International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 7, Issue 11, 2019

# The Insight of the Industrial Revolution 4.0 in the Higher Education System

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The fourth industrial revolution involves automation technology presenting new challenges to all sectors in the country that require them to make changes in line with the digital transformation to remain competitive. The higher education sector is one of the sectors most impressed with the development of this fourth industrial revolution. To achieve that goal, it requires a higher education institute that is more flexible and ready to face new challenges so that any class of society will not be left out in the globalisation and digital era. This paper will focus on exploring the impact of Higher Education (HE) 4.0 on the challenges, chances and opportunity in engineering education. The question is how does the institution, curriculum and readiness of the infrastructure adapt to the changes? What new skills are needed to deal with uncertainly and risk enhancing creativity in business thinking? Many articles are analysed and summarised to provide insight to the challenges, chances and opportunities of the Industrial revolution 4.0 in HE. Finally, this article will update the engineering education system status quo and prepare to implement and be a driving factor for the industrial revolution 4.0.

**Key words:** *Industrial Revolution 04, Engineering education, Higher Education.*

## Introduction

The industrial revolution is an approach used to design the technology introduced by Arnold Toynbee in 1889 to 1975 (Zulkifli, 2017). The development of the industrial revolution began with the first industrial revolution that relied on the use of water converted into steam (Lasi, 2014). The steam power generated used to drive the machine that attempts to boost industrial production and lead to a steam engine that made a difference to the world of the transportation system. The period of the second industrial revolution from 1870 to 1914 involved the production of electric power. The development of the second industrial revolution has further boosted industrial activity to large-scale production. The third industrial revolution parallels with the development of information technology and computers as the main driver of technology development.

At the third industrial revolution, automation technologies realised the capabilities of technology operation without involving humans (Raimi, 2016). When the computer program was loaded into the machine, it was capable of operating on its own the tasks it has been assigned. The impact of this automation technology takes place when the concept of mass production is introduced. Through the development of ICT technology and internet infrastructure and combined with the automation technology, the fourth industrial revolution was introduced (Tritularsih, 2017). Through this system, the consumption of robots continuously used in line with the development of artificial intelligence and the internet of things (IoT) (Prasetyo, 2017). So, if the complexity of new technological challenges is not properly considered, it could cause Malaysia to lag behind in the global competition.

According to the world bank's higher education expert, Francisco Marmolejo, the fourth industrial revolution seminar said that the higher education system across the country would undergo a change due to the industrial revolution 4.0. Imagine the knowledge we have today contributing to only one percent in the next 30 years and the job market will be filled with highly skilled, creative and critical thinking personnel. To this end, we require a more flexible institute of higher education that is ready to face new challenges so that any group of people will not be left behind in this globalised and digital era. Malaysia is the first country framing the industrial revolution 4.0 elements challenged through the education framework (higher education) 2015-2025. The higher education development plan that includes ten spikes innovative frameworks is seemingly good not only for the future but also the present. The ideas practiced in Malaysia are the most innovative steps to determine how the country will become a significant player in the global economy of the future. Even though there are a lot of frameworks planned, education need to be emphasised in order to prepare students and graduates to deal with the new challenges of the industrial revolution 4.0.

Lately Malaysia's higher education system has been growing rapidly. Over the past ten years, the increase in student enrolments has increased significantly. This has been observed by increased worldwide recognition through various aspects such as publishing, research, patents, the quality of institutions, as well as a significant increase in the number of international students. Nevertheless, to remain competitive globally the higher education system needs to be transformed in line with the development of the industrial revolution 4.0. For example, the development of advanced technologies such as robotics, the internet of things, and automation of work-related knowledge is expected to change the landscape of higher education system in Malaysia. Through 10 spikes in the development of Malaysia education (higher education), the first four spikes focused on the success of higher education people, including students in the academic and TVET courses, the academic community and all Malaysians pursuing lifelong learning. Six Spikes further focused on the enablers of higher education eco-systems, including funding, governance, innovation, online learning, internationalisation and delivery.

This article is organised as follows; section one is an introduction to the industrial revolution 4.0 in the Malaysian higher education system. The second section discusses the concept of the industrial revolution 4.0. and the higher education system in Malaysia is discussed in the third section. Next the impact of industrial revolution 4.0 in the higher education system in Malaysia according to micro, meso and macro level discussed in section 4. Furthermore, the challenges and future direction of higher education in Malaysia will be discussed in section 5 and finally, a conclusion in section 6.

## Characteristics of the Industrial Revolution 4.0

The 4th Industrial Revolution represents a non-linear break with previous economic orders. Earlier Industrial Revolutions based on advances of steam-powered transportation and mechanical production (late 18th century), standardised electrically powered mass production (late 19th century), and the computer revolution (late 20th century). The 4th Industrial Revolution, according to Schwab, is the integration of digital, physical, and biological systems. Embedded within the 4th Industrial Revolution are new industries and modes of production made possible by advances in artificial intelligence (A.I.), the Internet of Things (IoT), 3-D printing, autonomous vehicles, biotech, nanotech, green energy production and energy storage.

**Higher Education (HE) System**

The connection between education and society is often implied to be one-way where education is expected to fit in with economic and political trends, rather than, opposing them and representing something different. Such general understandings of the relationship between education, the socio-economic structures and what the education position involves, help us to form a projection of the future of higher education associated with the fourth industrial revolution.

Higher education has profound origins starting in the 6th century monastic schools and later evolving into the medieval European University beginning in Bologna in 1088 which focused on theology and philosophy, and progressing into the current modern higher education system. In this evolution universities evolved from just being centres of teaching and learning, to include research and thereafter to include service to society. In its early stage, university education was catered for tiny elites. In that time, higher education was intended to mould the minds and characters of the ruling class.

In the late 20th century, the tension between education as a private right or a public good prompted the trend to ‘massification’, i.e. providing higher education to many people. During this period, the higher education spawned changes in a massive way in terms of many factors such as the size and shape of systems, the curriculum designs, the organisational structures, the pedagogical methodologies, the delivery modes, the research patterns, and the relationship between institutions and other external communities. The main goal of mass higher education was targeting the transfer of skills and preparation for a wide variety of technical and economic roles.

Higher education has gradually progressed from the elite phase to mass higher education and then to post-massification stages. Many advanced and some developing economies enjoy the tertiary participation rates of over 50%. Another characteristic of this trend is internationalisation of both students and staff.

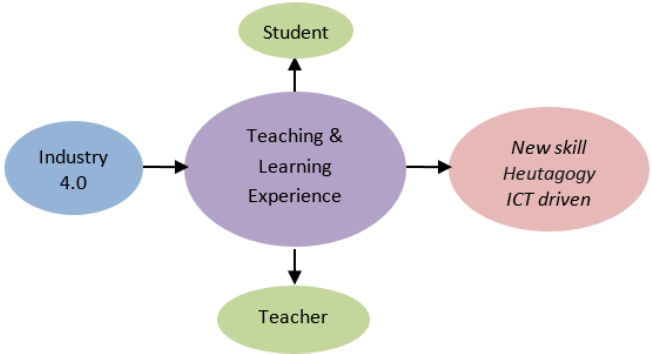
**The Present Impact of the Industrial Revolution 4.0 on the Malaysia Education System**

The revolution of manufacturing technology from mechanical systems to advance digital systems is also known as the Industrial Revolution 4.0 (IR4.0) and has greatly affected not only the industrial sector but how we practice daily life together. Higher education plays a critical role in supporting the IR4.0 ecosystem to produce a skilled workforce and pioneer new technological development. In this paper, the impact of

IR4.0 to the Malaysian higher education system (MHES) in micro, meso and macro level perspectives has been discussed.

### *A. Micro Level*

**Figure 1.** Impact of IR4.0 to Student and Teacher

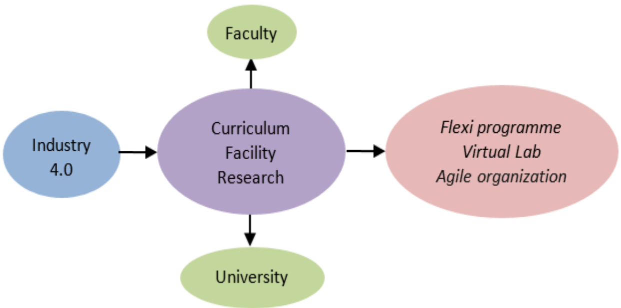



At this level, students are the main characters produced to drive new technology in the future with adequate skill level. Whereas, the teachers' role is to deliver relevant knowledge with a multitude of effective methodologies. Figure 1 shows the relationship between IR4.0 to students and teachers in a way of teaching and learning experience. The advancement of ICT technology makes it possible for the learning process to happen regardless of time and space (heutagogy). The technology trend also indicates how the younger generation use the internet almost 21 hours in a week by the latest survey conducted by the Malaysian Communications and Multimedia Commission (MCMC). The ICT driven method such Massive Open Online Courses (MOOCs), M-learning (Mahat, Ayub, Luan, & Wong, 2012) or by using social media (Said & Tahir, 2013) are new learning methods to enable knowledge sharing from the entire world resources. In terms of skill demand for future needs, undergraduates should be equipped with the 4Cs: communication, creativity, collaboration and critical thinking (News, 2017). The report presented by the World Economy Forum (WEF) 2016 indicated a list of ten skills needed in the year 2020, namely: complex problem solving, critical thinking, creativity, management, coordinating, emotion intelligence, judgement and decision Making, service orientation, negotiation and cognitive flexibility (Higgins, 2013). Furthermore, Jeschke (2015) added that the future engineer may require to 'speak code' to meet the context of the digital industry. This will make the new generation student prone to adapt IT technology in their daily life activities. Entrepreneurship is another important element for future business activity. Thus, entrepreneurship requires a more complex skill set with the capability to innovate in very fast manner (Din, Anuar, & Usman, 2016).

In Malaysia, Massive Open Online Courses (MOOC) were introduced in 2013 as mini courses in Taylor's University. This initiative aims for the teachers to explore new delivery methods through the ICT advantages (Fadzil, Abdol, Tengku, & Munira, 2016). Presently, MOOCs initiatives in Malaysia attracted about 220,000 students from over 170 countries and have been recognised as the first nationally co-ordinated MOOCs in the world (Star, 2017a). Heutagogy education is another concept of learning which has been proposed in the Malaysian education system. This concept is taking the advantage of ICT and technology that would allow students to upgrade their skills in learning either through formal, informal and non-formal in which the students themselves determine the direction of their progress. The concept is now under a pilot study in a rural area in Perak to study its impact on community (Malek, 2017). As the IoT is a common thing in our life, it is good to conduct a survey online that can reach so many people from different ages and different backgrounds in a short period of time.

### *B. Meso Level*

**Figure 2.** Impact of IR4.0 to faculty and university

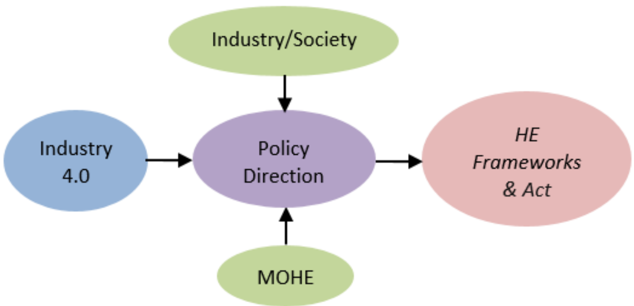



The Figure 2 shows the impact of IR4.0 on departmental and university organisations. The faculty plays an important role in designing the curriculum of program and its contents to meet the job market demand and accreditation criteria. However, the current fix structure will no longer fit to new generation student since the future job is no more specific on certain area but keeps changing based on innovation (Jeschke, 2015). Thus, flexibility in the curriculum structure is more promising to this scenario. Moreover, the students tend to design their own program based on their interests or market demands. Xing & Marwala (2017), state that the internationally-linked program will forge various kinds of institutional linkages, both domestically and internationally, to offer more versatile degree programs. This scenario indicates that the faculty can no longer determine the career path of the student but the student themselves. The impact of digitalisation also makes it possible for the application of augmented reality (AR) facilities in the program. This facility not only has the power to engage a learner in a variety of interactive ways that have never been possible before but can also provide each individual with one's unique discovery path with rich content from computer-generated three-dimensional environments and models (Lee, 2012). Besides the best curriculum to ensure a skilled workforce for IR4.0, the faculty also has a responsibility to explore new technologies and collaborations with industrial partners through high impact research. Data sharing platforms will enable the industry partner and university to expedite new innovation in locally or globally. In the university structure hierarchy, some of the departments may not relevant and should change or be redesigned. The role of library with hard-copy book may not be relevant anymore since the younger generations may prefer to find sources through their devices. This example gives indication that the university government must keep agile to reflect disruptive changes.

To tackle this revolution era, Malaysia has made an early step to adapt to the change. The initiative 2u2i shows the example of the university industry partnership that allows students to be in an industry for two-years to get industrial experience and be counted as part of their curriculum program. This program will benefit students who follow the mainstream education path. However, for those who are already in the job, they can also improve their education level with an initiative of TVET Modular. While, the APEL program allows the previous experience to be counted as part of a structured curriculum. These examples will provide the flexibility to a new generation and old generations to enhance their education level.

### *C. Macro Level*

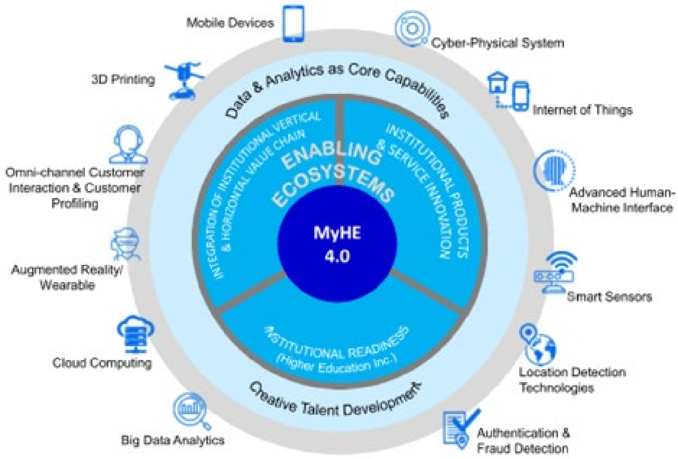
**Figure 3.** Impact of IR4.0 to Higher Education System




At the macro level, the Ministry of Higher Education (MOHE) will need to address how disruptive technology and the digital era will shape the current education system. The HE system must leverage from this technology to produce a holistic nation as well as developed new technology. Therefore, the MOHE has to come up with clear direction to keep evolving and to stay abreast with this global trend as shown in Figure 3.

At the moment, Malaysia has developed an education master plan known as the Malaysian Education Blueprint (MEB) 2015 - 2025. The MEB was developed through a collaborative and consultative process through various stakeholders. This plan outlines 10 Shifts that will spur continued excellence in the higher education system. All 10 Shifts address key performance issues in the system, particularly with regard to quality and efficiency, as well as global trends that are disrupting the higher education landscape. Recently the ministry has redesigned higher education to put special focus on the Industry Revolution 4.0. The priority is the big data program, but emphasis has also been given to the liberal arts program to infuse creativity and innovation into science, technology and engineering-based products (Star, 2017b). Furthermore, this step forward has been taken to propose new higher education frameworks known as MyHE4.0 as shown in Figure 4.

**Figure 4.** Proposal of Malaysia Higher Education 4.0 (MyHE 4.0) Framework reproduced by (Selamat, 2017)




## The Challenges and the Way Forward

Despite the positive impact in the way of HE to facing the disruptive changes and global trends, there are certain considerations that must be critically looked at. In the Malaysian context, the challenge is how to ensure a smooth transition between the current education system to a more dynamic education system in the future. To enable the right ecosystem for HE4.0 requires a huge investment from the government to provide the infrastructure. For example, the MOOCs learning concept is only workable if the internet coverage is inclusive and meets the standard speed quality. At the moment, the Malaysian speed of internet was reported at average 8.9 Mbps according to Akamai's *First Quarter 2017 State of the Internet Report.* Another concern is that to ensure balanced development and growth with equity whereby participation in the knowledge-based economy reflects the ethnic composition and the general demographic characteristics of the population (Cheah & Merican, 2012). The obsessiveness with the digital world may shift the educational goal where the humanity aspect is put aside with regard to the educational purpose to guide people in human life. Furthermore, the comprehensive education policy will look into this humanity aspect to balance between knowledge and ethic or moral aspect. Apart from that, credential challenge is another factor to consider in applying the digital component in HE4.0.

In order to meet the challenges, some suggestions for improvement in the HE eco-system in some areas are now described, with a focus on: teaching, research and development and education service system.

### *A. Teaching in the Fourth Industrial Revolution (Teaching 4.0)*

Teaching has long been constrained by the following scenario: students needed to gather in a lecture hall to hear the professor or sit around a table to discuss with peer fellows. Technology innovation is relaxing those constraints, however, and bringing radical change to higher education. Massive open online courses, or MOOCs, is a form of education that provides stand-alone instruction online (Xing, 2015). Though much experimentation lies ahead, MOOCs threaten different universities in distinct ways. Two big factors underpinning a university's costs: physical proximity requirements and productivity limitations. Because of the need for physical proximity enrolling more students is expensive considering the increase in buildings and instructors. Because of productivity limitation, the maximum number of students that can be compressed into lecture venues and exam-marking rosters are limited. MOOCs can eliminate these obstacles by working completely differently: off campus, online modules and once an online course is created, teaching extra students becomes an advantage.

The aftermath of this learning process is that only parts are recognisable by students, while the comprehension of the overall working mechanism is paralysed. In this regard, the main objective for a lecturer is to let students acquire the conceptual knowledge (i.e., essential relationship between knowledge fragments and their functions in the whole knowledge system) which are applied to not only microeconomics but many other subjects as well. To address this issue, we believe a generalised blended learning (i.e., mixed e-learning and face-to-face learning methodology) may contribute to this. It is well-known that virtual environments offer great educational value in the process of information transmission and interactive participation, either in real time (e.g. video conferences), or non-simultaneous participants involvement (e.g. forums and chats). In such processes, the face-to-face teaching and evaluation can be used to develop analytical expressions and problem-solving capabilities related to mathematical matters. Lecturers at this stage can get physical feedback about the effectiveness of their knowledge transmission to students. Then the understanding of some specific conceptual issues are further assessed and reinforced via online graphic representations and multiple-choice test questions and this offers students an advantage of reviewing their results immediately. In closing rather than fighting against these new technologies and the associated novel teaching patterns, higher education systems need to look at how they can accept them and transform the teaching and learning environment to the benefit of both students and academics.

### *B. Research in the Fourth Industrial Revolution (Research 4.0)*

Open innovation, refers to the combination of humans and computers to form distributed systems for the purpose of accomplishing innovative tasks where neither can be done alone. Despite the debate about accuracy, information science has begun to build on some early successes to demonstrate the potential of evolving open innovations that can model and resolve wicked problems at the junction of economic, environmental, and socio-political systems. A typical open innovation process includes:

(a) Micro-tasking under crowd-sourcing mechanism where the respective strengths of a crowd and machines can be magnified.
(b) Designated workflows guide crowd-workers to use and augment the information offered by workers at the previous step.
(c) To create problem-solving eco-systems, researchers can then combine the cognitive processing of many ordinary contributors with machine-based computing to establish faithful models of the complicated, inter-dependent systems that underlie the world's most demanding tasks.

Under higher education in the fourth industrial age, a country's higher education system should put innovation, both evolutionary and revolutionary, high on its agenda. In general, innovations based on existing technologies are so-called evolutionary type; while revolutionary type of innovations focus are inventions of new technologies. Ideally, hybrid innovation is a sound strategy but it is difficult to implement. Established academics are often victims of their own accomplishments.

Leading scholars have long succeeded by exploring new research domains that could lead to incremental research output growth. Emerging researchers have aggressively followed a similar strategy. As one research area matures and competition increases severely, the degree of research outputs being published in the form of patents or journals inevitably gets very low. Introducing new research directions means going up against entrenched competition (Xing and Gao, 2014).

In the era of the 4th industrial revolution, higher education needs to deepen its technology system reforms by breaking down all barriers to innovation. One noteworthy obstacle is resource allocation for funding different research projects. For those technology innovations that are important for industrialisation, re-industrialisation, and neo-industrialisation, but are unable to profit in the marketplace in the near-term, financial support from institutions and government levels should be made available. However, for applied technologies where commercialisation is possible, social capital can play an active role (Xing, 2017). Additionally, several other hindrances should also be dealt with properly: first, with its hybrid innovation strategy, higher education practitioners need to have a global perspective. The trend of world technology development should be well-perceived and thus, appropriate plans need to be made. Each stream of innovation resources, internally, locally, regionally, and globally, should be utilised properly. Second, by having various development strategies and incentive policies across different departments, the connectivity among them should be optimised to avoid potential overlapping. Third, the speed of technology transfer needs to be raised to boost the economic and social development.

New technological advancements are often ranked as the most important driving force for research and design (R&D). Technology-driven R&D comes in many forms and it can mean employing mobile capabilities to improve data acquisition accuracy; using advanced big-data analytics to spot hidden statistical patterns; harnessing artificial intelligence techniques to re-tool information searches, collection, organisation, and knowledge discovery, to name just a few. The bottom line, in all cases, is that the advanced technologies can be leveraged across many domains to continue to deliver impact. Briefly, advanced technologies can bring benefits to higher education R&D in at least four areas: cost and timeline reduction; operation transformation; R&D process enhancement; and, most significantly, research direction innovation via the creation of new ideas and theories. Take the example of additive manufacturing (or 3D printing), this new technology can be used to reduce the cost of producing prototypes, which are generally time consuming and cost inefficient in conventional higher education R&D. This innovation results in both significant efficiencies and more flexible experimental plans which, in turn, lead to the use of technology where cost had previously been prohibitive in the laboratory environment. In the fourth industrial age, R&D processes with the help of advanced technologies treat functions such as IT and analytics as 'centres of value' rather than of service or cost; nurture partnership attitude; and, more and more frequently, form an agile style of R&D. One of the most important and difficult tasks, is to shift higher education R&D culture from an outdated 'waterfall approach' to idea development. Higher education institutions that make this change will become good at absorbing ideas from all kinds of sources.

Higher education institutions to be aware of research trends as they emerge and catch up with competition. In comparison to commercial R&D house, higher education institutions' overly-long development times are the most-blamed obstacle to generating positive returns on innovation. In practice, fast movers are much more likely to also be strong innovators as they are also more disruptive. Brainstorming, conceptualising, model-design, theoretical proving, experiment setting-up, components procurement, prototyping, test conducting, results analysis, and deliverables submission can be organised into teams that work closely with group leaders to quicken responsiveness to emerging research trends.

In closing, as we have indicated herein, the strongest innovators and leading researchers draw on swiftness, well-pruned processes, and the exploitation of advanced technology to explore and capture research opportunities. Any higher education institutional thinking about research in the fourth industrial revolution should first determine where its gaps are vis-à-vis in the areas mentioned above and make a plan to address those issues.

### C. *Service in the Fourth Industrial Revolution (Service 4.0)*

Typically, in the age of 4th industrial revolution, once every couple of decades, a disruptive new technology arises that essentially changes the blueprint of many sectors. In terms of higher education, the massive proliferation of affordable mobile devices, internet broadband connectivity and rich education content start a trend of transforming how education is delivered. Cloud computing, amongst other techniques, creates a new way of educating people that might eventually disrupts the existing higher education systems. With the support of education cloud, government decision makers and business practitioners can answer some key strategic questions comprehensively: deliver education in the quickest, most efficient and best affordability form; develop 21st century students' skills and prepare students for the new job market in the most appropriate way; encourage native innovation with the strongest incentives; and share resources across institutions, districts, regions, or the entire country in the smoothest fashion.

When universities think of embracing EaaS, they often imagine profound advertising campaigns, big promotional budgets, and huge amounts of infrastructure investment. Fortunately, Education as a Service (EaaS) has a healthier respect for the students than academics have for disruptive ways of delivering educational services. At the heart of EaaS is the belief that students' needs should be met effectively. Therefore, when a higher education institution sets out to attract a potential student as a customer, it needs to create an all-round educational experience that is genuinely capable of satisfying the customer's needs. Although, this process is not as simple as it may seem. EaaS is not the creation of pseudo differences via a change in logo, location, or making vague promises with empty sounding words. Furthermore, higher education institutions are accountable to a host of stakeholders such as governments, accrediting agencies, the public and private funding sources, academics, management, support staff, and students. An EaaS orientation that translates into an effective education scheme will achieve these broader concerns. Nevertheless, many institutions adopt EaaS strategy poorly by giving lip service to various stakeholders. Education and technology have advanced over the past few decades. Many technology-assisted / enhanced educational practices are no longer as simplistic. In Service 4.0, EaaS as a guide has to discover newer and more advanced strategies to cope with the ever-increasing societal complexity.

## Conclusion

The fourth industrial revolution involves automation technology presenting new challenges to all sectors in the country that require them to make changes in line with the digital transformation to remain competitive. The higher education sector is one of the sectors most impressed with the development of this fourth industrial revolution. To achieve that goal, it requires a higher education institute that is more flexible and ready to face new challenges so that any class of society will not be left out in the globalisation and digital era. Malaysia is the first country to devise elements of Industry 4.0 challenges in the 2015 - 2025 Education Development Plan (Higher Education). A higher education development plan that spans 10 spikes is a very good narrative framework not only for the future but also for today.

**Acknowledgment**

Special thanks to Associate Professor Dr. Arieff Salleh bin Rosman for the knowledge and insights to do analysis and discussion regarding the Fourth Industrial Revolution

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