal skills, and product, process, and system building skills, as well as disciplinary knowledge (Standard 2 CDIO);
3. Ability to develop an integrated curriculum, designed with mutually supporting disciplinary courses, with an explicit plan to integrate personal and interpersonal skills, and product, process, and system building skills (Standard 3 CDIO);
4. Ability to develop and implement an introductory course within the integrated curriculum, that provides the framework for practice in product, process, and system building, and introduces essential personal and interpersonal skills of graduates (Standard 4 CDIO);
5. Ability to organize design-built activities of students through the implementation in an integrated curriculum of at least two or more design-implement experiences at basic and advanced levels (Standard 5 CDIO);
6. Ability to create engineering workspaces and laboratories that support and encourage hands on learning of product, process, and system building, disciplinary knowledge, and social learning (Standard 6 CDIO);
7. Ability to ensure integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal and interpersonal skills, and product, process, and system building skills (Standard 7 CDIO);
8. Ability to apply active learning methods (team work, case-study, games, problem based learning, context learning) improving the quality of training and enhancing the level of acquired learning outcomes (Standard 8 CDIO);
9. Ability for actions that enhance faculty competence in personal and interpersonal skills, and product, process, and system building skills (Standard 9 CDIO);
10. Ability for actions that enhance faculty competence in providing integrated learning experiences, in using active experiential learning methods, and in assessing student learning (Standard 10 CDIO);
11. Ability to assess student learning in personal and interpersonal skills, and product, process, and system building skills, as well as in disciplinary knowledge (Standard 11 CDIO);
12. Ability to evaluate educational program against all CDIO standards, and provide feedback to students, faculty, and other stakeholders for the purposes of continuous improvement (Standard 12 CDIO).

Table 9 Personal Attributes of faculty members are mirrored with attributes of entrepreneurs

Passion, commitment
Perseverance, determination
Ability to take initiatives and decision making
Risk taking – not afraid to fail
Self-leadership and dynamism
Orientation to clear goals and results
Able to take challenges and manage change
Optimism and sense of humor

The outcomes of our qualitative research indicate that instructors who have mixed industry experience with teaching experience proved to be more efficient in teaching and fostering entrepreneurship.

Conversely, instructors' personal attributes or qualities are important determinants of their abilities to promote and cultivate a culture of innovation and entrepreneurship (Table 9).

5.7 Role of Faculty Members in Building a Culture of Entrepreneurship

The role of faculty is evident through their involvement in teaching entrepreneurship courses, implementing PBL, CDIO, and applied education, organizing and running activities and events. Teaching using Socratic Methods is based on asking and answering questions to stimulate critical thinking and to draw out ideas through argumentative dialogue. Teaching using the PBL and CDIO approaches encourages students to think "outside the box" which enables them to explore and share their ideas in a more open-minded way, rather than directed learning.

The steps to foster innovation and entrepreneurship are as follows:

- Adopt a pedagogy based on applied education
- Hands-on experience is encouraged through applied education in a "two plus two" system
- Structured on problem and PBL
- Internship with various employers in the industry
- Exposure to real work experience
- Graduation projects are often presented in a ceremonial exhibition which acknowledges and rewards best project ideas particularly the ones that demonstrate technology and process innovation
- Many graduation projects can be extended to a startup business
- Teamwork: various skills are instilled; team work, critical thinking, problem solving and decision making

- Caring culture that empowers students and staff to reach their highest potential
- Event Management Course: based on real events such as Health Day
- Marketing Planning & Strategy course: case studies on shopping centers in Kuwait such as "The Boulevard" and Al-Yaal" malls
- Selected assessments are designed based on real cases

5.8 ACK's Teaching and Learning Strategies

The teaching and learning strategies are based on the internal developments that have taken place at ACK to foster innovation and entrepreneurship. ACK has implemented strategies to develop the following pillars:

1. Education (curriculum);

   Introducing multiple courses on Entrepreneurship to help students recognize and capitalize on entrepreneurial opportunities. The learning outcomes for these courses are focused on helping students develop an entrepreneurial mindset. The learning outcomes also include the following:

   - Understanding and implementing the various stages of developing a successful entrepreneurial business.
   - Learning how to position new products or services to capture new and or unaddressed market opportunities.
   - Recognizing and evaluating emerging business models and their critical success factors.
   - Learning, managing and optimizing team dynamics and performance.
   - Restructuring the idea to prepare for incorporation.
   - Developing effective entrepreneurial business strategies.
   - Understanding entrepreneurial financing, such as debt, equity, venture capital, etc.
   - Developing preliminary business plans for potential new business.

2. Collaboration with local funding and investment centers. ACK has already signed and activated a Memorandum of Understanding with the Kuwait National Funds;
3. Building relationships and agreements with important private and government organizations to help foster new entrepreneurs;
4. Establishing a Leadership/Mentorship Program. The purpose of this program is to establish a network of experts and advisors; foster collaboration and knowledge sharing across projects. This program will also enlist local CEO's to participate and accept our graduates for a short leadership mentorship training program;
5. Establishing a Small Business Development Center initiative (SBDI) within the Innovation and Entrepreneurship Center (IEC) to provide funding, legal and business structure advising, and patent protection, technology transfer and invention disclosures;

The goal of this center is to provide a wide range of services including the following:

(a) Counseling: Provide financial and legal counseling to assist set-up and growth of small businesses.
(b) Capital: Secure seed funding for Start-ups and SME's.
(c) Collaboration: with local & International entrepreneurship centers to foster an environment for entrepreneurship, creativity and innovation. This includes all public and private research centers and universities and institutes in Kuwait and abroad.
(d) Copyright and Patent protection: Provide assistance with legal protection of unique ideas and products.

6. Business Incubation Center (BIC) which is needed to provide an environment to incubate new startup businesses for specified periods before full launch to the marketplace;
7. Entrepreneur Alumni Network (EAN);
8. Promote research in the areas of entrepreneurship, product and process innovation; and
9. Participate in reputed international conferences about innovation and entrepreneurship.

6 Conclusions

There is a clear difference between entrepreneurship as a "mindset" that drives a person to become an entrepreneur and entrepreneurship as a "venture" journey that ends up with running and maintaining successful startups. Both are described as "dynamic processes" subject to continuous challenges and changes.

Cultivating the entrepreneurship mindset is a very important process that could take years to mature and settle. Many personal, social, cultural and environmental factors influence the individual's intentions and behavior in this stage. The favorable outcomes of this process are the development of "willingness" to practice entrepreneurial behavior reinforced by self-motivation, self-confidence, self-efficacy as well as perception of control.

Teaching entrepreneurship starts with cultivating and building the entrepreneurial mindset. It influences intentions and willingness to become an entrepreneur. This is a longitudinal process that takes time to mature. Teaching entrepreneurship as a venture or a journey to success is more challenging because it includes two separate components the 'knowledge" (i.e. science of entrepreneurship) and "skills" (i.e. ability and tactics). ACK provides a role model in teaching that develops this process. As a result, many non-businesses majors, especially engineering students have shown great interest in entrepreneurship education. As a matter of fact, many of the entrepreneurs who have completed the ACK entrepreneurship courses and received funding, were non-business majors.

Faculty members can easily transfer the underpinning knowledge to students using many teaching methods including conventional education. The challenging part is teaching entrepreneurial "skills" which are fundamental to implement the acquired knowledge and transform ideas to real enterprises.

Internship and interaction with real entrepreneur's startup business simulation are recommended tools to teach the skill part of the entrepreneurship venture. On campus, startup incubation provides an effective solution to teach and mentor skills needed to go through the entrepreneurship journey.

The personal attributes of faculty members contribute to the education of both processes, building the mindset and going through the entrepreneurial venture. Hesitation will always be there, but fostering self-confidence is the key to start.

References

1. Zhou M, Xu H (2012) A review of entrepreneurship education for college students in China. Adm Sci 2(37):82–98. https://doi.org/10.3390/admsci2010082
2. Bygrave W (2010) The portable MBA in entrepreneurship, 4th edn. Wiley, Hoboken. ISBN: 978-0-470-48131-8
3. Hynes B, Xu H (1996) Entrepreneurship education and training – introducing entrepreneurship into non-business disciplines. J Eur Ind Train 20(8):10–17. https://doi.org/10.1108/03090599610128836
4. Anderson AR, Kirkwood S, Jack SL (1999) Entrepreneurship education within the enterprise culture: producing reflective practitioners. Int J Entrep Behav Res 5(3):110–125. https://doi.org/10.1108/13552559910284074
5. Ronstadt R (1990) Contributing editor's feature. Entrep Theory Pract 14(3):79–79. https://doi.org/10.1177/104225879001400307
6. Gartner WB, Shaver KG, Gatewood E, Katz JA (1994) Finding the entrepreneur in entrepreneurship. Entrep Theory Pract 18(3):5–9. https://doi.org/10.1177/104225879201700110
7. Lee SH, Wong PK (2004) An exploratory study of technopreneurial intentions: a career anchor perspective. J Bus Ventur 19(1):7–28. https://doi.org/10.1016/S0883-9026(02)00112-X
8. Bandura A (1979) Self-referent mechanisms in social learning theory. Am Psychol 34(5):439–441. https://doi.org/10.1037/0003-066X.34.5.439.b
9. Ajzen I (2001) Nature and operation of attitudes. Annu Rev Psychol 52(1):27–58. https://doi.org/10.1146/annurev.psych.52.1.27
10. Autio E, Keeley RH, Klofsten M, Ulfstedt T (1997) Entrepreneurial intent among students: testing an intent model in Asia, Scandinavia and USA. In: Reynolds PD (ed) Proceedings of the 17th annual entrepreneurship research conference. Bobson College, Wellesley, pp 133–147. Available at: https://fusionmx.babson.edu/entrep/fer/papers97/autio/aut1.htm
11. Schumpeter JA (1989) Economic theory and entrepreneurial history. In: Clemence RV (ed) Essays on entrepreneurs, innovations, business cycles and the evolution of capitalism. Transaction Publishers, New Brunswick. ISBN-10: 0887387640
12. Drucker P (1985) Innovation and entrepreneurship. Butterworth-Heinemann, Oxford. ISBN-10 0887306187
13. Hornaday JA (1982) Research about living entrepreneurs. In: Kent CA, Sexton DL et al (eds) Encyclopedia of entrepreneurship. Prentice Hall, Englewood Cliffs, pp 20–34
14. Greene PG, Brush CG, Eisenman EJ, Neck HM, Perkins S (2015) Entrepreneurship education: a global consideration from practice to policy around the world. WISE Initiative, Qatar. Available at http://www.wise-qatar.org/2015-wise-research-entrepreneurship-education

15. Aronsson M (2004) Education matter- but does entrepreneurship education? An interview with David Birch. Acad Manag Learn Educ 3(3):289–292. https://doi.org/10.5465/amle.2004.14242224
16. Brush CG, Neck HM, Greene PG (2014) Teaching entrepreneurship: a practice-based approach. Edward Elgar, Cheltenham. ISBN-10: 1782540695
17. Rauch A, Hulsink W (2015) Putting entrepreneurship education where the intention to act lies: an investigation into the impact of entrepreneurship education on entrepreneurship behavior. Acad Manag Learn Educ 14(2):187–204. https://doi.org/10.5465/amle.2012.0293
18. Anderson AR, Gaddefors J (2016) Entrepreneurship as a community phenomenon; reconnecting meanings and place. Int J Entrep Small Bus 28(4):504–518. https://doi.org/10.1504/IJESB.2016.077576
19. Gartner WB, Vesper KH (1994) Experiments in entrepreneurship education: successes and failures. J Bus Ventur 9(3):371–391. https://doi.org/10.1016/0883-9026(94)90028-0
20. Robinson P, Haynes M (1991) Entrepreneurship education in America's major universities. Entrep Theory Pract 15(3):41–52. https://doi.org/10.1177/104225879101500304
21. Sexton DL, Bowman NB (1987) Evaluation of an innovative approach to teaching entrepreneurship. J Small Bus Manag 22(2):35–43. Available at SSRN: https://ssrn.com/abstract=1505256
22. Gorman G, Hanlon D, King W (1997) Some research perspectives on entrepreneurship education, enterprise education and education for small business management: a ten-year literature review. Int Small Bus J 15(3):56–77. https://doi.org/10.1177/0266242697153004
23. Brodeur DR, Crawley EF, Malmqvist J, Edström K, Östlund S (2014) Rethinking engineering education: the CDIO approach, 2nd edn. Springer, Cham. https://doi.org/10.1007/978-3-319-05561-9
24. Chuchalin AI (2014) Modernization of engineering education based on international CDIO standards. J Assoc Eng Educ Russia 16:14–27. http://aeer.ru/filesen/io/m16/art_2.pdf

Reserch and Development Challenges and Opportunities in the Arab World: Case Study on Kuwait Institute for Scientific Research (KISR)

Samira A. S. Omar Asem

Abstract The Arab World has witnessed enormous growth in the past two decades in the establishment of universities and specialized research centers. Over the years, the R&D models in the developed countries have undergone radical changes in terms of emergence of new institutional structure and governance, establishment of science parks, technological incubators, centers of research excellence and industrial clusters based on best practices and technologies developed by the R&D sector. However, many countries in the Arab World now have a vision that is, largely, in-line with modern global trends and based on knowledge planning.

Since its establishment in 1967, the Kuwait Institute for Scientific Research (KISR) focused its R&D efforts in petroleum, techno economics, oceanography and aquaculture, environment and agriculture, water resources, and building materials. More recently, the energy sector was included to conduct applied research in renewable energy, energy efficiency, and nanotechnology. Many of KISR's research recommendations outcomes were adopted by the government of Kuwait and the private sector. These include the establishment of renewable energy park (Shegaya Park), Petroleum Research Center (PRC) at Ahmadi to serve the oil-sector companies, Water Research Center (WRC) to assist the Ministry of Electricity and Water and commercialization of locally produced desalinated water from shallow beach wells using technology developed by the institute, in addition to establishment of protected areas, rehabilitation of damaged lands, enhancement of marine biodiversity, aquaculture of local fish and others.

Nevertheless, research institutions in developing countries such as KISR face several challenges, such as insufficient government R&D funding, difficulties in attracting and retaining experts and young scientists due to market competitiveness, and inadequate client contributions to R&D activities. Moreover, commercialization of research outcomes has been a strategic drive; however, its implementation has been met with many challenges by the government due to the lack of a legal instrument which caused delays in establishing these specialized companies.

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Political pressure has also created some hindrance to move forward in the development and funding of international strategic alliances. It has become obvious that the role of R&D in national development is not clearly understood and/or supported by the legislative sector creating uncertainty at the decision-making level. This is generally reflected in the relatively lower percent allocation to R&D in GDP.

The outlook of KISR for 2020–2030 is to direct its R&D activities towards achieving Knowledge Economy, seeking business opportunities based on its long R&D experience and expertise, driving the spirit of its staff and cultivating the culture of entrepreneurship as well as developing a second line of leadership and young scientists.

Keywords Strategic planning · Industrial connections · Employment · Intellectual property · Commercialization · Marketing · Legal instruments · Quality assurance · Knowledge economy · Entrepreneurship

1 Introduction

The progress of any society depends on the progress it has made in research and development (R&D) and how well it has utilized the R&D findings to achieve their developmental goals. Like other regions of the world, the Arab World also has witnessed enormous growth in the past two decades or so in the establishment of universities and specialized research centers that are similar to those established in developed countries in the second half of the last century [1–3] Over the years, the R&D models in developed countries have undergone radical changes in terms of the emergence of new institutional structure and governance, establishment of science parks, technological incubators, centers of research excellence, and industrial clusters based on best practices and technologies developed by the R&D sector [4–6]. In the past, the growth of the R&D sector in the Arab World was quantitative rather than qualitative. However, many countries in the Arab World now have a vision that is, largely, in-line with modern global trends and based on knowledge planning [7, 8]. Likewise, Kuwait's developmental plan, Vision 2035, relies on building a knowledge-based economy to achieve balanced, sustainable economic and human development. By recognizing the role of science and technology in the growth and development of the nation, Kuwait has established a number of institutions, specialized research centers, and scientific bodies to undertake basic and applied research with the ultimate aim of building modern Kuwait. These include the Kuwait Institute for Scientific Research (KISR), Kuwait University (KU), Kuwait Foundation for the Advancement of Sciences (KFAS) and scientific club, besides several private institutions. Through efficient implementation of its S & T strategy, Kuwait has emerged as the regional leader for technology development and application.

For more than five decades KISR has supported the implementation of the nation's development strategy and served as a steward for Kuwait's science and technology heritage. This has been achieved through the development of 5-years strategic plans taking into consideration the national priorities in environmental, social, economic, and industrial developments. In 2010, KISR adopted a transformational strategy (7th Five Year Strategic Plan) that required the initiation of research and development activities in new thrust areas while prioritizing current ones and rethinking the way it conducts its current R&D activities. This required the development of a new organizational structure whereby KISR's research and technology capabilities were reorganized into four centers, Petroleum, Energy & Building, Environment & Life Science, and Water Resources. The focus of these centers is to provide appropriate solutions to national challenges through a cooperative innovation system with other such as local, regional, and international institutions.

2 Background Information

2.1 Arab Region

Scientific research in the Arab region is going through an important phase facilitated by economic and technical advancements that pave the way for new prospects [9–11]. Nevertheless, investment in R&D in the Arab world is modest if not weak and it is clearly not directed or aligned with developmental plans influencing socioeconomic advancement. These have resulted in low rankings in the Global Innovation Index (G11) where only Kuwait and Saudi Arabia are listed as 64 and 65, respectively [12]. A comprehensive study by McGinn (1991) showed that out of 4 societal agents (government, the private sector, the public at large, and culture), government and culture have the most potent influence on science and technology in this region [13]. Many other studies also identified many reforms to address the gap of Arab R&D and to align it towards development plans [14, 15].

Interestingly, the most important reform seems to be in the reform of the early education years where we need to start cultivating and nourishing R&D in the minds of the youth (coming generations). The Knowledge Economy needs these types of mindsets that consider scientific curiosity as part of its basic inspirational resources. Other factors to fill the gaps include but not limited to the following [16–20]:

(i) Strengthening R&D centers in the region through partnership with renowned international institutions.
(ii) Creation of refereed scientific journals in the region or in partnership with interested international partners.
(iii) Investors to be encouraged to invest in fruitful scientific research that bears results to the private sector, communities, or the country at large.

(iv) R&D to be integrated in country's National Development Plans (short and long term) with a set percentage target of GDP.
(v) Creation of a National Scientific Council (Committee) to oversee all R&D and innovation activities in the respective country ensuring efficient use of resources and non-duplication of efforts.
(vi) Expand the role of Arab universities to participate effectively in instituting R&D.
(vii) Establish key indicators to assess impacts of R&D on country's knowledge economy and wellbeing of communities (National Developing Plan).

2.2 Kuwait Institute for Scientific Research (KISR)

Since it is establishment in 1967, KISR's role and responsibilities have expanded greatly on both national and regional levels. KISR brings a combined approach to any scientific challenge, by being: (a) "Open" i.e. providing a transparent environment where ideas, creativity, and innovation can thrive; (b) "Customer focused" i.e. committed to scientific excellence with customer/partner goals at the center of everything KISR does; and (c) "Knowledge-based" i.e. leveraging on the expertise supplied by the groups of professionals in the diverse research programs to meet the divergent demands of the nation. In 2010, KISR developed a unique organizational structure to keep pace with ever-increasing international STI developments. Four major research centers were established as follows:

1. Petroleum Research Center (PRC), which acts as a strategic partner to the local petroleum industry. It functions under five programs: Improved Oil Recovery; Corrosion Assessment and Mitigation Technology; Refining Capacity Expansion and Flexibility; Optimization of Petroleum Refinery Processes and Polymetric Products Enhancement and Customization.
2. Energy and Buildings Research Center (EBRC), which sets up foundations for the effective management of energy and buildings. It has five research programs as follows: Energy Efficiency Technologies; Renewable Energy; Construction and Building Materials; Sustainability and Reliability of Infrastructure; and Nanotechnology-Advanced Material.
3. Water Research Center (WRC), which is a national and regional leader in confronting the challenge of sustainable water resource management. It comprises four programs namely: Innovative Desalination Technologies; Thermal Desalination Technologies; Wastewater Treatment and Reclamation Technologies; and Water Resources Development and Management.
4. Environment and Life Sciences Research Center (ELSRC), which has played a pioneering role in addressing the plethora of environmental challenges from the development of sustainable food production to assessing the long-term health risks of pollution. It has eight research programs namely: Environmental Pollution and Climate; Coastal Management; Ecosystem-Based Management of

Marine Resources; Crisis Decision Support; Aquaculture; Desert Agriculture and Ecosystem; Food and Nutrition; and Biotechnology.

These four scientific centers are supported by sectors of Administration and Finance as well as Marketing and Commercialization. These sectors strive for excellence in providing reliable and creative services while maintaining transparency and responsiveness. The Marketing and Commercialization Sector in particular coordinates the efforts of KISR staff inventors, patents, and other stakeholders as well as assessment of market analysis and commercialization of KISR-developed intellectual property.

The "Vision" of KISR by 2030 is internationally acknowledged as the region's most highly respected STI and knowledge gateway and recognized as a driving force for sustainable economic prosperity and quality of life. To achieve this vision, KISR must strengthen its international collaboration with global research and development leaders in various fields. For this purpose, the Science and Technology Partnership and Agreement (STPAO) was established to initiate R&D projects that are mutual interest to Kuwait, KISR, and institutions in developed and developing countries. This partnership in of paramount importance for KISR to develop, deploy, and exploit the best science, technology, and innovation for both public and private sectors. KISR's long-term strategic plan is to become customer-focused STI organization; achieving global technological leadership; establishing programs of excellence; setting up knowledge centers; and achieving commercial objectives (Fig. 1).

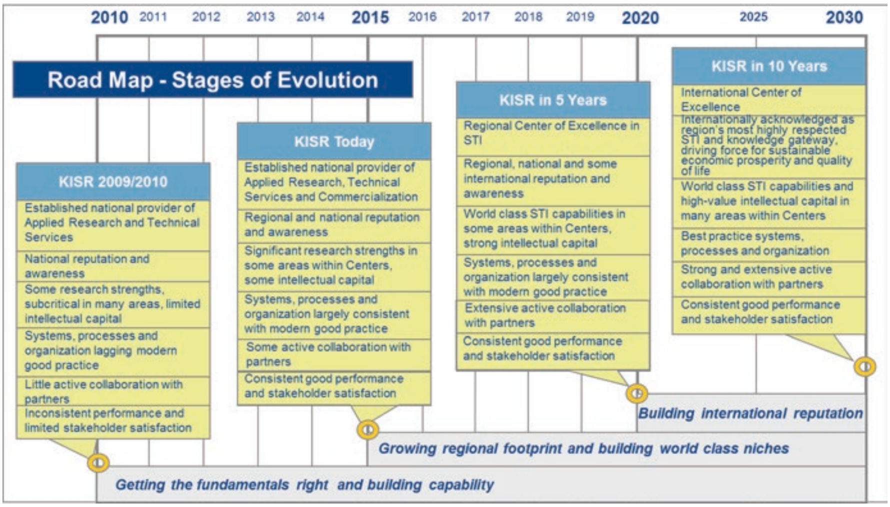

Fig. 1 Kuwait Institute for Scientific Research (KISR) long-term strategy 2030 Targets

3 Challenges and Opportunities in R&D

It is evident that global R&D environment has changed over the past 3 years since 2015. Global surveys conducted to assess perspectives on the future of R&D showed that 60% of the 1000 surveyed researchers and engineers indicated that their organization's performance had shown improvement over these years. Additionally, six times as many respondents indicated that R&D was now more important and nearly three times as many respondents indicated that they were now more successful in their R&D than in 2015 [21, 22]. This reveals an improving global R&D environment. However, due to many challenges, the Middle East statistics on R&D expenditure is still lagging in terms of funding availability, skilled employees, brain drain, revenues, and national priorities that affect funding [23, 24]. This has also been confirmed by a global survey that showed among the factors that affected R&D, limited R&D budgets ranked the highest (47% readers agreed) followed by priorities, limited organization revenue growth, and changing regulations (Fig. 2). Some of these challenges that are also relevant to KISR will be addressed in more details in the following section.

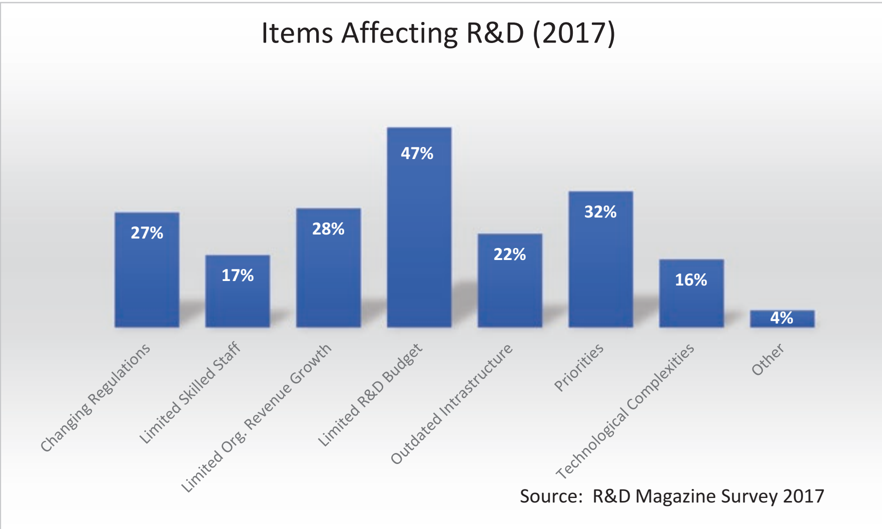

Fig. 2 R&D survey created by the editors of R&D Magazine in 2017 showing constraints affecting R&D [12]

4 Funding R&D

The Global R&D spending report indicates that R&D spending in the US is expected to increase by 2.9% to USD 553 billion, and in China the R&D speeding is expected to increase by 6.7% go to USD 475 billion, and that Asian countries strong R&D spend account for 43.6% of Global R&D [25]. It is also reported that more than two-thirds of all global R&D investments are supported by industrial organizations. Of these industries, information and communication technologies (ICT) are expected to be the main driver of innovations among all of them over the next 10 years. Artificial intelligence, automation and robotics, and associated software involved in ICT will change the overall R&D environment by the mid-2020s. However, the shares of US and European R&D investments as shares of the total global R&D spending have been declining over the past 10 years, while Asian investment, especially that of China, have been increasing such that this country's share is now more than 43% of the global total [12].

The share of Middle East Countries (13 countries) showed a slight increase over the past 3 years [2016 (2.43%); 2017 (2.50%) and 2018 (2.51%)]. This shows that the Middle East is not increasing at substantial rates and is expected to maintain their comparatively small shares of the overall global R&D. Table 1 shows R&D Investments in 13 Middle Eastern countries during 2017 and 2018. Kuwait is ranked 77 globally with R&D investment in 2017 and 2018 totaling 0.61 (0.20%) and 0.63 (0.21%) billion USD, respectively.

Table 1 Middle Eastern countries R&D investments in 2017 and 2018 [12]

Middle Eastern R&D investments					
		2017		2018	
		GDP	R&D	GDP	R&D
Global rank		BIL USD	BIL USD	BIL USD	BIL USD
22	Israel	$309.3	$12.53	318.6	$12.90
25	Iran	1503.0	11.57	1567.6	12.23
29	Qatar	340.4	8.51	349.9	8.82
32	Saudi Arabia	1758.0	8.09	1780.9	8.37
33	Egypt	1198.0	7.19	1279.5	7.68
55	UAE	678.9	1.36	708.8	1.42
62	Iraq	627.1	1.25	643.4	1.29
74	Oman	188.3	0.66	193.8	0.68
77	Kuwait	303.1	0.61	313.7	0.63
90	Jordan	87.6	0.35	89.8	0.36
96	Lebanon	86.9	0.26	89.1	0.27
105	Bahrain	68.2	0.14	70.2	0.14
107	Yemen	70.5	0.07	72.5	0.07
13 countries		**$7219.3**	**$52.59**	**$7477.8**	**$54.86**

Source: R&D Magazine Survey (2018) [12]

In the case of KISR, the annual expenditure for the FY 2016/2017, 2017/2018 and 2018/2019 ranged from USD 200 to 300 million. This is a very small share of overall global R&D expenditure as well as of Kuwait's GDP. The annual budget is allocated covered by the Ministry of Finance, and any income generated from R&D goes to the Ministry and usually is deducted from the annual budget. The budget plan for 2016/2017 and 2017/2018 were cut by more than USD 100 million by the Ministry of Planning due to external macro-economic developments leading to lower oil prices and consequently, to government's new policies that have adversely impacted KISR's budget and operations. In addition, the closure of both Wafra Joint Operations (WJO) and Khafji Joint Operations (KJO) of KGOC since 2015, has also affected KISR's revenues. This funding mechanism hinders the opportunities for conducting more R&D from the generated funds (contracted research projects and services) and creates more financial constraints on creativity and innovation in the institute.

5 R&D Revenues

The outcome of KISR's R&D activities supports industry and development. For example, KISR R&D in the Petroleum Research Center (PRC) supports Kuwait Oil Company (KOC) by transferring technology of oil-well water injection and its implementation leading to increase in the recovery factor by 10–15%. Another example is the development of a demonstration pilot power station at Shagaya for renewable energy to produce 70 MW using multi-technology of solar (Photovoltaic (PV) and Concentrated Solar Power (CSP)) and wind power. KISR also contributes to food security by developing advanced techniques to produce local commodities, including shrimp and fish using advanced techniques in tissue culture and aquaculture. Thousands of superior varieties of date palm trees and potato seeds are produced and sold annually local producers. The research outcomes of some projects are many times the cost of investments such as the establishment of protected marine and desert areas in Kuwait. These areas were surveyed and classified by KISR as important reserves for biodiversity conservation and environmental protection. Despite the importance and economic values of the research outcomes conducted by KISR, however, the annual revenues from R&D in KISR are still below the target. KISR revenues in 2015/16 and 2016/17 were USD 18.8 million (target = USD 28.5 million) and USD 17.8 million (target = USD 20.2 million), respectively, representing 68% and 88% of the planned target income. This is without the additional in-kind income/support received by KISR from international organizations in the form of highly sophisticated equipment and technical consultancies.

During the 2015–2018 period, KISR conducted research activities/technical services for 31 clients. These are distributed among three major sectors, namely National Public/Private, Regional, and International. Seventeen of KISR's stakeholders were private-sector companies, illustrating KISR's successful efforts to enhance its engagement with the private sector, which is in line with the government directives in its 5-year development plan 2015–2020 to empower the private sector in the development of the national economy. In addition, KISR strengthened its relationship with the Supreme Council for Planning and Development that resulted in the funding and implementation of new government initiatives and embarked on an ambitious plan to develop strategic alliances with the public and private sectors. The client-satisfaction survey results conducted during the period 2013/14–2015/16, covering only the 1st year of KISR's 8th Strategic plan showed an overall weighted average rating of 79%, almost meeting the planned target ≥80%, thus reflecting a good client confidence in KISR's work. These results show that KISR is playing an important role in sustainable development at the national level and in order to increase its productivity more funds are needed to support its strategic programs.

6 Commercialization

Development of a business models for commercialization of KISR products, such as potable water, tissue-cultured date palms and potato seed tubers requires high-level administrative support by the government. KISR proposed the establishment of a holding company that will be able to commercialize technologies and know-how. However, governmental support was not forthcoming due to legal uncertainties. Efforts were exerted to issue new policies and procedures to guide and support the efficient commercialization of the institute's relevant outputs.

In summary, KISR needs to assess its potential in marketing and commercialization of developed products and technologies by considering the following actions:

- Develop business models to generate financial income for KISR.
- Strengthening an active commercialization program and developing staff awareness and capabilities through understanding the application potential and business value of research.
- Enhancing marketing skills by articulating and communicating the value of research, technology transfer skills, and documenting and protecting know-how.
- Achieving greater awareness and recognition, by government and by the public.
- Developing a robust IP portfolio and building relationships with other STI organizations

7 Brain Drain and Expatriate Employment

Every year, many highly educated non-Kuwaitis born in Kuwait migrate to countries in the Organization for Economic Cooperation and Development (OECD) [26]. Information on highly educated emigrant population that was born in Kuwait and living in OECD countries totaled 57500 in 2010/11. Emigration rate of highly educated Kuwait is above 18%. Kuwait has a good opportunity in making use of highly educated non-Kuwaitis to work in research and academic institutions; however, the employment policies and opportunities are more inclined towards Kuwaitis [26]. The Central Statistical Bureau's Labor Market Information System (2014) showed that the labor force participation in Kuwait has reached 72% out of which 20.1% work in the government sector and 4.4% of them work in state-owned enterprises, compared with 59.6% who work in the private sector and 15.7% work in the household sector [27]. Unemployment ranged between 1.8 and 2.9% during 2003–2014, respectively. The unemployment rate among Kuwaitis and non-Kuwaitis reached 2.4% in 2014 [27].

In the past 3 years, KISR has experienced difficulties retaining and attracting new R&D talent. The number of permanent employees is about 1000 with the percentage of Kuwaitis more than 80%. A detailed study conducted by KISR showed that the main reason for the high number of staff resignations (about 120 in 2017) was better wages offered in the oil sector (mainly Kuwait Oil Company KOC). The study showed that among those who resigned in 2018 were from the 20–25 age group. The early-career and newly employed graduates are usually uncertain about their future career and may shift from one organization to another when the opportunity arises. The study also showed that the annual employment turn rate is above 9%, among the highest in Kuwait after the Audit Bureau (11%).

It should be emphasized that KISR will continue having difficulties in attracting new R&D talent and new policies need to be issued to encourage both Kuwaitis and non-Kuwaitis with high-level education and research experience to work in the institute. The expatriate employment policies need to be encouraging in order to support research organization and higher-education academic institutions in Kuwait (Fig. 3 and 4).

8 Conclusions

KISR succeeded in establishing a strong platform for R&D in the country and the Arab Region. It is a unique R&D system that supports the industrial and economic development in the country and can be presented as a study case for institutional R&D and science, technology, and innovation (STI) management. The strategic plan defined priorities for R&D and focused on achieving specific targets; however, external macro-economic developments leading to lower oil prices and consequently to new government policies have adversely impacted KISR's budget and operations. These were exacerbated with several internal challenges that spanned organizational-related issues including: difficulty of retaining and attracting new R&D talent, limited availability of private-sector R&D funds, and budget deficiency in the implementation of new processes that collectively impacted on operational excellence.

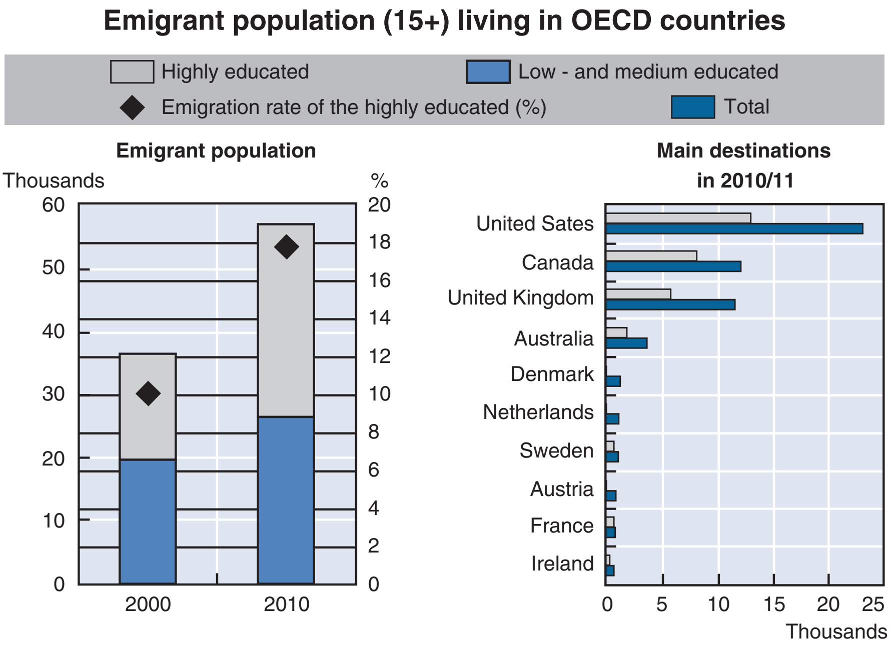

Fig. 3 Emigrants population (15+ age) of persons born in Kuwait living abroad in OECD countries [26]

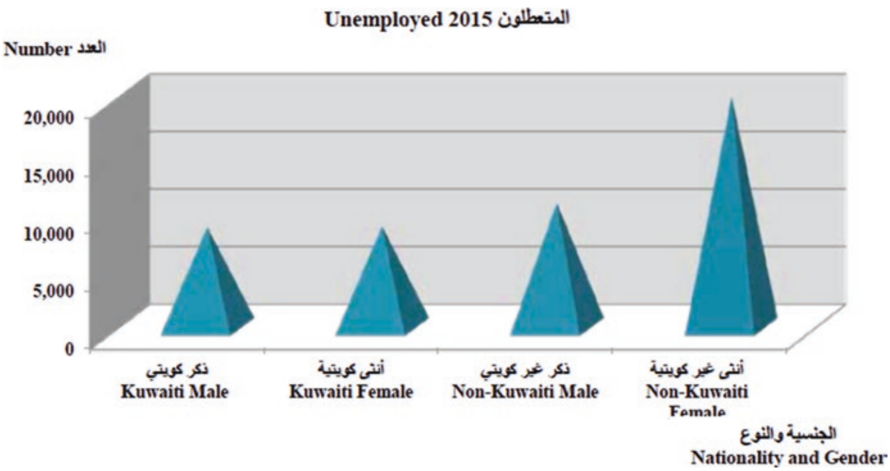

Fig. 4 Nationality and gender of unemployed people in Kuwait [27]

In order for the state of Kuwait to meet the Sustainable Development Goals (SDG 9) Target 9.5 "*Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending*") it is necessary to develop a national policy for STI. Currently, KISR is in the process of developing its 9th 5–Year Strategic Plan (2020–2025); however, a new policy for R&D and STI needs to be issued by the government. The Kuwait Foundation for the Advancement of Science and the Secretary General of the Supreme Council of Planning and Development (SCPD) are currently working with many relevant institutions to provide an international perspective on the Kuwaiti STI system and policies in collaboration with Directorate for Science, Technology and Innovation of the Organization for Economic Co-operation and Development (OECD). The OECD will review innovation policies in Kuwait to offer a comprehensive understanding of the strengths and weaknesses of a national innovation system and the opportunities to enhance it through government policy. It is also envisaged that this review and its recommendations will provide important international perspective for developing priorities in R&D of KISR's 9th Strategic Plan (2020–2025).

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References

1. Mahmoud KW (2013) A study on the role of research centers in the Arab world. Arab Center for Research and Policy Studies, Qatar
2. Ismail MS (2014) Scientific research between the orient and the Arab and the Western world, 1st edn. The Arab Group for Training and Publishing, Naser City, Cairo
3. Bizri OF (2018) Science, technology, innovation, and development in the Arab countries. J Sci Direct (Online). Available at https://www.sciencedirect.com/book/9780128125779/science-technology-innovation-and-development-in-the-arab-countries#book-description
4. Tirupati D (2008) Role of technological innovations for competitiveness and entrepreneurship. J Entrep 17(2):103–115
5. Tejinder S (2010) Role of innovation in growth of countries. Perspect Innov Econ Bus 4(1):15–17
6. Scheel C (2002) Knowledge clusters and technological innovation systems. J Knowl Manag 6(2):356–367
7. M-Said O (2011) A development perspective of technology-based entrepreneurship in the Middle East and North Africa. Ann Innov Entrep 2 (Online). Available at https://www.tandfonline.com/doi/full/10.3402/aie.v2i1.7986
8. ALECSO Committee for the development of science and technology in the Arab nation. A strategy for the development of Arab science and technology: the general report and the sectoral strategies (1989). Centre for Arab Unity Studies, 1989 (in Arabic), Beirut, Lebanon

9. Sawahel W (2014) New Arab strategy for science, technology and innovation (Online). Available at https://www.universityworldnews.com/post.php?story=2014031411375640
10. Zewail A (2011) The Middle East is ripe for a scientific revolution (Online). Available at https://www.newscientist.com/article/mg21028095-700-the-middle-east-is-ripe-for-a-scientific-revolution
11. El Kenz A (1997) Prometheus and Hermes. In: Shinn T, Spaapen J, Krishna VV (eds) Science and technology in a developing world. Kluwer, Dordrecht, pp 323–348. ISBN 978-94-017-2948-2
12. R&D (2018) Global R&D funding forecast. A supplement to R&D Magazine. Winter 2018. http://digital.rdmag.com/researchanddevelopment/2018global_r_d_funding_forecast/?pg=32&pm=2&u1=friend. Accessed 20 Apr 2019
13. McGinn R (1991) Science, technology and society. Prentice-Hall, Upper Saddle River. ISBN-13: 978-0137947362, ISBN-10: 0137947364
14. Zahlan AB (1978) Established patterns of technology acquisition in the Arab World. J Sci Direct (Online). Available at https://www.sciencedirect.com/science/article/pii/B9780080224350500067
15. Zahlan AB (1994) The integration of science and technology into development planning. In: Proceedings of the workshop in the development planning and management process in the ESCWA region. United Nations, New York, pp 5–34
16. Al-Jawareen A (2018) The reality of innovation and technology in the Arab world. https://www.academia.edu/9420316/the_reality_of_innovation_and_technology_in_ the_arab_world
17. Rossi PL (2010) Scientific production in Arab countries: a bibliometric perspective. Sci Technol Soc 15(2):339–370
18. Satti NS (2005) Science and technology development indicators in the Arab region. Sci Technol Soc 10(2):249–275
19. Zahlan AB (2006) Arab societies as knowledge societies. Minerva 44:103–112
20. Zahlan AB (1980) Science and science policy in the Arab world. Croom Helm, London. ISBN-10: 0856649708, ISBN-13: 978-0856649707
21. Gaillard J (2010) Measuring research and development in developing countries: main characteristics and implications for the Frascati manual. Sci Technol Soc 15(1):77–111
22. UNESCO (2010) Measuring R&D: challenges faced by developing countries. Available at http://uis.unesco.org/sites/default/files/documents/measuring-rd-challenges-faced-by-developing-countries-2010-en.pdf. ISBN 978-92-9189-094-1
23. Eurostat Statistic (2015) Gross domestic expenditure on R&D. http://ec.europa.eu/eurostat/statistics-explained/index.php. Retrieved 22 August 2017
24. OECD (2016) Research and development (R&D) – Gross domestic spending on R&D – OECD Data. data.oecd.org. Retrieved 10 February 2016
25. World Bank (2017) Research and development expenditure (% of GDP) Data. data.worldbank.org. Retrieved 28 February 2017
26. OECD (2015) Connecting with emigrants: a global profile of diasporas, Kuwait. https://doi.org/10.1787/9789264239845-110-en. Accessed 18 Apr 2019
27. Annual Statistics Abstract 2015–2016. Central Statistical Bureau of Kuwait 2015–2016. Kuwait, Ministry of Planning. https://www.csb.gov.kw/Pages/Statistics_en?ID=18&ParentCatID=2

Imperatives to Achieve a Successful Technology-Transfer Model: A Perspective from the Arab World

Sami Bashir

Abstract Technology transfer in universities has always been akin to deployment and realization of research discoveries as market products capable of addressing technological challenge(s). In developed countries, various technology-transfer models have been introduced and adopted, and they are still evolving, with measurable success. Whilst, here in the Arab world, adopting a technology-transfer model that can effectively contribute to the overall innovation ecosystem is still underway with a few emerging successful study cases and stories.

Now, there is a greater need than ever to capture the value of the universities' research intellectual capabilities and transform their outputs to the betterment of the society. Hence, it is becoming critical to develop a technology-transfer model that can support innovation in the Arab world capable of, not only addressing technological challenges, but also advancing the entrepreneurial and innovation ecosystems.

Universities in the Arab world operate differently and exist in different jurisdictions. With this understanding, this chapter is an account to highlight some common challenges that we believe these universities, despite their operational differences, face in developing a working technology-transfer model. Challenges such as intellectual-property laws, policies, and progressive partnerships are addressed; and recommendations are provided on how these challenges can be resolved.

Keywords Technology transfer · Innovation · Intellectual property · Research commercialization · Invention

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1 Introduction

In recent years, there has been great emphasis in the Arab world for universities to incorporate an "economic development mission" within their strategic vision and operation so as to contribute towards their local and/or regional economies. This has been more critically important in this region with the global economic downturn and the drop in oil prices and some other political uncertainties. Furthermore, most of the Arab countries have always relied on natural resources, such as oil and minerals, to support their economies. These natural resources are gradually facing scarcity and global or technological competitiveness. Additionally, these countries, like the rest of the world, are challenged with environmental and energy changes that can slow or hinder their economies in the imminent and/or long-term time plans. These challenges, to name a few, include water scarcity, energy shortages, climate change, and urgency to advance developments in agriculture and healthcare. These factors have led most of the countries in this part of the Arab region to realize the necessity to find ways to diversify their economies and become less dependent on natural resources as a way forward to advance their economies and improve lives. Therefore, innovation and entrepreneurship have become cornerstones for the vision of new economies in these countries. The integration of innovation and entrepreneurship within the economic strategic visions of these countries has been more relevant with the high-growth trends in their youth populations.

It is apparent that to address these challenges and to shape the future economies, there has to be more emphasis on scientific research, especially that coming out of universities. Historically, universities have always been considered as *Beit Al Hikma* or House of Wisdom and Expertise when it comes to looking at scientific challenges. This resulted in universities being well positioned to be an integral part in the formation and advancement of the new economies. So, universities have been viewed as promising outlets that not only provide scientific discoveries, but also can create of business opportunities in a form of technology-based startups. Possibly, universities can be stations and hubs for creating entrepreneurial ecosystems that allows technology-driven companies to advance their market by tapping into skilled and talented students and researchers.

In return, it is critical for universities to revisit the way they conduct their operations and businesses and reforming their overall scientific-research agenda. With this in mind, governments started looking closely on developing and/or investing in either existing universities or building new ones so as to become technology developers and research clusters. Evidently, some countries started investing in building new universities encompassing this idea of innovation ecosystems that can address scientific challenges and that are capable of conducting research at the highest level. For example, in the United Arab Emirates, the Masdar Institute that is part of Khalifa University of Science & Technology was built and developed in partnership with

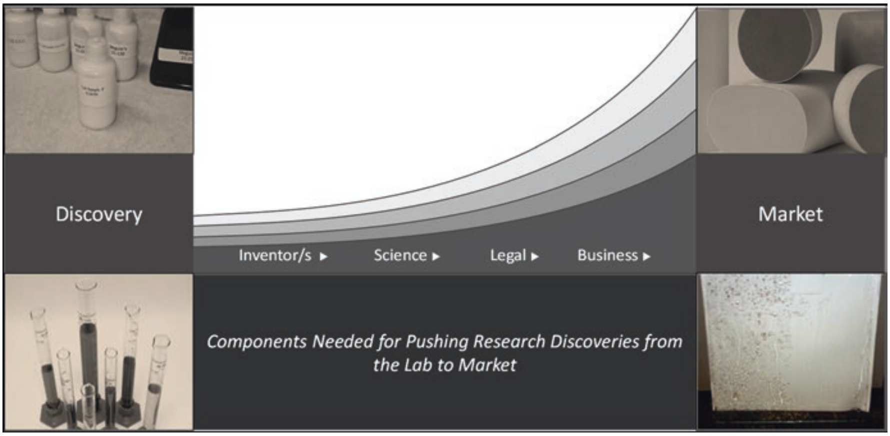

Fig. 1 Components involved in technology transfer in universities

Massachusetts Institute of Technology (MIT) to address the challenges of water, environment, and energy. In Saudi Arabia, King Abdullah University of Science & Technology was built with an ambitious research agenda to look into scientific challenges in the areas of energy, food, environment, and water.

In this part of the world, there is an urgent need to establish a viable technology-transfer model that allows the capture of research outcomes from universities and translate them into viable commercial products and startups (see Fig. 1). To do this, there must be a well-established operational model that can contribute to an innovation ecosystem. Yet, as in any other part of the world, development of such an innovation ecosystem needs detailed understanding of other factors such as investment policies, research and development resources, regulations on establishment of new companies, and the overall entrepreneurial environment [1]. Nonetheless, in this chapter our focus will be on common challenges that universities face on their efforts to push scientific research outputs to the market, in addition to providing some recommendation on how such challenges can be addressed to establish a proper technology-transfer processes that can accelerate application of such research. We will look at issues related to the extent of technology-transfer resources for universities in the Arab world to make them capable to capture researchers' inventions and discoveries. What are the mechanisms available in these countries in terms of intellectual property and patent law to protect inventions and know-how coming out from these scientific entities? The status of early technology development, not only in the form of industry-like R&D but the university-industry partnership and collaboration that can support technology development and commercialization will be considered. All of these aspects are critical for universities to play more effective roles in technology transfer and, consequently, economic development.

2 Technology-Transfer Trends in the Arab World

Traditionally, technology transfer has been conducted in the Arab world in a form of bringing technologies from overseas for individual businesses to conduct commercial activities. This type of technology transfer was more prominent and successful in the oil and gas industry where technologies have been adopted in the Gulf States [2]. This has been primarily based on general technology license contractual agreements from some of the other oil and gas industries where there has been dissemination and exchange of knowledge. For instance, in Saudi Arabia, there was a marked tendency to acquire new technologies in the oil and petrochemical industry sectors. Most of these acquired technologies are related to refinery technologies, polymer manufacturing, catalysis, and chemicals. These technologies are directly related to the growth of the country's economy and as a result patents of these technologies represent over 60% of the patent portfolio as per the 2014 statistics of the Saudi Patent Office [3]. However, recently there has been a shift at the strategic level of diversifying the economy of the country and a move away from reliance on oil to other industries. These include pharmaceutical, water, medical, agricultural, and non-fossil-fuel energy. Approaches as such have included funding for university research, and encouraging the private sector to partner with universities and other research centers. In North Africa, such as in Egypt and Morocco, technology transfer has been more towards establishing international factories for consumer products, making use of high numbers of cost-effective skilled labor [4]. However, this is becoming less sustainable, not only because of political uncertainties but also due to increasing industry competitiveness and automation. More advanced technologies are emerging almost on a daily basis providing better performances and more quality for people's lives. These emerging economies soon realized that although such traditional technology-transfer methods are important, they only provide limited impact on these countries' economies because most of the benefits go back to the technology developers.

Accordingly, research and education funding has relatively increased in most Arab countries. However, one can argue funding still does not reach acceptable levels when compared with those of developed countries. Yet, there are some promising examples such as establishment of research-funding agencies such as Abu Dhabi Department of Education & Knowledge in the United Arab Emirates and King Abulaziz City for Science & Technology in Saudi Arabia, both of whom are running a research-funding program in their respective countries. Hence, technology patenting and commercialization among some of the institutes funded by these entities has been increasing leading to significant advancement in cutting-edge research focusing primarily on innovations in life sciences, information technology, and software and data management. Even so, research funding in other parts of the Arab world is coming out from non-governmental and international agencies in the form of financial support that is not adequately managed or administered as formal research funding. It is worth mentioning here the topic of intellectual-property (IP) ownership will be addressed in another section of this chapter. As IP ownership is still largely linked to a great extent with government funding bodies, this in turn has limited the ability of universities to further develop any generated IP. In addition, this has left universities reluctant to file patents or not fully exploit the commercial value of the filed patents.

It is also important in the case of the Arab world to consider the issue of the financial and investment regulatory framework as well as company laws; all of these aspects are integral parts of facilitating the technology-transfer processes. Unfortunately, the existing regulatory framework in this regard does not suit development of new technologies or the creation of new technology-based startups; it is more tailored towards existing technologies that proved profitable. Nonetheless, there are recent regulations and laws allowing creation of platforms such as industrial clusters, free economic zones, and research parks in different countries to tackle these issues and create a friendly ecosystem for new businesses and startups; encouraging entrepreneurs and investors alike. With this it is anticipated these clusters will have different regulatory financing and investment reforms to allow foreign investment and ownership of companies as well as attracting entrepreneurs with great business ideas. All of this is intended to create a vibrant innovation ecosystem. The majority of governments in the Arab world have started programs incentivizing inventions, technologies, and industries in areas of strategic needs in a form of subsidized operational fees, reduced or removed taxes, or in some cases, reducing IP-filing expenses. All of this is being dome in order to ensure successful outputs from those newly established technology-targeted free zones.

An integral part of technology-transfer is IP law and regulations [5]. The IP-law framework in the Arab world is still developing and needs significant reforms to cope with technology transfer and open innovation. The first aspect to consider is the need for strengthening and enforcements of patent laws. This entails establishing specialized patent enforcement agencies that can take quick actions and decisions when it comes to IP infringement and patent disputes. There are concerted efforts in the United Arab Emirates where IP infringement is becoming part of the regular checkups by enforcement authorities such as port customs. This will definitely encourage inventors and entrepreneurs as well as investors willing to create startups or bringing new technologies.

Some universities in the Arab world are beginning to appreciate the importance of transforming research findings into commercial products. This approach becomes more significant as industries start to see universities in a different light from traditional unreformed universities that remain purely academic ("living in an ivory tower") and not relevant to resolving technical and socio-economic challenges. Rather, universities are steadily being regarded as being more relevant to the technology marketplace and easy to do business with. As a result, more universities have begun to create formal research-administration or technology-transfer offices to support translation of business ideas into viable technology products or processes. For many universities, this concept of technology development and/or business creation from university research is in its infancy. Some challenges need to be addressed and tackled from the beginning so that universities can play more effective roles as partners in economic development.

3 Technology-Transfer Challenges Facing Arab Universities

The role of universities in advancement of economic development has been prominent since 1980's with the declaration of the Bayh-Dole Act in the United States [6]. This Act has allowed universities to become more independent in commercializing research discoveries and, in some cases, benefit universities financially for their research commercialization successes (see Fig. 2). Nonetheless, two observations can be made from the considerable long tradition of practicing technology transfer in the United States, namely (a) the resulting economic impact is not immediate – rather it takes between 20 to 25 years to be materialized (see Fig. 3); (b) technology transfer is not stationary model but is a dynamic and progressive model, therefore it continuously needs evaluation, assessment, and modernization to be relevant and fit for purpose.

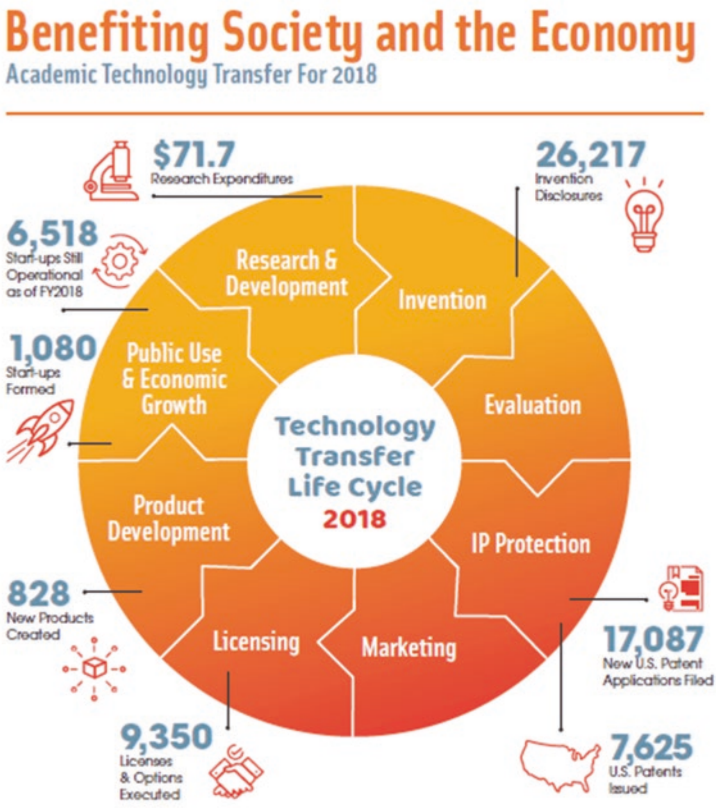

Fig. 2 An infographic from the 2018 licensing survey report showing some technology transfer metrics for US universities; the survey was conducted by the Association of University Technology Managers (AUTM) in the United States

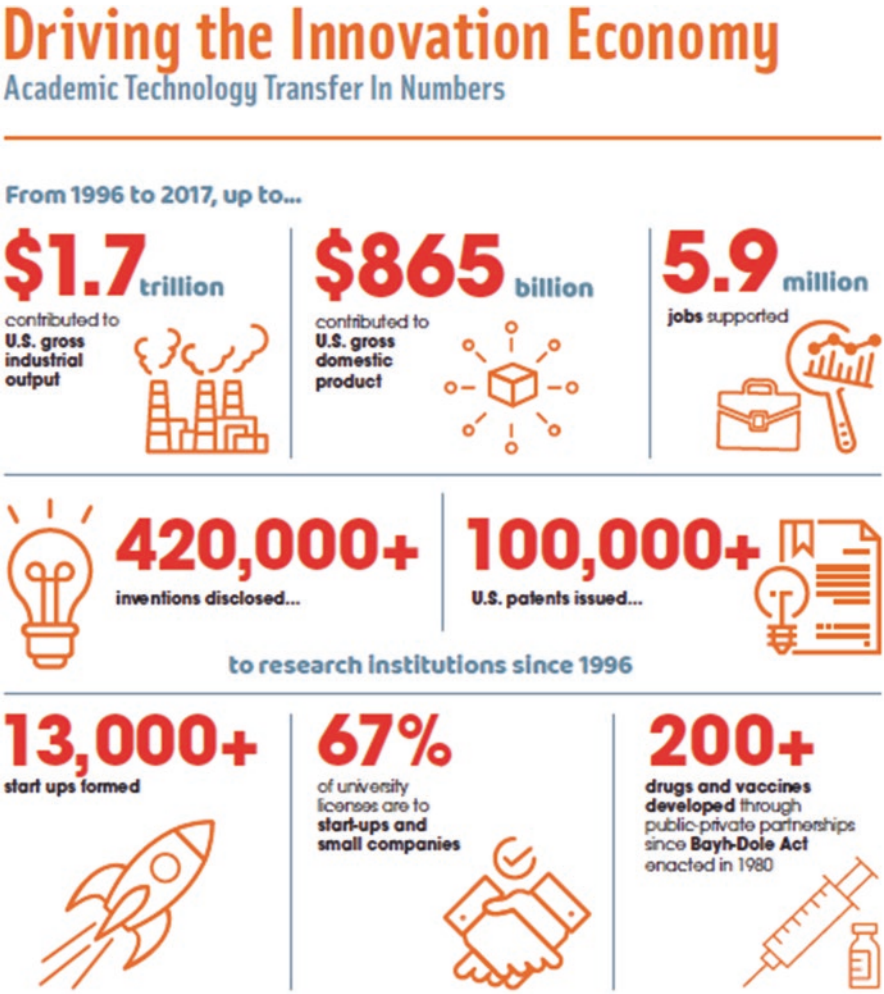

Fig. 3 An infographic from the 2018 licensing survey report showing economic impact of US universities in the past 20 years from technology-transfer activities; the survey was conducted by the Association of University Technology Managers (AUTM) in the United States

Hence, although it is possible to learn from the experiences of universities in the US and Europe, the adoption of impactful technology-transfer models in the Arab world must be established through its own learning and experiences reflecting the ever-changing operating environments. With this in mind, it is possible to foresee the challenges that universities here in the Arab world would face in adopting their own technology-transfer models. Those challenges can be categorized into internal challenges and external ones. The internal challenges are those within universities themselves such as governance, policies, human resources, and financial assets and management. External challenges are those related to government regulatory framework, patent law, and employment policies.

3.1 Internal Challenges

One of the critical internal challenges is the adoption of IP policies by universities in the Arab world. Most universities seemingly lack policies and guidelines that clarify the rights of researchers with respect to their universities as employers when it comes to their rights with regard to commercialization of their research discoveries, how these discoveries can be managed by the university, and how the benefits can be vested into the involved parties. The lack of such policies and guidelines renders researchers more apprehensive in disclosing inventions to their universities or responsible technology-transfer offices or units. This deficiency, in turn, reduces the chances of research commercialization [7]. Another challenge is that most universities in Arab world are considered as government non-profit entities. This raises the governance challenge for these universities on how they can accept revenues in exchange of their research discoveries and patents. This becomes even more problematic when universities would like to take equities and shares or convertible notes from potential licensees and/or startups. This rethinking of the status quo has created real dilemma for universities as it needs to be considered at a governmental-policy level to revisit their approach to the financial management of universities. One of the ways some universities are now considering is the creation of independent entities or creating separate enterprises that do not only manage university patents but also can provide seed funding. In all cases, this area is still requiring further developments until best practices can be figured out, especially with different government policies in each of the Arab countries.

At Khalifa University, in the United Arab Emirates, a model has been established to allow seamless transition of research discoveries from the university domain to the business/investment domain and hopefully to the market. This has been done through establishing Khalifa Innovation Center (KIC), which is a center established and funded by multiple national investment entities. One of the primary objectives of the center is to work closely with university technology transfer office in financially supporting promising startups. In addition, KIC work as an entrepreneurial hub to help scientists in developing their business plans and prepare them to pitching to potential investors. Most importantly, KIC guides those potential startups with company registration and other legal and regulatory matters that is necessary to allow these startups to become operational. This part is of crucial importance as government policies and guidelines when it comes to this part of business is still progressing and more guidance on how to approach will be needed. This model of having a pseudo-investment and incubation entity within the university is a promising one particularly when it comes to formalizing creation of startups within a new innovation ecosystem. For instance, one of the startups (Jinomix) that deals with genetic material analysis and discovery of biomarkers is challenging the status quo. That despite the challenge it was facing with registering as a startup, it is the nature of its business that requires certain new and untraditional medical and health approvals and conformities at the university and national levels prior to operation. Such challenges to the status quo is positive as it allows the regulatory framework becomes more adaptable to the new reality of technology advancement. Furthermore, many of these startups with their science-based platforms need laboratory facilities such as proof-of-concept or scale-up laboratories; which are currently lacking. So, the question becomes how and where to establish such technology-based incubation? On one hand, most of professors and inventors prefer to resort to their laboratories where they have access to their research resources such as materials and students. On the other hand, universities are mindful of using their facilities for what might be personal businesses. So, this area is still under development and requires more clarity in terms of policies and regulations. Nonetheless, it seems universities in this region are well positioned to take that role of technology incubation and development. However, such transformation needs the full commitment of universities' management and administration to accept adapting to the role of providing marketable technologies. This commitment must translate to being supportive, problem solving, and facilitating for professors to conduct in-house prototyping and development research work for their research without bureaucratic procedures or resistance. Similarly, professors must be aware of university rights in taking reasonable equities in their new ventures, advancing universities' research and academic agendas, and respecting policies particularly those related to conflict of interest.

Al Shumaimri et al. [8] stated that one of the most serious internal challenges in adopting best technology-transfer practices in the Arab world is the lack of technology-transfer professionals. Such specialized all-rounded professionals are much needed to progress the agenda of research commercialization and achieve economic outputs. For instance, the need for individuals to act as technology developers capable of integrating technology-development tasks with clear business plans and milestones is critical. Also, the lack of availability of law professionals in domains such as IP, IP licensing, and early-stage technology investment for new companies is problematical. Hence, universities can start by providing their students and staff with training on some of the fundamental aspects of technology transfer, management of IP, and commercialization of early-stage technologies. This can be done in collaboration with some of the specialized international organizations such as World Intellectual Property Organization (WIPO) that provide excellent programs to advance many aspects of this rapidly developing field. Access of universities to skilled staff in the area of technology transfer will be a quantum leap in making universities effective contributors to economic development.

Another challenge is the inability of universities in the Arab world to establishing progressive external industry partnerships. In our view, this can be due to the communication gap and the lack of a clear framework whereby this partnership can be conducted to create win/win scenarios. Here in the Arab world, universities traditionally were looked at as entities that can only provide academic scholarly activities and are not relevant to applied research to satisfy industry needs. On the other side, industries have been lacking research and development (R&D) capabilities to help them with conceptualizing and translating research findings into viable products or processes that can allow them to be competitive. All of this, in parallel with the absence of funding mechanisms for industry-sponsored research work as well as poor contractual understanding on how this partnership can be established, has

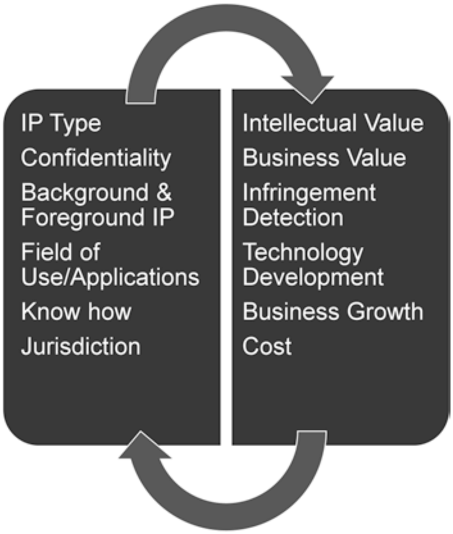

Fig. 4 A schematic showing some contractual aspects that can be considered to strengthen university–industry partnerships and accelerate research commercialization

impeded progress. Hence, it is of great significance for industries to understand that research in universities is conducted differently where knowledge dissemination, publication, and information sharing is critical for researchers and university rankings. In parallel, universities must quickly start putting relevant framework in their contractual arrangements such as confidentiality, know-how transfer, and IP licensing to accommodate for industry research needs (see Fig. 4). This issue of university-industry partnership has started to be addressed in many universities in the Arab world where industry engagement offices started to emerge and the universities started gradually to attract industry funds in their research activities. For instance, at Khalifa University in the United Arab Emirates, this partnership has been demonstrated in the creation of an innovation partnership center (EBTIC) in the field of information and communication technology (ICT) between Khalifa University and two telecommunication industry partners: Etisalat and British Telecom. Such a partnership, as per Chesbrough [9], is of significance and it leads to open innovation where industries as technology users can work in close juxtaposition with university researchers as technology creators to solve problems and maximize the benefit of the created intellectual property and as result enhance the delivery of research results to market.

3.2 External Challenges

When it comes to external challenges, the issue of patent or IP law comes first to mind of the challenges facing Arab universities. There is no dispute on the role that patents and patent law can play in the advancement of scientific research, innovation, and economic growth [10]. This has been documented by various articles and legal reports such as that of the European Commission [11]. The importance of patent legal protection and enforcement procedural framework in respect of technology transfer and innovation is of great significance especially when it comes to investment in university early-stage technologies [12]. In other words, better enforcement laws are more attractive to foreign investors in new technologies and startups. Again, improvements in recent years in patent enforcements are taking place in countries such as Saudi Arabia and United Arab Emirates by the introduction of Arbitration Courts to decide expeditiously on patent disputes. This starts to give patent holders and investors alike some certainty and assurances to develop further early-stage technologies and inventions coming out from universities.

Patent law in general has been enacted recently in the Arab world; for instance, it was enacted in Saudi Arabia in 1985. In most of countries, the patent system was established with the purpose of protecting technologies and businesses coming from outside and not home-grown inventions and technologies. It is clear that the patent legal framework here in the Arab world needs modernization and reforms to accommodate for the registration and protection of research discoveries coming out from universities. Finding and implementing an effective and efficient value-for-money patent legal framework to file and protect home-grown inventions quickly and cheaply as well as facilitates the materialization of these patented inventions, is a matter of urgency. The framework must fill the gap between inventors and entrepreneurs/investors who can bring inventions quickly to the market and, therefore, encouraging technology transfer and collaboration activities. For instance, costs attached to patent filing here in the Arab world is far more expensive than those in other countries including United States and Europe. This is due to the high costs associated with official fees, translation costs, and other costs involved in notarization and legalization of patent documents. In addition, the existence of cumbersome steps associated with patent filing, such as presence of inventors in person for registering and assigning patent documents in front of authorized personnel, is not practical and consumes more time than necessary.

In parallel, the system should be attractive enough for inventors and investors from abroad. Most Arab countries have their own patent offices where patents can be filed and registered. In addition, these countries are part of Patent Cooperation Treaty (PCT) that is governed by WIPO. This allows these countries to adopt new and agreed policies and practices in management of patents. Different efforts have been emerging in different countries to encourage universities and inventors to file patents such as the adoption of e-filing system by the Saudi Patent Office to allow quick filing and registration of patents. Another example in the United Arab Emirates where the patent office waives some parts of the filing fees for local inventors. Also, some patent offices started to accept patents in English for initial filing for a limited period in order not to lose priority before being translated into Arabic. This exemplifies the need for flexibility from patent offices with regard to filing of patents specially those conceived within the Arab world. Relevant to this is the enforcement of patents under the national jurisdictions in the Arab world. So far, the mechanisms for enforcement are not clear within the legal framework; nonetheless, there have been a few cases in the past where foreign companies have been compensated for infringement of their patents by local industries.

Some challenges also present themselves when it comes to creating and registering university grown startups as legal entities. The first challenge is the high cost associated with establishing these startup entities. As the system is still catering for companies with medium to high capital with clear operational and revenue plans, which is quite often not the case with startups. This imposes a great burden on entrepreneurs when it comes to establishing startups. Besides the bureaucracy and extensive administrative work associated with registration due to the gap in understanding the operation of startups at early stage. This is apparent at the outset with poorly designed paper work and application forms for registering newly established university startups. Another aspect is the issue of foreign ownership considering that a significant number of researchers and faculties in this part of the world are coming from countries different from those where they are serving, even within the Arab countries themselves. This issue of foreign ownership of entities is slowing creation of startups as it discouraging professors with foreign nationalities in establishing entities that possibly they might not own in the first place. In the United Arab Emirates, there have been major steps in tackling these issues by establishing what is called Free Zones districts where registration of new companies is quiet easy and to some extend cheaper. Certainly, the recent example of Abu Dhabi Global Market (ADGM) in the United Arab Emirates is a promising model that should be looked at with great optimism towards encouraging establishing university startups. ADGM is a financial authority in Abu Dhabi working under British common legal framework that allows for registration of entities from all nationalities with very reasonable fees; it is already starting to attract foreign investors who are encouraged by the operation under British Common Law. Hence, university startups will not only take advantage of the smooth processing of startup registration but also getting access to potential investors.

4 Conclusions and Path Forward for Technology Transfer in the Arab World

To conclude, it is the belief of the authors that the journey of technology transfer and commercialization of scientific research has started in the Arab world and possesses great potentials. This is supported by the high percentage (over 65%) of the youth in Arab populations that can create invaluable resources for active expansion of entrepreneurial ecosystems critical for creating new businesses and other technology-transfer activities. Hence, it is of material advantage for universities to include entrepreneurship-training programs within their academic curricula. Furthermore, most of the universities in the Arab world are appreciating the importance of being an integral part of national economic development and, therefore, need to change and transform the way of conducting business. Some universities have already gone ahead with establishing technology-transfer offices, industry engagement units, and revamped their campuses to include either research parks or incubators or both to advance commercialization of new technologies. Accordingly, there is no doubt that technology transfer will be taking the center stage in these universities to enable them to achieve their economic-development missions.

However, success of technology transfer depends on other internal and external factors. Diversification of research funds is one of the critical factor whereby governments must increase their research funding to be at least in the range of 5–10% of national GDP. In parallel, universities must change the status quo of the way they conduct business and become more open and efficient to attract industry funds. This part needs building capabilities to administer and manage these funds in an effective manner. Universities must start thinking of new ways of conducting research and collaboration partnerships with other universities or external collaborators to generate that dynamic of knowledge sharing. This becomes even more important for universities to advance their scientific and research capabilities and compete at a global level.

That being said, and with the ambitious innovation and economic development agenda for these universities, the need for reforming patent policies and laws is apparent. Universities might need to think of establishing incentivizing IP policies that can encourage researchers to come forward with inventions and discoveries. Parallel to this, there is a great necessity for building capabilities to record these inventions and implementing triage processes to identify their commercial value. With this, some patent registration reforms are needed at governmental level to allow universities to file and register patents as quickly and as cheaply as possible. This requires patent offices to adopt best practices to become competitive at international standards. We recommend methods akin to those established by countries like the United States, specifically the fast-track system allowing patents to be examined faster in areas of strategic interest or technological need. Furthermore, it would be beneficial to have patent laws and procedural framework more harmonized among the Arab countries. This will definitely make patent filing among these countries easier and more attractive resulting in even further research collaboration. A good example of this is the establishment of the Gulf States Patent Office that allows patent filing in one Gulf State to be protected in all other States. Similarly, regulatory frameworks for establishing new businesses and startups including foreign investment must be further improved to enable inventors and investors alike to accelerate the creation of technology startups. To quicken research commercialization, it is important for universities to be able at best to own or at least share ownership of patents so as to ensure these patents have a greater chance of commercialization success. Thus, government entities and industry sponsors must refrain from the approach of owning rather than sharing patents because they are research funders. The current approach is proving to be unsuccessful because it is less incentivizing for researchers and universities alike, and as a result progress of the research towards commercialization is hindered.

The need for technology-development entities or inclusion of applied research in universities and/or establishing advanced R&D capabilities can be important for all technology-based innovation ecosystems. It is clear that the Arab world is desperately in need of such capabilities to scale-up, prototype, and demonstrate the feasibility of new technologies and products. Nonetheless, this can be also a new area where universities can strengthen their collaboration activities to accelerate commercialization of their research discoveries. This also highlights the need for close partnerships between universities, industries, and government entities where each can bring its expertise to tackle specific technical challenges.

Finally, the role of universities in the Arab world is expanding to become effective contributors to development of the regional economy. Hence, the need for dynamic and sustainable technology-transfer models is much needed. Development of such models will lead to positive change in the status quo of how these universities do business. Similarly, it will draw the attention of governments to modernize their IP and investment laws to become more flexible and efficient. Many universities now are starting to have technology-transfer offices that are mandated by pushing technologies to market. However, there are still some challenges remaining ahead for these discoveries and research outputs to become manifest. Further, collaboration between universities in the region to address this issue of how to tackle these challenges is needed.

References

1. Sherwood R, Scartezini V, Siemsen P (1999) Promotion of inventiveness in developing countries through a more advanced patent administration. IDEA J Law Technol 39:473–505. ISSN: 0019-1272
2. Al Sodais S (2013) Science, technology & innovation in Saudi Arabia. WIPO Mag 5:23–25. https://www.wipo.int/export/sites/www/pct/en/news/extracts/2013/wipo_magazine_05_2013_science_technology_innovation.pdf
3. World Intellectual Property Organization- WIPO – https://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=SA. Accessed Apr 2019
4. Saidi N, Prasad A (2018) Trends in trade and investment policies in the MENA region. MENA-OECD Competitiveness Program. http://www.oecd.org/mena/competitiveness/WGTI2018-Trends-Trade-Investment-Policies-MENA-Nasser-Saidi.pdf
5. Richards G (2012) University intellectual property: a source of finance & impact. Harriman House Ltd, Hampshire. ISBN(s): 9780857192325 – 978085719227
6. Swearingen W, Slaper T (2012) Economic impacts of technology transfer: two case studies from the US. Department of Defense, Les Nouvelles, pp 163–173. https://techlinkcenter.org/wp-content/uploads/2017/06/Swearingen-and-Slaper-Economic-Impacts-of-DoD-Tech-Transfer-June-2012.pdf
7. Sherwood R (2002) Global prospects for the role of intellectual property in technology transfer. IDEA J Law Technol 42(1):27–36. http://ipmall.law.unh.edu/sites/default/files/hosted_resources/IDEA/2.Sherwood02.pdf
8. Al Shumaimri A, Aldridge T, Audretsch DB (2010) The university technology transfer revolution in Saudi Arabia. J Technol Transf 35(6):585–596. https://doi.org/10.1007/s10961-010-9176-5
9. Chesbrough H (1999) Open innovation; the new imperative for creating & profiting from technology. Harvard Business School Press, Boston. ISBN 1-57851-837-7

10. Pisano G (2006) Profiting from innovation and the intellectual property revolution. Res Policy 35(8):1122–1130. https://doi.org/10.1016/j.respol.2006.09.008
11. European Commission: Intellectual Property and Technology Transfer. http://ec.europa.eu/invest-in-research/policy/ipr_en.htm. Accessed 21 Apr 2019
12. Mazzoleni R, Nelson R (1998) Economic theories about the benefits and costs of patents. J Eco Issues 32:1031–1052. https://www.tandfonline.com/doi/abs/10.1080/00213624.1998.11506108