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Redesigning Teaching and Learning towards Sustainable Education

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MESSAGE FROM THE CHAIRMAN OF ICEPEE'21

Ali Sophian
Chairman
4th International Conference on Engineering Professional Ethics and Education (ICEPEE 2021)

Assalamu'alaikum warahmatullahi wabarakatuh.

Sincere greetings to all.

Praise be due to Allah the Lord of the Universe. We are pleased and grateful to convey that ICEPEE has been revitalized following some hibernation, where the last one, the 3rd ICEPEE, was held back in 2013. International Islamic University Malaysia (IIUM) is a strong supporter of value-and-ethics-based education that will produce not just good professionals and scholars but also those who value and observe ethics in both their professional and personal lives. ICEPEE is one of the examples of the commitment shown by the university in this integrative, holistic education.

After the hibernation, this year ICEPEE is revived by the Faculty of Engineering of IIUM with a humble restart and we are aiming high *inshaAllah* for the future and will contribute more significantly towards integrative engineering education internationally. This year, we have received nearly 20 abstract submissions that involve authors from five different countries.

With the rise of digital transformation and other disruptive technologies and the concern over sustainability in social, economic and environmental aspects, new teaching and learning approaches and technologies are an inevitable future for all educators. This is even more true as the world has been hit by the current Covid-19 pandemic that has forced us to adapt our pedagogical systems quickly and effectively. With this in mind, ICEPEE'21 was launched with the theme "Redesigning Teaching and Learning for Sustainable Education".

I would like to thank the Conference Committee who have worked hard for the success of this conference. I would also like to extend my sincere gratitude to our distinguished keynote speakers, to all presenters and participants.

Finally, on behalf of the Organizing Committee, I welcome you all and wish you an enjoyable and fruitful virtual conference.

Best regards,

Ali Sophian
Chairman, ICEPEE'21

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Mechatronics Engineering Curriculum in the New Perspective

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Abstract— Mechatronics Engineering nowadays is no longer restricted to the simple combination of the traditional disciplines like mechanical, electrical and computer engineering. Emerging technologies like micro-actuators, distributed sensory systems, medical robotics in healthcare, soft actuators and robotics are a few to name that need a wide range of knowledge for their design and realization. To add to that, the demand of Industrial Revolution 4.0 (IR 4.0) also requires future graduates to have adequate digital and data literacy, while the elements of sustainability and ethics also need to be upheld to produce well-balanced engineers with good work ethics. For this, understanding in complex decision algorithms, advanced control systems and artificial intelligence are gradually becoming essential and therefore need to be integrated in mechatronics engineering curriculum. That being said, it is a big challenge to develop an effective mechatronics curriculum to produce graduates who will be able to support modern mechatronics systems that involve so many foundations, as well as to include sustainability and ethics elements in related subjects. This paper presents a Mechatronics Engineering curriculum that has been recently revised in the International Islamic University Malaysia to accommodate most of the fundamentals in its core while grouping the elective courses in three streams to be opted by the students; namely Artificial Intelligence, Robotics and Automation and Instrumentation and Control. It is expected that the graduates of this program will be able to support specialized areas of mechatronics as well as will be able to switch to other areas with minimum training to cater with the needs of IR 4.0.

Keywords: *Mechatronics Engineering, Curriculum, digital and data literacy.*

1. Introduction

Mechatronics Engineering is an interdisciplinary academic programme that has been existing for almost five decades in many universities in different countries of the world, specifically in Asia and Europe. This discipline requires knowledge of Mechanical, Electrical, Electronic, Information Technology, Instrumentation and Control, Robotics engineering and so on [1-2]. With the passage of time, it has become such that this discipline now integrates most of the interdisciplinary engineering fields and has been playing a vital role in developing modern smart products and systems [3]. And with the evolving technologies within the fourth industrial revolution, Mechatronics Engineering curriculum needs to be further updated to equip the students with the tools of trade for current and the future [4-5]. The revision is also timely as the International Islamic University Malaysia (IIUM) has just recently introduced the *Sejahtera* Academic Framework (SAF), which demonstrates that the university envisions preparing the present students to face the future that may have so many disruptions and that the university emphasizes the need of humanising education that will nurture holistic, well-balanced and *sejahtera* human beings instead of merely employable graduates [6].

2. Revised Mechatronics Curriculum at IIUM

The Mechatronics Engineering curriculum of IIUM underwent its latest review in 2020. After running the programme for more than 25 years it was felt that the field and scope of such a discipline had expanded significantly and had become difficult to be accommodated just with a list of courses from the constituent disciplines without highlighting clear goals of the programme [7-8]. The hype cycle of emerging technologies

shown in Fig.1 highlights the trend of technological advancements by the next 5 to 10 years and beyond [8]. Technologies related to Mechatronics Engineering discipline have been extracted from Fig.1 and are presented in Table 1. It is evident from Table 1 that robotics, control, and artificial intelligence will be the core elements of many of these products and technologies.

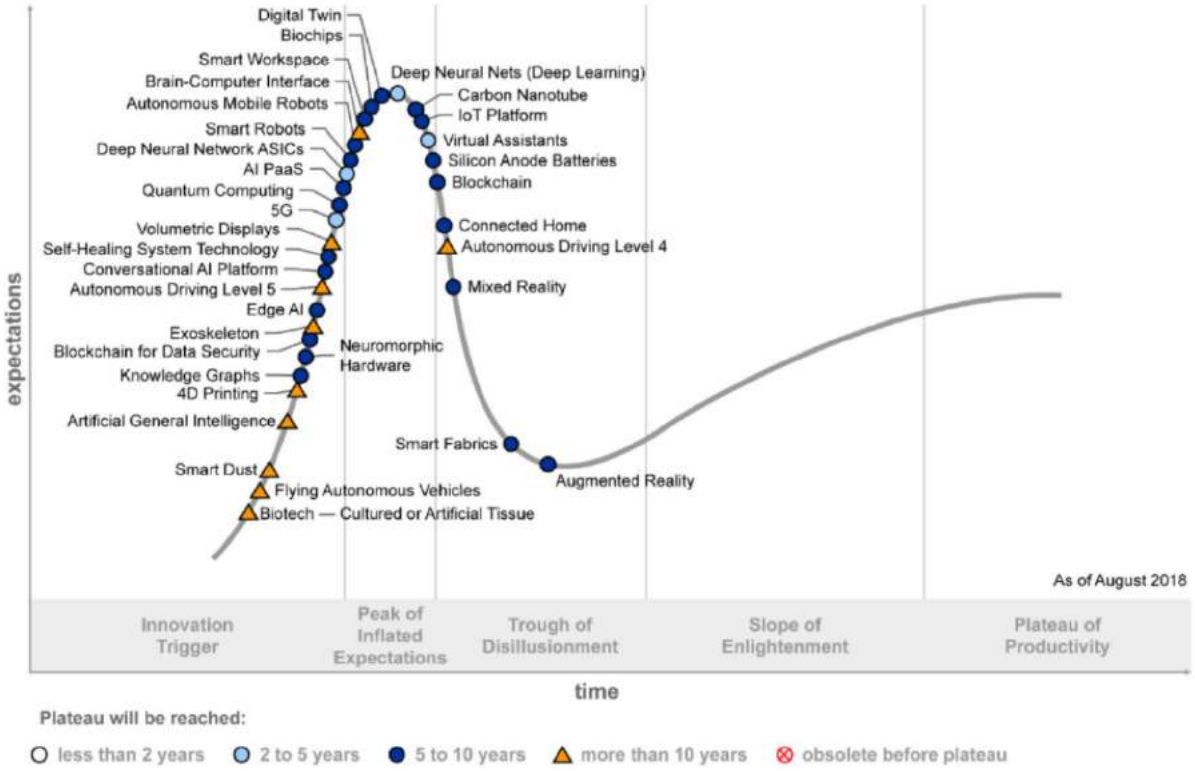

Fig. 1: Hype Cycle for Emerging Technologies, 2018 [9]

Table 1: Emerging Technologies related to mechatronics engineering discipline

Autonomous mobile robots
Smart robots
Deep Neural network and deep learning
IoT Platform
Exoskeleton
Flying Autonomous Vehicle
Autonomous Driving
4D Printing Platform
Digital Twin

To have a better structure of the revised mechatronics engineering curriculum that would be able to provide sufficient scope of theoretical knowledge and skills of applying theory and software in realizing mechatronics products an analysis based on the future trend of technologies was conducted. The analysis is presented in Table 2. Input from the alumni and industries was also considered in responding to the questions set in column 1 of this table. Expectations of graduate competencies from the industries are summarized in Table 3.

Table 2: Analysis on programme relevancy for the next 5-10 years

What are the future trends and demands in areas related to the programme?	**Innovators** of smart, affordable, and sustainable products that involve knowledge of • Sensors and instrumentation • Actuators and dynamic systems • Robotics and autonomous systems • precision control • AI based decision • IOT and • IR4.0 **Self-learner** with ethical practices and Islamic values **Technopreneur** in the area of robotics, automation and AI
What changes need to be made to meet the future challenges?	• Core courses need to be aligned to understand and solve complex problems of the future that need robotics, AI, sensor fusion, IOT and IR4.0 • Sufficient software practice and software-hardware interfacing need to be enhanced • Students' hands on skill must be improved to the level of self-engaging in product development • Self-learning needs to be inculcated in the core curriculum • Entrepreneurship must be incorporated to the level that the graduates will be able to create job
Will the programme be still relevant to meet the needs of society and industries 5-10 years from now?	• Yes • New products and services will involve more and more smart products like new kinds of robots and autonomous systems. The revised Mechatronics engineering curriculum aligned in line with the elements listed in row 1 and 2 of this table will be able to meet the needs of the industries and society.

Table 3: Expectations of graduate competencies from the industries

Technical Skills	Soft skills and Managerial Skills
1. Very good in theories in the field of study 2. Multitasking and quick problem solver with minimum cost. 3. Expertise (hands-on) in robotics, embedded systems, and control systems. 4. Hands-on experience in designing machines or robots simple as well as complex. 5. Strong programming skills especially C++/Python. 6. Experience with ROS 7. Hands on skills	1. Integrity 2. Decision making skills 3. Engineering management skills 4. Competence and multitasking 5. Good attitude 6. Passionate in any job given 7. Have a pilot view on the interest area and seeing the milestone of it ahead

To cope up with the trend of technological advancements and to fulfill the expectations of the industries, in the new curriculum three specialization streams have been introduced where each stream consists of four courses in the respective specialization area. Graduates who will take courses from a particular stream will require minimum training either to work in the industries or to become technopreneur. Specialization streams and the list of courses under each stream are presented in Table 4.

Table 4: Specialization stream in the revised mechatronics curriculum at IIUM

No	Robotics and Automation	Control and Instrumentation	Artificial Intelligence
1	Autonomous Robotic Systems	Electronic Instrumentation and Design	Natural Language Processing
2	Underwater and Aerial Robots	Biomedical instrumentation	Machine Learning
3	Manufacturing Mechatronics	Modern Control Design	Deep Learning
4	Smart Infrastructure	System Modelling and Identification	Machine Vision

To fulfill the requirements of integration of interdisciplinary courses, in most of the Mechatronics Engineering curriculum, fundamental engineering discipline courses such as Electrical and Electronics Circuits, Engineering Mechanics, Thermal Sciences and Fluid Mechanics are taught within the first four to five semesters of the programme. Then, the integrated courses like Control System, Robotics and Industrial Automation are taught during the last three semesters. Such practice helps the students to understand the concept of Mechatronics Engineering, however, fails to show the students any pathway to real-life integrated smart products. It is also observed that not all graduates of Mechatronics Engineering will be able to master all the components of Mechatronics. As such, it would be wise to introduce core courses in the early stage of the curriculum that are highly involved in some specialization areas. For example, in the case of Robotics, Dynamics and Mechanism are

heavily involved. Similarly, Statistics and Computational Intelligence are highly involved in Artificial Intelligence. Table 5 shows the list of courses that show pathways for choosing specialization.

Table 5: Core courses to show pathway of specialization.

Core courses to support the specialisation streams Robotics and Automation, Control and Instrumentation and Artificial Intelligence		
Machine design and Theory of Machines	Instrumentation and Measurement	Statistics and Numerical Analysis
Fundamentals of Robotics	Two control courses	Computational Intelligence

In the revised Mechatronics Engineering curriculum, emphasis has also been put on equipping students with entrepreneurial skills. Three courses namely Engineering Design, Integrated Design Project and Entrepreneurship have been designed in such a way that a group of four to five students will work for three consecutive semesters on building a prototype of a product starting from market survey until the scheme of commercialization. In line with the newly introduced *Sejahtera* Academic Framework in IIUM, the element of Islamic ethics has been incorporated into selected courses, including Robotics and Computational Intelligence to inculcate responsible use and design of the technology in this field in the perspective of Islam. A designated course on Sustainability Development to be taken before Engineering Design is also introduced as a university required course to discuss related issues, policies and practices for holistic product and service development considering multiple stakeholders.

3. Conclusion

The revised Mechatronics Engineering curriculum at IIUM has been designed to equip all graduates with core competencies that would lead to smart product design and development capabilities. Specializations in three crucial fields - Robotics and Automation, Control and Instrumentation, and Artificial Intelligence have been introduced to help students cope with the advanced technologies of the future. Integration of software and hardware at course level along with three dynamically designed courses in consecutive semesters to expose students to entrepreneurial skills have also been incorporated. Islamic ethics and values have been integrated inside courses like AI and robotics for practicing Mechatronics Engineering in a better way.

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