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# Embedding technopreneurship with mechatronics engineering in outcome-based curriculum development for postgraduate education in Malaysia

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ABSTRACT: This article describes the curriculum design of a new postgraduate degree programme in mechatronics at the Universiti Teknologi MARA, Malaysia. The main objective of this postgraduate programme is to address the country's need for producing qualified and skilful mechatronics-trained engineers with entrepreneurial skills. Therefore, one of the programme's educational objectives is to build tomorrow's technopreneur leaders. The needs of the students, industries and other stakeholders of this programme will also be highlighted in the development of the programme educational objectives and programme outcomes. Data and analysis of the market survey conducted from both the industry and student perspective will be presented. The curriculum structure of the programme to accomplish the programme outcomes will also be discussed in this article.

Keywords: Outcome-based education, mechatronics, curriculum development, technoprenuer, entrepreneur, postgraduate programmes

## INTRODUCTION

The Mechanical and Electrical Engineering programme at the Universiti Teknologi MARA has emerged since the early 1940s, when it started as an advanced diploma programme. In 2001, the Faculty of Engineering began offering the Bachelor degree programme which included a concentration in mechatronics, robotics, automation, machine vision and other technical electives. Due to the overwhelmingly positive response of students to the electives offered, the industry need and the government demand for a mechatronics course, the Faculty was required to develop a separate Master of Science in Mechatronics. In May 2011, the Academic Board from the Faculty of Mechanical Engineering approved the establishment of the Master of Mechatronics with the integration of entrepreneurship knowledge in the curriculum. The programme will be made available to students in 2012.

## THE NEED FOR TECHNOPRENEURSHIP KNOWLEDGE IN THE OUTCOME-BASED APPROACH

The education of engineers must be a multi-frontal effort. The fundamentals of engineering must be instilled into the student. The knowledge of how to manage an enterprise must be taught and the practical method of problem solving must be applied. The engineer who barely knows how to take his or her theory out of academic idealism progresses to being someone who is a master craftsman. They become a manager of an enterprise with several roles. They must train new engineers, must operate the engine correctly, and they must review the economics of the enterprise. They must have technical, economic and people skills - not a commonly found combination. It is easy to find two of the three skills in one person; but it is difficult to fine all three skills in one person [1]. Therefore, there is a need to address this issue in the design of a new curriculum.

The need in the design of the new curriculum is to make a genuine shift within the engineering education system from the conventional prescriptive-based system towards an Outcome-Based Education (OBE) system [2]. In addition to that, it is the Malaysian Prime Minister's vision that Malaysia should become one of the more successful industrial nations in the developing world and be able to secure the future by successfully steering Malaysia into the new economy.

The Prime Minister has another challenge and that is to create a better environment for technology entrepreneurship or technopreneurs in Malaysia. Therefore, it is the aim of this research proposal to embed in the postgraduate curriculum realistic training to encourage and develop technopreneurship in potential postgraduates. This would enhance their

contributions to the economy by equipping them with the knowledge of the processes and mechanisms by which new ideas can be commercialised in the market, whether within an organisation or as an independent entrepreneur.

It is a new practice in Malaysia that all undergraduate programmes should incorporate OBE elements in the curriculum. Even though it is not a government requirement that OBE be included in postgraduate education, it is timely for the faculty to embark on this shift towards OBE with integrated entrepreneurship skills and to embed it in the curriculum for its new proposed postgraduate-level engineering programme, the Master of Science (MSc) in Mechatronics Engineering.

The new programme will be developed by designing the curriculum backwards by first identifying the major outcomes as the focus and linking planning, teaching and assessment decisions directly supporting these intended outcomes, as shown in Figure 1 [3][4]. The new developed programme will have a more directed and coherent curriculum so as to produce strategic thinking technoprenours, who will have the skills to succeed in a rapidly changing global business environment. This will provide an avenue for students to compete in the global business area and emerge as successful future entrepreneurs [5]. The main design objectives of this new programme can be summarised as follows:

- To carry out unprecedented investigation on the level of implementation, and development of mechatronics in Malaysian industries and universities.
- To address the industry and country's need for qualified and skilful mechatronics-trained engineers with entrepreneurship skills.
- To propose a novel outcome-based educational model for the mechatronics postgraduate programme and its impact on student learning, curriculum development and assessment.

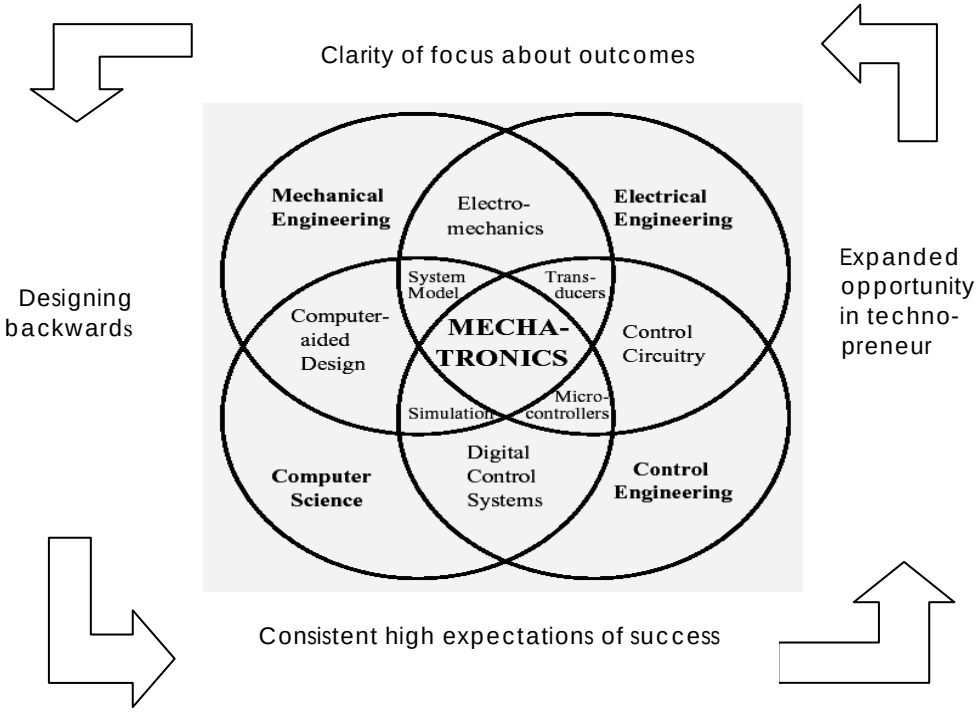


Figure 1: Correlating mechatronics with the basic principles of OBE.

UNDERLYING PRINCIPLES IN THE DESIGN

The key underlying principles in the design of the outcome-based curriculum reflects the requirements and the needs of the main stakeholders of the postgraduate programme, namely the university, industry, students and parents, and the government as illustrated in Figure 2. The initial programme educational objectives (PEOs) were exact duplicates of the five PEOs for the Bachelor of Engineering degree.

However, based on inputs from stakeholders, the six PEOs were modified and further developed. The thirteen programme outcomes (POs) were then formulated to support the PEOs. The PEOs have been formulated to be consistent with the mission and vision of the university.

In addition to the above underlying principles in the design of the outcome-based curriculum, the programme must also abide by the statutory regulations set by the university. The set of guidelines adopted for the content of the new postgraduate programme can be summarised as follows:

- The curriculum is packaged as a three semester (one and half year) programme.
- The programme must have a minimum of 41 credit hours (1 credit is equivalent to 1 hour of lectures or 2 hours tutorial/laboratory work).
- The curriculum is to be built upon the foundation of a balance between electrical, mechanical and information technology (IT).
- The programme must instil technopreneurship knowledge in the students.
- The curriculum must include courses from the health sciences and pharmaceutical faculty.

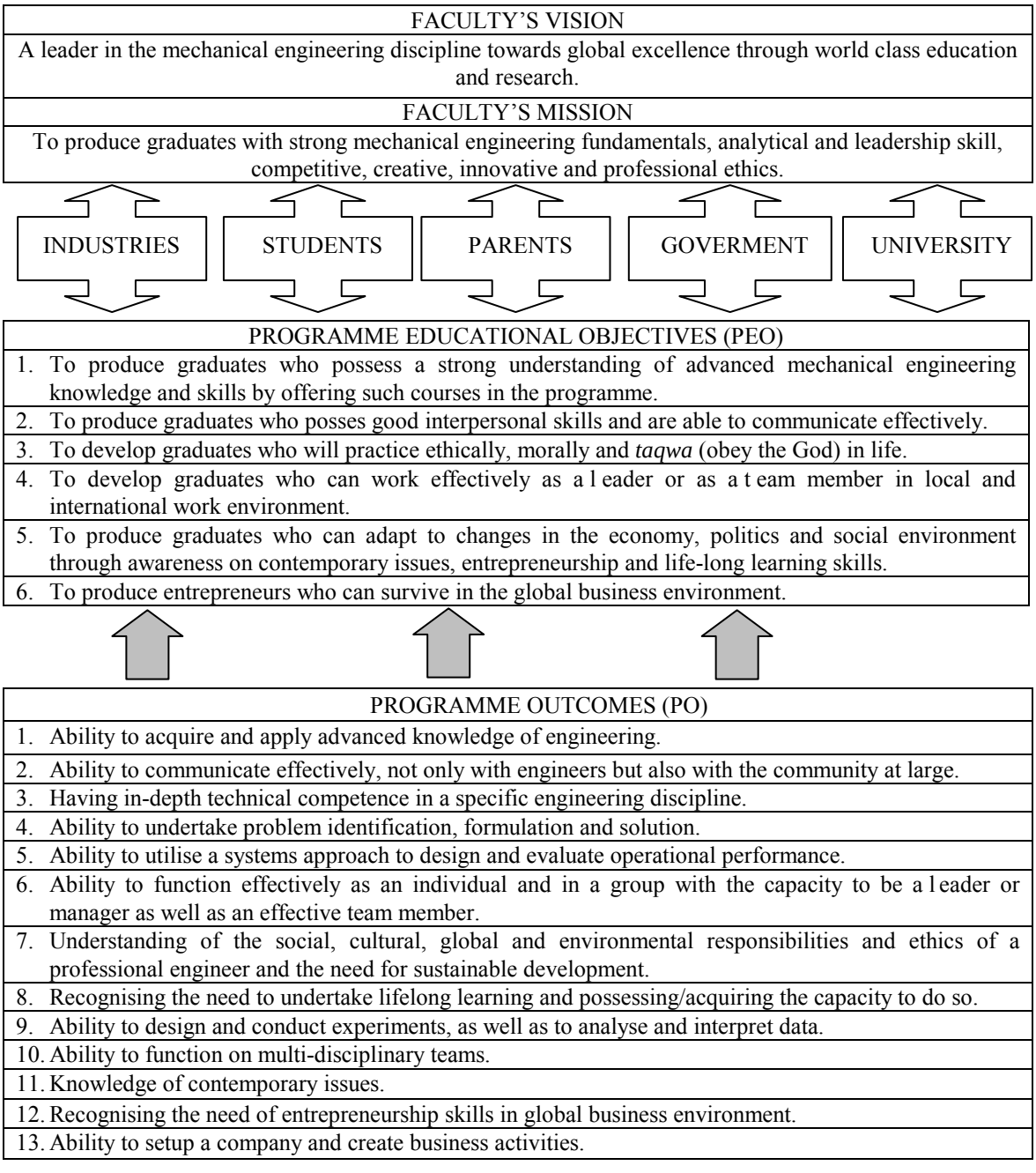


Figure 2: Interaction of stakeholders with the vision, mission, PEO and PO.

## DATA AND ANALYSIS OF MARKET SURVEY

Two hundred mail surveys (questionnaires) were distributed to companies in the states of Selangor and Kuala Lumpur. The selected companies were from the mechanical specialisation area (e.g. manufacturing electronics, network power, heavy metal manufacturing, etc) because of their relevance to mechatronics applications.

The main goal of this survey was to understand the competitive and economic (job) environment, to gather information on the job market for the graduates of this new programme. The purpose was also to determine the educational needs of the key stakeholders which, in this case, were the industries. The questionnaires were structured to gather information to guide the new programme development in terms of the suggested course's relevancy to the organisation and industrial needs.

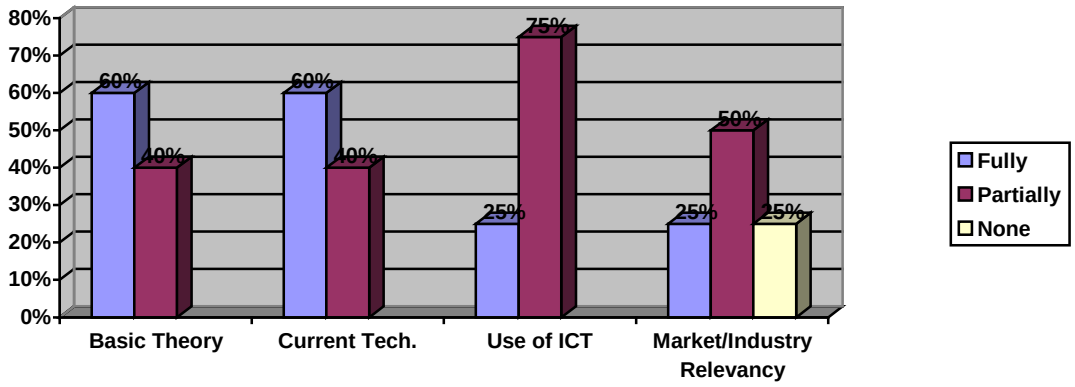


Figure 3: Fulfilment criteria.

One of the questions asked in the survey was on the fulfilment of criteria such as the basic theory, current technology, use of ICT, market and industry relevancy. From Figure 3, 40% respondents replied partially for the coverage on basic theory and current technology aspects in the programme, while 60% respondents replied fully. For the use of ICT, 25% respondents replied fully and 75% respondents answered partially. For the market/industry relevancy, 25% replied fully, 50% respondents replied partially, and 25% respondents chose *none* as their answer.

About 100 survey forms were distributed to students of the exiting Bachelor Engineering (Hons) mechanical programme, as well as those from the Bachelor Engineering (Hons) electrical programme as these students are potential candidates to enrol in the programme. The questionnaires were delivered to them during classes. The questions were closed-ended and very brief (a few questions taking five or fewer minutes). The purposes of conducting this survey were:

- To profile the respondents that are most likely to enrol in the proposed programme.
- To understand the educational needs of the respondents.
- To gather information to guide development of the new programme (preferred mode of study, location, etc).
- To determine the viability of the new proposed programme.

Approximately 93% of the candidates expressed the opinion that the Faculty of Mechanical Engineering should offer its own postgraduate programme in mechatronics engineering and the preferred mode of study is one based on coursework and research.

OUTCOME-BASED CURRICULUM DEVELOPMENT

Since the core academic staff come from the Faculty of Mechanical and Electrical Engineering, the curriculum was designed to strengthen students' knowledge in the core courses with a total of 18 credit hours. The students have to take specialised elective courses, which are offered as specialisation in robotics and automation, intelligent control, health sciences or pharmaceutical sciences. The three electives in the specialisation area total nine credit hours.

The proposed curriculum includes three integrated projects and the topic chosen in the project must be related to the specialisation area. In the first integrated project, students need to prepare themselves by carrying out laboratory work and a literature review relating to their final semester project. The project must be proposed and defended at the end of the first semester. In the second semester research project, students are required to master the research tools that are required in their final semester project. Examples of research tools are software familiarisation such as Matlab, CAD, machine vision software, development of the test-rigs, and other preliminary works for use in their final semester project.

In Research Projects I and II, one integrated project will be given to students in each semester and this will be a teamwork effort. The final semester research project is based on individual work and the work is mainly on data collection, data analysis and improvement of the results of the research work. The lower semester integrative project is a prerequisite to the upper semester research project, amounting to 11 credit hours. A detailed curriculum structure is shown in Figure 4.

The Mechatronic Technopreneurship course is offered in the third semester. In this course, students will be taught about the knowledge of business organisation and management, accounting and marketing, business proposals and business financial issues. Case studies will be used to strengthen their soft skills and enhance their business strategy. This course is a co-requisite to their final year project and the assessment is based purely on reports and presentations. In the technepreneurship course, students are required to write up a proper business plan pertaining to the commercialisation aspect of their research work in the final year project.

| Component | Semester 1<br>Courses | Semester 2<br>Courses | Semester 3<br>Courses | Total Credits = 41 |
|---|---|---|---|---|
| University's requirement | 1. Research Methodology (Compulsory) | 1. Thesis Writing & Presentation Skills (Compulsory) | - | 0 |
| Core | 1. Programming *[3 credits]*<br><br>2. Microcontroller Applications *[3 credits]*<br><br>3. Digital Control *[3 credits]*<br><br>4. Design Method and CAE *[3 credits]* | 1. Mechatronic System Design *[3 credits]*<br><br>2. Robotic Systems *[3 credits]* | 1. Dissertation (Integrated Project Work) *[9 credits]* | 27 |
| Non Core | 1. Research Project I *[1 credit]* | 1. Research Project II *[1 credit]* | 1. Mechatronic Technopreneurship *[3 credits]* | 5 |
| Electives | 1. Select any one *[3 credits]*:<br><br>(i) Factory Automation<br>(ii) Manipulation and Industrial Control<br>(iii) Instrumentation & Sensors<br>(iv) Machine Vision<br>(v) Industrial Design and Human Factors | 1. Select any two *[6 credits]*:<br><br>(i) Factory Automation<br>(ii) Manipulation and Industrial Control<br>(iii) Instrumentation & Sensors<br>(iv) Machine Vision<br>(v) Industrial Design and Human Factors | - | 9 |

Figure 4: Curriculum structure for Masters of Science (Mechatronics).

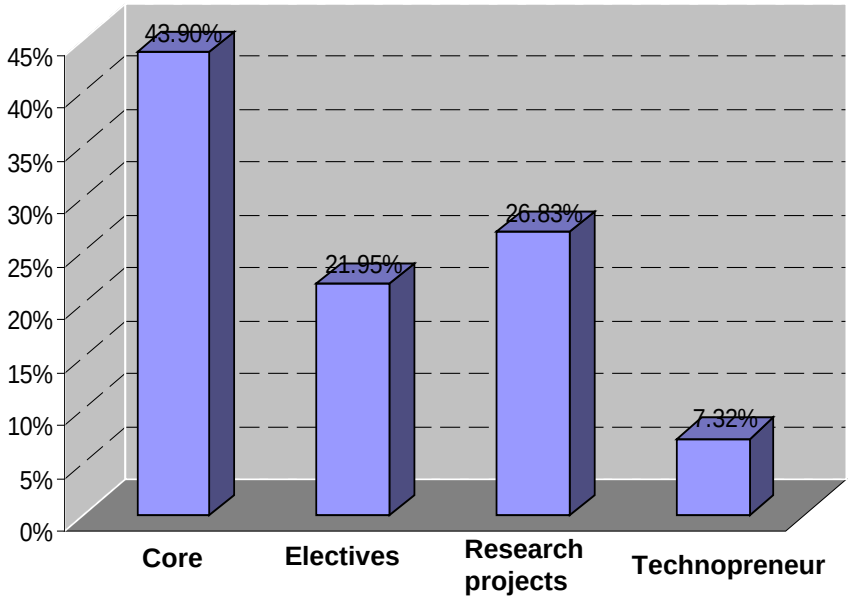


Figure 5: Percentage of credit hours.

In addition to the core and elective courses, all students are required to take courses that are common to all postgraduate students from all disciplines. These courses are research methodology and thesis writing, and a presentation course. The distribution of the credits hours on key components such as the core, elective research project, and technopreneurship courses are shown in Figure 5.

## CONCLUSIONS

Many factors have the potential to reshape or redirect the engineering world. Significant changes in the responsibilities and expectations of engineers have occurred over the last ten years and will continue for the next ten. To meet the challenge of employability or marketability, engineers will still be judged by what knowledge and skills they have acquired from their education. They must equip themselves with technical expertise or risk being phased out.

Moreover, engineers graduating in mechatronics, outside the technical knowledge, their skills must include components such as business, soft skills and interdisciplinary mechatronic knowledge. Given the rapid advancement of mechatronic technology, specific job training will not prepare engineers for an entire career, but they will need additional skills such as tenhnopreneurship skills along with the ability and desire for lifelong learning. Therefore, engineers will need to have technopreneurship skills to stay employable. It is hoped that this new postgraduate course will consolidate the following aspects:

- Creating a t echnopreneurship culture and increasing the supply of new entrepreneurs through a mechatronic project-based programme.
- Driving a culture change towards OBE for learning in engineering programmes that can anticipate real benefits and improvement.
- Enhancing relationships between university and industries, leading to useful linkages and seamless collaboration.

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## BIOGRAPHY

Muhammad Azmi Ayub is an Associate Professor of mechatronics in the Faculty of Mechanical Engineering at the Universiti Teknologi MARA, Malaysia. He received his Bachelor of Engineering (Mechanical) degree from the University of New South Wales, Sydney, Australia, in 1989, and MSc and PhD (Mechatronic and Optical Engineering) from Loughborough University, Leicestershire, United Kingdom in 1996 and 2004 respectively. He was Deputy of the Faculty from 2004 to 2009. Currently, he is the Head of the Research Centre for Humanoid Robot and Biosensor. His research interests include mechatronics, visual feedback control of mechanical systems and engineering education.

Roseleena Jaafar is an Associate Professor in the Faculty of Mechanical Engineering at the Universiti Teknologi MARA, Malaysia. Previously, she was a senior lecturer at Ngee Ann Polytechnic, Singapore. She received her diploma in mechanical engineering in 1987 from Brighton Polytechnic, UK, the Bachelor of Engineering (Hons) degree in mechanical engineering in 1991, and Masters of Science in computer integrated manufacturing in 1992 from Loughborough University of Technology, United Kingdom. Her areas of expertise include robotics and automation, manufacturing processes and outcome based education. She is a member of the Board of Engineers Malaysia.

Associate Professor Zulkifli Abd. Majid is presently attached to the Faculty of Electrical Engineering at the Universiti Teknologi MARA (UiTM), Malaysia. His career spans more than 20 years with the UiTM since 1991. He was involved in curriculum development (BEng and MSc). He graduated from Hanyang University, in the Republic of Korea with the BSc degree (Honours) and the Master Degree both in Electronics Engineering. Currently, Zulkifli is a coordinator at a Faculty's Microwave Technology Centre. He has served as Deputy Dean of the Faculty. His current research activities are failure analysis, circuit design and low power IC design.