ASEAN JOURNAL OF ENGINEERING EDUCATION

VOLUME 7 I ISSUE 1 I 2023

UTM
UNIVERSITI TEKNOLOGI MALAYSIA

ASEAN JOURNAL OF ENGINEERING EDUCATION

VOLUME 7 I ISSUE 1 I 2023

Editorial Boards

Contents

Validation Assessment of a Relationship between Teaching Practice and Professional Engineer Certification: A Pilot Study and Survey Evaluation

Article history
Received
22 February 2023
Received in revised form
25 April 2023
Accepted
9 May 2023

Nurul Asmak Md Lazim[a]***, Rini Asnida Abdullah***[a,b]***, Sharifah Hafizah Syed Ariffin***[a,c]***, Sitti Asmah Hassan***[a,b]***, Narina A. Samah***[a,d]***, Mohamad Hidayat Jamal***[a,b]***, Siti Norafida Jusoh***[a,b]***, Hadijah Jaffri***[a,d]*****
[a]*Center for Advancement in Digital and Flexible Learning (UTMCdex), Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia*
[b]*Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia*
[c]*Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia*
[d]*Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia*
**hadijahjaffri@utm.my*

Abstract

Engineering courses are regarded as challenging that require a solid foundation in mathematics, physics, and chemistry as well as critical thinking and problem-solving skills. Inadvertently, these components present challenges to the teaching and learning (T&L) process in the classroom and up to the author's knowledge, there is no study reported in relation with professional engineer certification and UTM-NALI teaching practices. Therefore, this study examined the relationship between engineering educators with professional engineer certification and their teaching methods in particular UTM-NALI. This is a pilot study with small respondents and to validate survey questions for assessment in larger samples. Additional questions regarding the obstacles, recommendations, and example characteristics are also offered. The data on the performance of students and the distinction between certified and uncertified lecturers are discussed. Through their participation in T&L in the classroom, lecturers with and without professional engineer qualifications can be seen experiencing the effects of the NALI model. Even though hybrid classes that were conducted to help pupils catch up with previous Malaysian MCOs (movement control orders) can limit this study, through the test findings, this study can be carried out for larger samples to get congruent conclusions of proposed research.

Keywords: NALI, Professional Engineer Certification, Teaching Practice, Teaching and Learning, Validation Assessment.

Introduction

Engineering courses are notoriously challenging, and students were required to learn the fundamentals of mathematics, physics, and chemistry. To achieve the demanding curriculum requirements that must be met in a short amount of time, the content of engineering courses necessitates those students be adept at higher-level reasoning skills, such as problem-solving. These variables indirectly complicate the teaching and learning (T&L) process in the classroom. Teaching and learning (T&L) for engineering courses demands unique attention and inventive initiatives to prepare graduate engineers for the challenges they will face in the profession. Instructors that can provide coursework and relate it to the job of actual engineers will be able to assist students in better comprehending course material (Ditcher,2001).

However, it is also emphasised that a person's notion of learning will differ and have a substantial impact on their approach to learning, particularly in the classroom. Prior phenomenological study revealed that when learners are asked to describe their understanding of learning, their responses may be categorised into five distinct conceptions of learning (Marton et al., 1993): 1) acquiring new information, 2) memorization and reproduction, 3) acquiring applicable knowledge and abilities, 4) understanding; and 5) interpreting reality in a novel way.

Universiti Teknologi Malaysia's UTM CDex (Center for Advancement in Digital and Flexible Learning) has fostered the New Academia Learning Innovation (NALI) in teaching and learning (T&L). This framework for learning is a more productive, innovative, and creative approach to education (Ujang, 2012). This concept differentiates between two categories:

Md Lazim, N.A., Abdullah, R.A., Syed Ariffin, S.H., Hassan, S.A., A. Samah, N., Jamal, M.H., Jusoh, S.N., Jaffri, H. (2023), Validation Assessment of a Relationship between Teaching Practice and Professional Engineer Certification: A Pilot Study and Survey Evaluation, *ASEAN Journal of Engineering Education*, 7(1), 1-11.

Pedagogy/Andragogy learning strategies and Digital Resources. There are eight strategies that fall under the Pedagogy/Andragogy learning strategies which are Outcome-Based Education (OBE), Case Study Teaching, Problem-Based Learning (PBL), Scenario-Based Learning (SBL), Peer Instruction, Service Learning, Job Creation, High-Impact Educational Practices (HIEP), Conceive, Design, and Implement and Operate (CDIO). For the learning digital resources or also regarded as learning material platform, there are six types which are UTM Open Courseware (OCW), UTM MOOC, UTM-MIT BLOSSOMS, Video of Exemplary Professionals, Student-to-Student Edutainment, and UTM e-Learning (Alias and Aris, 2016).

However, up to the author's knowledge, there is no study reported in relation with professional engineer certification and UTM-NALI teaching practices. Therefore, this study was conducted to examine the relationship between engineering educators with professional engineer certification and their teaching methods in particular UTM-NALI. This is a pilot study with small respondents and the study was carried out to validate survey questions for assessment in the next study (larger sample).

Literature review

The world 21st Century

The world in the 21st Century is relying more on technological transformation and digital explosion as the beginning for Industry 4.0 that will focus on a combination of physical, digital, and biological systems. This change will influence our lives, businesses, and industries which in turn alter the need for skills, talents and jobs (Helmi et la., 2019, Canbulat et al., 2020, Chen, 2021, Diocos, 2023). Thus, it is important to improve our education approach for future needs.

The World Economic Forum in 2016 has highlighted the skills needed in the 21st Century as shown in Table 1.

Table 1: Skills needed in 21st Century (Helmi et al., 2019)

Foundational Literacies	• Literacy • Numeracy • Scientific literacy • ICT literacy • Financial literacy • Cultural and civic literacy
Competencies	• Critical thinking/ problem solving • Creativity • Communication • Collaboration • Life-long learning
Character Qualities	• Curiosity • Initiative • Persistence/grit • Adaptability • Leadership • Social and cultural awareness

New Academia Learning Innovation (NALI) model

New Academia Learning Innovation (NALI) was introduced in 2013 (Figure 1). NALI highlights the concept of entrepreneurship in academics which emphases are on productivity, creativity and innovation (Ujang, 2012). There are three main objectives of the NALI initiative which is to align UTM teaching and learning models, activities, materials, environments and systems with the Malaysian National Higher Education Strategic Plan, the needs of employers and the requirements of accreditation bodies. In addition, the initiative is also aimed for UTM academics to emulate best teaching and learning practices from the World's best universities. To suit with UTM's identity, the last objective is targeted in developing UTM's own identity related to teaching and learning models, activities, materials, environments and systems.

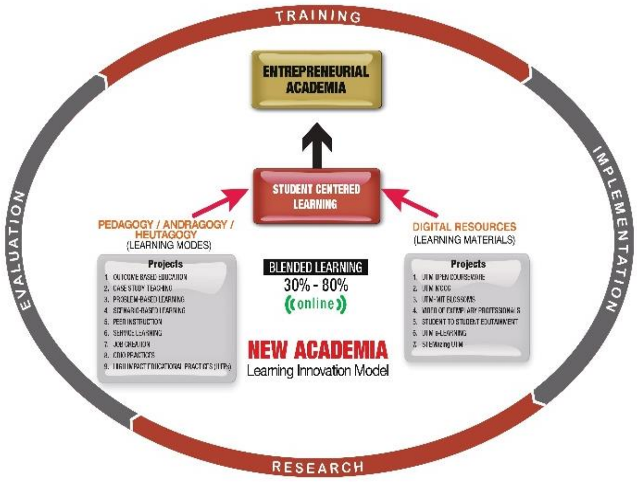


Figure 1. UTM NALI model (UTMCdex, 2023)

i) Outcome-Based Education (OBE)

A technique called outcome-based education (OBE) involves designing the curriculum and including instruction that is focused on the results of the instruction (in this context-lecturers). In a nutshell, it is the abilities that a student must display after receiving training (Chong, 2008). Through a variety of measurement instruments, this can be evaluated and assessed. OBE practitioners must concentrate their techniques on (i) planning, (ii) delivering, and (iii) assessment in order to get the intended results.

In example, OBE can be assessed through three methods namely Program Educational Objectives

(PEO), Program Outcomes (PO) and Course Outcomes (CO). PEO was measured through employer satisfaction survey (yearly), alumni survey (yearly), placement records, and better education records. PO was coming with CO. CO was assessed from Mid - Semester and End Semester Examinations, tutorials, assignments, project work, labs, presentations, employer/alumni feedback, etc, (Japee and Oza, 2021, Syeed et al., 2022).

ii) Case Study Teaching

This approach involves conducting a lengthy, in-depth study of a business or situation that is closely related to reality and has problems and conflicts that need to be resolved. This approach has the benefit of teaching students how to organize their thoughts and conduct conversations based on the facts, which makes their arguments more well-organized, reasonable, and credible.t

Case study is a traditional teaching method by the Harvard Business School (HBS). The class discussion basically starts with pre-class arrival, opening the case, sequences of questioning, listening and responding, to transitions and finally closing the case. To evaluate the students, some of the techniques suggested by Garvin (2009) include identifying students':

- ability to work independently and lead the class discussion as they progress in learning
- engagement with the issues and enthusiasm about the discussion
- skill at applying previous learning in subsequent lessons

iii) Problem-Based Learning (PBL)

A type of active learning known as problem-based learning (PBL) pushes students to "learn to learn," working cooperatively in small groups with the instructors serving as facilitators to find solutions to problems from the real world (Hmelo-Silver and Cindy, 2004, Duch, 1995). PBL's major objective is for students to work cooperatively and creatively to solve a problem (Abed et al., 2023).

PBL is differed than problem solving. In problem solving exercises, students are believed to have the knowledge and skills required to solve the problems. Students will apply the existing knowledge to formulate hypotheses to guide them for more investigation to the problem. But, in PBL, students are encouraged to analyse a problem, or a case presented to them and from there, they make a problem list and formulate possible hypotheses or explanations in order to perform further investigation to get more knowledge about the problem. PBL can help students master a number of useful skills in learners including critical thinking, communication and cooperative or teamwork skills. Students also have the ability to analyse and solve real-world problems and apply classroom learning to address complex problems outside the classroom (Duch et al., 2001).

iv) Scenario Based Learning (SBL)

In order to encourage deep learning and awareness, Scenario Based Learning (SBL) involves participants in actual critical occurrences where they are required to weigh a variety of considerations, make decisions, and reflect on the results and what they have learnt from the events. In essence, SBL is focused on employing scenarios to augment the teaching of knowledge that calls for critical thought on the subject matter that was previously covered in lectures with the students (Thomsen et al., 2010).

Students are the focus of SBL approach; they required to partake in the construction of their knowledge; participate actively in the learning process, which almost similar situations (contextual), practice to make appropriate decisions and reflect on what was learnt related to their professional practice (Errington, 2011, Zitouniatis et al., 2022).

v) Peer Instruction

Peer Instruction (PI) is an active learning strategy in which students engage in conversation with peers and the instructor. Additionally, PI draws on the ideas of cooperative learning as students collaborate with one another to learn, promoting participation-based active learning. By explaining course concepts in their own terms, students are able to use metacognitive techniques to improve their learning (Rivadeneira and Inga, 2023).

Students are asked to individually prepare a 15-minute lesson to teach a small group of their peers and has the right to choose their topic. These lessons are not solely for student presentations. Students can apply the creative process to an educational context, develop a lesson plan which including pertinent content in an engaging activity, and a mechanism for summative assessment (e.g., discussion, individual or group quiz, quality of activity outcome). Before completing this assignment, students are given a template to create a lesson plan and a brief (5-10 minute) description of the assignment during a class period (Jahnke and Lindgren, 2021).

vi) Service Learning

Service learning (SL) is a teaching and learning approach that promotes civic duty and integrates classroom knowledge into meaningful community service (Felten and Clayton, 2011). In order to enhance learning, promote civic responsibility, and strengthen the communities in which learners live and work, SL incorporates community service initiatives with academic courses. Fieldwork, applied service-learning research, and other academic activities are some of the methods used by SL to include students in project-based service endeavours with neighbourhood partners. Studies must attest to its capacity to considerably enhance student learning (Warren, 2012, Mamat et al., 2019).

After completing the task with community, students are evaluated based on the impact, successes, and challenges of the programme. This will help the SL experience in mutually beneficial exchange of knowledge and resources (Alias and Aris, 2016).

vii) Job Creation

A teaching and learning strategy called Job Creation (JC) emphasises active and project-based learning. JC places a strong emphasis on the knowledge acquired via working on a real-world tender project that was acquired through the bidding process or project proposals. It gives students the chance to create employment prospects while putting entrepreneurial principles into practise. Additionally, it exposes students to the actual world of project management and implementation, which will provide them the skills and experiences they need to be ready to take on real challenges in the workplace.

For example, in UTM, a total of 24 projects were offered to the student companies for bidding. after project approval by the company, students can register for Job Creation courses at the Centre for Co-Curriculum and Service Learning (CCSL). To implement the course, students will have to fulfil the program requirement which including attending talks, registering the company, preparing tender documents, evaluating papers and presenting to bid for projects. Students also will fill out written quotation and provide the necessary paperwork to be submitted before the closing date. Students will then be invited to present their paper quotes for evaluation purposes (Alias and Aris, 2016).

viii) High-Impact Educational Practices (HIEPs)

Research has demonstrated several educational strategies known as High Impact Educational Practices (HIEPs) to have a significant impact on student progress. HIEPs can contain a variety of learning tactics, including problem-based learning, service learning, project-based learning, capstone courses, field experiences, and other active learning strategies, according to the national survey on student engagement (National Survey of Student Engagement, 2007, Arikan et al., 2022).

The elements in HIEPs includes First Year Seminar/ Experience (FYS), Capstone Project (CAP), Internship (IN), Empirical Research (ER), Collaborative Assignment and Project (CAS), Diversity/ Global Learning (DGL), Service/ Community Based Learning (SBL), Interdisciplinary Approach to Assessment (ID) as well as Intensive Academic Writing (IAW). However, the implementation process is not a fixed procedure for HIEPs (Alias and Aris, 2016).

ix) Conceive, Design, Implement and Operate (CDIO)

Conceive, Design, Implement, and Operate (CDIO) is a project-based instructional method that makes use of instructional events where learning takes place through the development of a system, process, or product (Edström and Kolmos, 2014, Souppez and Awotwe, 2023). The different steps involved in developing a product, method, or system are represented by the CDIO approach.

To implement CDIO, mastering the principle CDIO is a must, followed by the focus of the intended learning outcomes of the engineering program. From here, the context, program goals, and specific objectives for learning can be established. Then, the curriculum, use of design-implement experiences and workspaces, approaches to teaching and learning, and assessment and evaluation practices can be evaluated (Alias and Aris, 2016).

x) UTM Open Courseware (OCW)

OpenCourseWare (OCW) is a term used to describe a free and open digital publication of excellent university-level educational materials that are arranged as courses and contain content, course design resources, and assessment tools. OCW is freely available and openly licenced on the Internet at all times and from any location (Vladoiu, 2011).

Often, the instructors are reluctant to join this as they have to share their notes, worrying the copyright issue. However, as the committee were selected by vice chancellor, they are allowed to make a decision to use the same software used in the university's e-learning system as a platform for the OpenCourseWare website. The reason is that they are trying to avoid technical difficulties among instructors who will be involved in developing the learning materials. In OCW, there are Course Selection, Intellectual Property Issues, Formatting of figures and multimedia materials, Content Design, Review by evaluators, Correction by Author, Final Editing, and Publication (Alias and Aris, 2016).

xi) UTM MOOC

Massive Open Online Courses, sometimes known as MOOCs, are free web-based distance learning courses intended for the participation of sizable numbers of students who are geographically distributed. The open educational resources (OER) movement gave rise to the term MOOC, which was first used to describe online courses in 2008. The UTM MOOC is created using five fundamental phases, including copyright, course setup, course design, course development, and course implementation. Each stage has been carefully created to meet the requirements of the course structure and to offer flexibility in developing active and interactive user engagement and learning methodologies.

As for UTM MOOCs, the course consists of multiple choices, true or false, text input and also online activities. The online activities are activities where the students were asked to solve a set of questions and the time taken for the students to finish the questions will be recorded (Alias and Aris, 2016).

xii) UTM-MIT BLOSSOMS

A video-based learning tool called BLOSSOMS is a supplement to the current curricula. Due to the teaching duet pedagogy method, which divides the video lesson into segments with learning activities in between and is led by subject-matter specialists, it differs from typical video-based learning. The major goal is to improve understanding of abstract topics, particularly in the areas of science, mathematics, and engineering. Launched on 8th January 2013, the BLOSSOMS project is a blended learning system for studying Science, Technology, Engineering, and Mathematics (STEM) courses in partnership with Massachusetts Institute of Technology (MIT), USA.

In order to produce BLOSSOMS video, UTM-MIT has highlighted 10 processes in the production which are; the development of concept, architecture and pseudo script documents; a series of evaluation from UTM and MIT content experts; thorough discussion with CTL video production team before video shooting; shooting and editing video; and approval from MIT for each level (Alias and Aris, 2016).

Meanwhile for teaching and learning, BLOSSOMS video may contain several segments and several learning activities. In T & L, BLOSSOMS lesson adopts a blended learning approach, where students were asked to watch a video (normally four minutes maximum) in the class. Then, the class will do class activities based on video and assisted by lecturers. The video will be watched again for next topic and it is repeated with different video until learning objectives were achieved. Normally, it took up to 50 minutes to finish the class (Alias and Aris, 2016).

xiii) Video of Exemplary Professionals

A collection of videos called Video of Exemplary Professionals (VoEP) shows the expertise and abilities of professionals from all around the world in a variety of professions. VoEP enables viewers to investigate the contributions made by authorities in a particular subject to creativity and cultural education. Experts' presentations may have an effect on students' learning as well as the lives of their families and communities.

To implement this method, lecturer will choose respective video for certain topic, and choose for teaching methods that suit the topic. To assess the students, lecturers will observe on high performance thinking minds among students based on the selected video, the best practice in selecting video, critical thinking and mutual communication between lecturers and students (Alias and Aris, 2016).

xiv) Student-to-Student Edutainment

Since 2013, UTM has made the decision to include edutainment as one of the initiatives in the New Academia Learning Innovation Model. This project demonstrates how to make a class enjoyable and exciting by fusing educational and entertaining aspects. Students' reception can be improved in this way, and learning is made more efficient. The goal of educational entertainment is to motivate pupils to discover new things through interaction, experimentation, and repetition. The majority of the time, students experience the excitement without realising they are also learning.

To achieve this method, students will get involve in competition. Normally, the competition will be held in second semester for every academic session. The purpose is to see student's critical thinking and performance (Alias and Aris, 2016).

xv) UTM e-Learning

The Moodle open source LMS is used by UTM for e-Learning delivery. Students and educators can access this online learning platform using their regular, school-based login credentials (Oye et al., 2012). Along with assessment resources like assignments and quizzes, students have access to course materials, lecture notes, and communication tools.

e-Learning in UTM focuses on the achievement of 30 % of information (A), resources (B), activities (C), assessment (D), as well as active index (E). To assess, the individual learner variables were focused (physical/demographic characteristics, learning history, affective attributes including learner attitude and learner motivation, familiarity with the technology) as well as environmental variables include (physical LE, subject LE, institutional environment). Other than that, contextual attributes, technology variables and pedagogic variables (accreditation and certification, methodologies, learner support systems, assessment and examination) also considered (Alias and Aris, 2016).

Methodology

Survey research was used in this study involving two groups of samples (**Figure 2**).

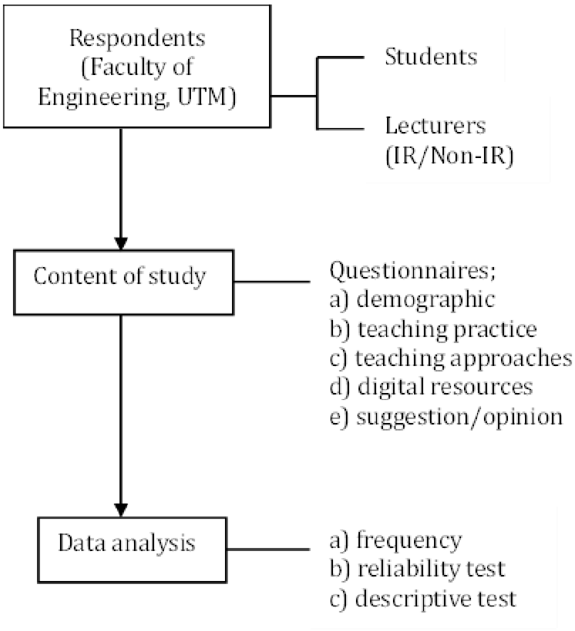


Figure 2. Design of experiment

The first group was students and the second group was lecturers. In specific, nine lecturers with and without professional engineer certification and 168 students from the Faculty of Engineering UTM were selected randomly. List of samples was acquired from the UTM database which contain a list of lecturers and students from the Faculty of Engineering. The research instrument used in this study was adapted from Hamdan et al. (2014). There are few changes have been made from the original instrument to suit with the objectives of the current study. However, the rating scales were retained as the original version using Likert-type scales with a range of 1 to 5 to denote different levels of agreement. The original instrument was meant for assessing UTM lecturers teaching practice. Since this study involved students, some items were adapted to ensure data could be collected from students as participants of this study. Thus, there were two sets of questionnaires were used in this study. There are 46 items including demographic items for the lecturers and there are 38 questions including demographic items for students. In addition, there are two sets of questionnaires in Malay and English prepared in this study. The questionnaire scales of measurement depict the teaching practices among engineering lecturers in the Universiti Teknologi Malaysia (UTM), Malaysia.

Quantitative Data Analysis

A questionnaire was distributed to lecturers and students from the Faculty of Engineering in Universiti Teknologi Malaysia, UTM, Johor Bahru. About nine respondents among lecturers with and without IR participated in this survey and a total of 168 respondents among engineering students answered the distributed questions. Basically, in this study, the questionnaire is consisting of five sections in which part A is for demographic info, part B and C are for teaching approaches, part D is for different types of digital used during teaching and learning and lastly, part E is for respondent's opinion and suggestion. Since the study conveyed of two different types of questions, we performed data analysis for different categories; one for lecturers and another one for the students. The discussion in this study also explained two different kind categories.

Data was analysed with descriptive and inferential statistics by using SPSS software version 16.0. For the first part, descriptive statistics was used to determine sample characteristics for both lecturers and students. Cronbach's alpha was carried out to determine the reliability of the respective constructs and a descriptive test was performed to examine the concept of questions delivered in the survey.

Results analysis

Demographic Analysis

i) Lecturers

There are 13 questions that were demonstrated in part A; demographic info which reflected the respondent's background. Generally, the question is included gender, age, position, school, highest academic qualification, Differentiated Career Pathways (DCP), total years' service in UTM, total teaching experience (including outside UTM), year courses taught, total industrial experience, how do the staff gain the industrial experience, staff professional qualification and years registered with professional qualification. The data analysis obtained from the study is tabulated in Figure 3.

From the figure, female respondents are more than male respondents. Female frequency is 6 (67%) while male frequency is 3 (33%) (question a). For age, most respondents are from 31 to 50 years old (89%), except one more than 51 years old (11%) (question b). All respondents who answered the questionnaire are senior lecturers (56%) and the other balance is from associate professors (44%) (question c). As of the school, most respondents are coming from School of Civil Engineering (89%) and other 11% are coming from School of Electrical Engineering (question d). All the respondents have highest degree academic qualification (100% doctor of philosophy), while their DCP are mostly from research (67%), followed by teaching (22%), and lastly leadership (11%) (question e). They are also mostly taught 2nd year students (78%), followed by 4th year students. This can be seen from Figure 3 (question f). As for industrial experience, most respondents have a great experience. This can be seen that most respondents answered 13 to 120 months industrial experience (67%) (question g). How do they have such great industrial experience? This is from their experience involving consultancy work while working in the UTM (88.9%), and also have working experience with industry before joining UTM (66.7%) (question h). All the respondents also registered with BEM. This can be seen from their chosen answers which 77.8% and 44.4%, respectively (question i). As for their total years registered with professional qualification is mostly 4 to 6 years (67%), followed by a new registration which nominated 22%. This is probably because the registration is yet announced or the registration is within a month (question j).

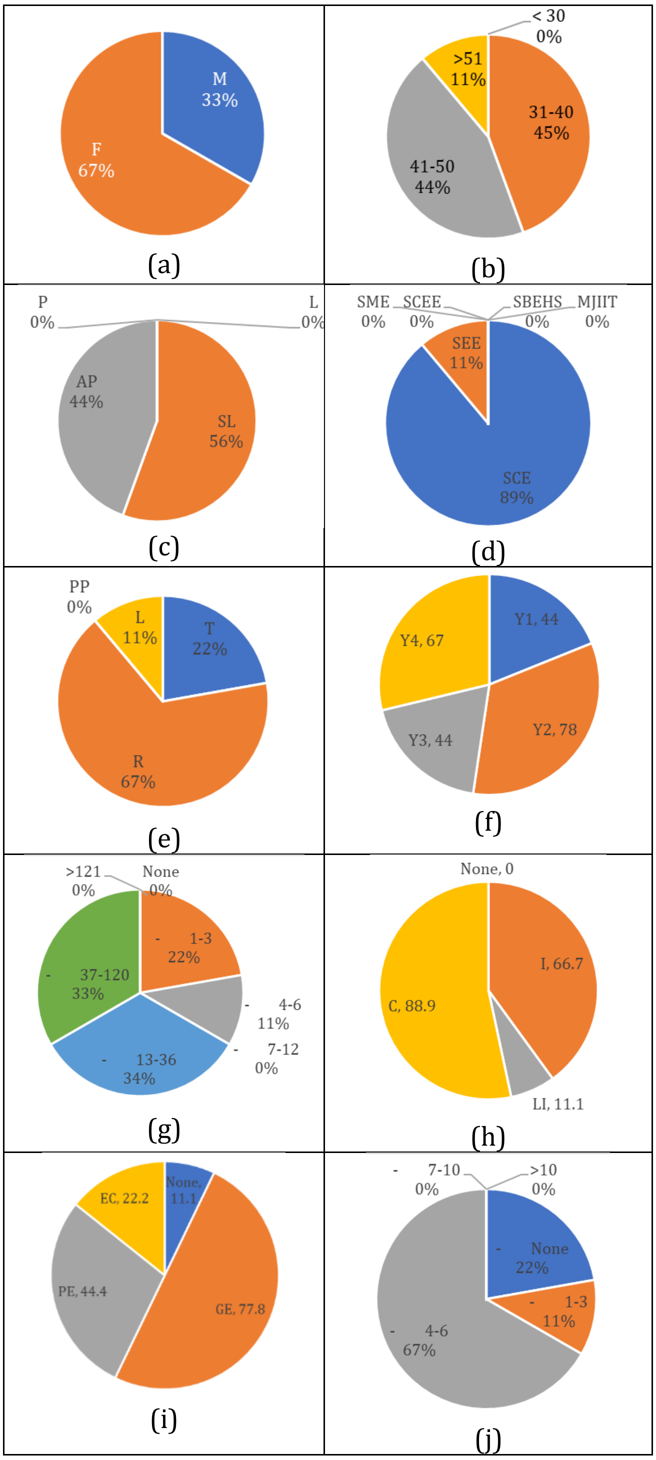


Figure 3. Demographic data for lecturers in UTM

(a) Gender; (b) Age (y.o); (c) Position; (d) School; (e) Differentiated Career Pathways (DCP); (f) Year courses taught; (g) Total industrial experience (mo); (h) How do the staff gain the industrial experience; (i) Staff professional qualification; (j) Years registered with professional qualification (y)

Legends: M- Male; F- Female; L- Lecturer; SL- Senior Lecturer; AP- Associate professor; P- Professor; SCE- School of Civil Engineering; SEE- School of Electrical Engineering; SME- -School of Mechanical Engineering; SCEE- School of Chemical and Energy Engineering; SBEHS- School of Biomedical Engineering and Health Sciences; MJIIT- Malaysia-Japan International Institute of Technology; T- Teaching; R- Research; PP- Professional Practice; L- Leadership; Y1- Year 1; Y2- Year 2; Y3- Year 3; Y4- Year 4; I- Previously worked with industry before joining UTM; LI- Undergone Latihan Ikhtisas; C- Involve with consultancy work while serving in UTM; GE- Graduate Engineer registered with BEM; PE- Professional Engineer registered with BEM; EC- Professional engineer registered with Engineering Council, UK

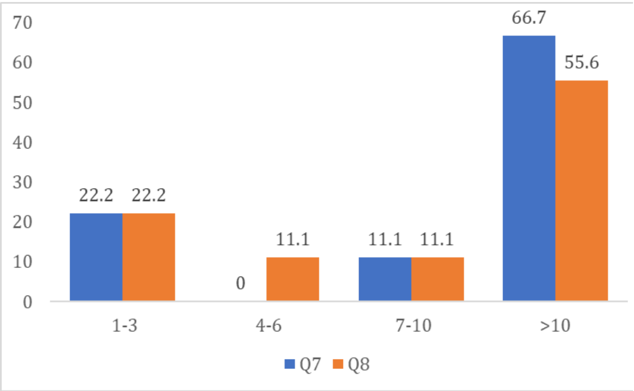


Figure 4. Total service and total teaching experience

(Q7) Total years' service in UTM (y); (Q8) Total teaching experience (including outside UTM) (y)

From Figure 4, most respondents have more than 10 years of service in UTM (66.7%) with the total of teaching more than 10 years (55.6%).

ii) Students

There are five questions were demonstrated in part A for students to answer; demographic info which reflected the respondent's background. The question is about gender, nationality, learning code, year of study, as well as school. The data analysis obtained from the study is tabulated in Figure 5.

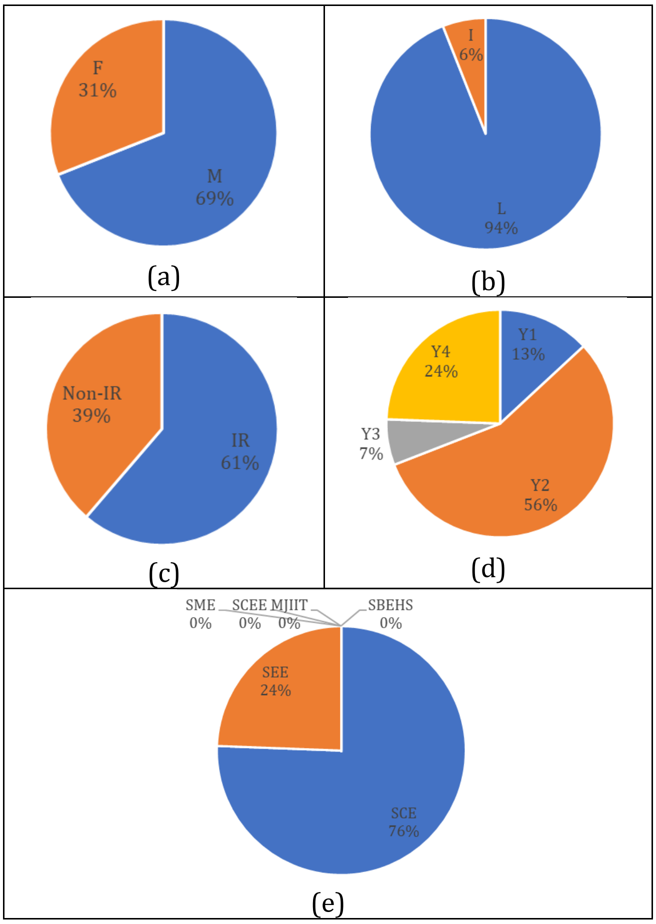


Figure 5. Students' demographic data

(a) Gender; (b) Nationality; (c) Learning code; (d) Year of study; (e) School

Legends: M- Male; F- Female; L- Local; I- International; IR- Professional engineer certification; Non- IR- Without professional engineer certification; Y1- Year 1; Y2- Year 2; Y3- Year 3; Y4- Year 4; SCE- School of Civil Engineering; SEE- School of Electrical Engineering; SME- -School of Mechanical Engineering; SCEE- School of Chemical and Energy Engineering; SBEHS- School of Biomedical Engineering and Health Sciences; MJIIT- Malaysia-Japan International Institute of Technology

Male respondents are nominated for the survey (69%) rather than female respondents (31%) (Figure 5) (question a). For nationality, most students are from local (94%) and only 6% are from international students (question b). Learning code is to represent whose lecturers are teaching them. So, from the figure, the students mostly learned from lecturers with IR certification (61%) and the other 39% were taught by experienced non-IR registered lecturers (question c). The students were also nominated by 2nd year students (56%), followed by 4th year students (question d). All of them are mostly from the School of Civil Engineering (76%) and only 24% are from the School of Electrical Engineering, respectively (question e).

Reliability Test

SPSS software is used to conduct the reliability test among the nine respondents from lecturers and 168 respondents from students in the survey. The results of Cronbach's Alpha for both categories are shown in Table 2.

Table 2. Cronbach's Alpha data

Categories	Parts	Cronbach's Alpha
Lecturers	B- teaching practice	0.924
	C- tendency of teaching	0.869
	D- teaching aids	0.465
Students	B- lecturer's teaching practice	0.816
	C- lecturer's tendency of teaching	0.939
	D- lecturer's teaching aids	0.773

From the table, the result of Cronbach's alpha of each category was above 0.7 which indicates that the survey questionnaire was valid and reliable except part D for lecturers with 0.465 Cronbach's alpha value. Even though the value is lower than 0.7, according to the study by Taber (2018) and Nawi et al., (2020), the value of 0.4 to 0.9 is considered acceptable and sufficient. This can be confirmed by the study of Griethuijsen et al. (2014) who obtained the result of 0.446 for their study and described that the Cronbach's alpha will increase as the number of items is increased. It is also plausible to say that the small number of respondents from lecturers might as well have influenced the results obtained in part D. This can be seen from part D for students where the number of respondents is slightly highest compared to lecturers. However, Bonett and Wright (2014) stated that there is no universal minimally acceptable reliability value that has been discussed relating to the samples. Meanwhile, the results with zero variance are removed from the analysis; for lecturer in part B, question 3 and 8, respectively.

Descriptive test

Descriptive analysis was carried out to both survey questionnaires; lecturers and students. The questions asked are the Likert-type scale. The mean score to part B is ranging from 3.22 to 5.00 which indicates that the respondents strongly agreed that they have significant teaching practice in their work. In this part, the item with the highest mean score is "I do not allow students to ask questions in class while I'm teaching" and "I do not encourage my students to give ideas or comments about what is being taught in class" (mean=5.00). These questions are reversed scored items. Which means that the score '5' means the lecturers strongly disagree by the method that they are not allowed to ask the students questions or comment on their teaching methods. On the other hand, the item with the lowest mean score is "I believe my students can do well by using only the materials given by me in class" (mean=3.22). This means that in order to be excellent in the study, the students must also look for other alternative resources to seek the knowledge instead of hoping for 'spoon-feed' by their respective lecturers. It will help the students with creative minds and diverse their knowledge with multiple references other than the materials used in the class. The other item with mean 3.78 to 4.44 agreed that they also used other practice in their teaching.

Meanwhile, for part C, the highest mean score is "I prefer to use the following inquiry-discovery methods because it emphasises experiential learning, i) Problem-based learning, ii) Case-based learning, iii) Project-based learning" (mean = 4.44). This means that most lecturers are using this practice in their teaching where they diversified their teaching methods instead of selecting one way of teaching in the class. The lowest score is "I prefer to give students service-learning based assignment" and "I prefer to use virtual reality in class" (mean = 3.44). Both questions mean the subject teaching may be not involving the community, thus, there is no service-based learning and no virtual reality means the lecturers are not using virtual situations in the class. This is because in order to obtain a real situation especially for the industry, there are a lot of procedures that must be considered for both parties; university (to be specific the school) and industry before having a visit or at least recording the video. Most of the time, there is a confidential part in the industry that must not be exposed directly to the public or the materials for recording are not suitable in that sector for example clean room for food processing or cosmetic industry. Thus, the virtual reality may be by referring to the video from YouTube or company website.

On the other hand, in part D, which is teaching aids, the lecturers mostly relied on UTM e-Learning (mean = 4.00) for their teaching and only a few are using OpenCourseWare (OCW) offered by UTM (mean = 2.78). This is probably due to not all subjects are available and covered by experts in the website that the lecturers can refer to.

As for students, in part B, the highest mean score is "My lecturers assign tasks based on the project which are relevant to topics learned in class" (mean = 4.51). On the other hand, the lowest mean score is "My lecturers believe that students can do well by using only the materials given to them in class" (3mean = 3.68). This means that most of their lecturers are given the task that is relevant to the class and not only expect that the students must use their materials to learn the respective topic in the class.

In part C, the highest mean score is represented by "I prefer my lecturers to use demonstration because it gives students example steps of conducting an activity or task" (mean = 4.55). The students prefer their lecturers to demonstrate any tasks given to them for better understanding of the topic taught in the class. The lowest score is referred to as "I prefer my lecturers to use cooperative methods because it allows students to work together including assessing their own group performance' (mean = 4.28). This shows that the students mostly prefer their lecturers to assess the group performance rather than students evaluating their own friends. Maybe for them, there will be no bias if their lecturers evaluated their performance instead of the students, so that the results obtained may be more accurate for them to polish their skills in certain subjects.

In part D, the highest mean score obtained from the study is "I prefer to use videos that my lecturers develop" (mean = 4.25), whereby the lowest mean score is "I tend to use OpenCourseWare (OCW) which is developed by UTM experts" (mean = 3.16). The students are most likely their lecturer who prepared the video rather than relied on OCW website for their studies.

Discussion

In this study, we have successfully retrieved engineering lecturers' profiles from school administration. The detailed profile background for lecturers as well as students was shown in the demographic data analysis section. A total of nine respondents from lecturers with and without IR answered the survey and approximately 168 respondents from students also participated in this study.

This objective was tested in the section reliability test and descriptive analysis. Cronbach's alpha test showed that the items tested were reliable and accepted (the alpha value is more than 0.4 and 0.7). The feedback from lecturers with and without IR showed that they consistently agreed with each other about the teaching approaches and materials used in their teaching in the class. The highest mean score is also more than 0.3 which means that they significantly practice the teaching technique in their work.

Students' perceptions on teaching and learning practice by their lecturers were demonstrated in section reliability tests and descriptive analysis. Reliability test showed that the items tested were reliable and consistent. This can be seen from Cronbach' alpha value that is more than 0.7 for all parts. Their lecturers also practice good approaches teaching when facing the students during learning (the mean score is higher than 0.3).

Conclusion

This pilot study has revealed that the suggested research is highly significant and has the potential to significantly enhance teaching and learning (T & L) for both engineering lecturers and class participants. From this point on, the number of people who took part in this poll reflects our first goal. Because this poll was conducted in the early stages of the epidemic, when it was still active, and since hybrid classes were used to help pupils catch up with previous Malaysian MCOs (movement control orders), it was carefully conducted. It is challenging to access and appropriately assess the educational process because the offered subject requires the students to practically learn in a variety of methods. Even if the reliability test and descriptive analysis for the nine lecturers in the sample are valid and reliable, more samples must be used in the real study to see whether the sample size has a substantial impact on our survey evaluation results. The survey question reveals that the instructors at the Faculty of Engineering use the NALI technique in class, which is encouraging because it will allow us to assess their methods through a broader study (qualitative and quantitative analysis for larger sample).

Acknowledgement

The authors acknowledge UTMCDex, Universiti Teknologi Malaysia for financial support under grant Dana Pembangunan Pengajaran (PY/2021/00799). Cost No. R.J130000.7716.4J521.

References

Abed, S. S., Al-Mansour, M., Ahmed, S. N., Khan, M. A., Martin, P. N., Shah, S. W., and Aga, S. S. 2023. Evaluation of Problem-Based Learning in College of Medicine: An Indicator of Quality Education in a Hybrid Curriculum. Education Research International. 2023; 9 pages. https://doi.org/10.1155/2023/9955409.

Alias, R. A., and Aris, B. 2016. A guide to New Academia Learning Innovation. First Edition. Universiti Teknologi Malaysia.

Arikan, S., Dochy, F., and Segers, M. 2022. Framing the Effects of High-Impact Practices from a High-Impact Learning Perspective. A Review of Studies. Creative Education. 13; 2994-3025. https://doi.org/10.4236/ce.2022.139190.

Bonett, D. G., and Wright, T. A. 2014. Cronbach's alpha reliability: Interval estimation, hypothesis testing, and sample size planning. Journal of Organizational Behavior. DOI: 10.1002/job.1960.

Canbulat, M., Direkci, B., Simsek, E. E., and Simsek, B. 2020. Investigating the School 2023 Project through the Lens of Teachers: A Case Study. Eurasian Journal of Educational Research. 89; 137-158.

Chen, D. 2021. Toward an understanding of 21st-century skills: From a systematic review. International Journal for Educational and Vocational Guidance. https://doi.org/10.1007/s10775-021-09511-1.

Chong, S. S. 2008. Why OBE? Selangor, Malaysia. Retrieved from http://.utar.edu.my/fes/file/OBE.pdf.

Ditcher, A, K., 2001. Effective Teaching and Learning in Higher Education, with Particular Reference to the Undergraduate Education of Profesional Engineers. International Journal Engineering Education, Vol 17, pp 24-29, 2001.

Diocos, C. B. 2023. 21st Century Skills of Practice Teachers: Inputs to Curriculum Enhancement and Instructional Development. International Journal of Research Publication and Reviews. 4; pp 300-306.

Duch, B. 1995. What is problem-based learning? Center for Teaching Effectiveness, Univ. of Delaware. Retrieved from http://.udel.edu/pbl/cte/jan95-what.html.

Duch, B. J., Groh, S. E., & Allen, D. E. 2001. The Power of Problem-based Learning: A Practical "How To" for Teaching Undergraduate Courses in Any Discipline. Stylus.

Edström, K., Törnevik, J., Engström, M., and Wiklund, Å. 2003. Student involvement in principled change: Understanding the student experience. In Improving Student Learning Conference, Oxford, England.

Errington, E. 2011. As close as it gets: Developing professional identity through the potential of scenario-based learning

Felten, P., and Clayton, P. 2011. Service-learning. New Directions for Teaching and Learning, (128), 75–84. http://doi.org/10.1002/tl.470.

Garvin, D. 2009. Case Method in Practice: Judging Success of a Class Session. HBS Christensen Center. Retrieved from http://.hbs.edu/about/video.aspx?v=1_q34d0scf.

Griethuijsen, R. A. L. F., Eijck, M. W., Haste, H., Brok, P. J., Skinner, N. C., Mansour, N., et al. 2014. Global patterns in students' views of science and interest in science. Research in Science Education. 45(4); 581–603. doi:10.1007/s11165-014-9438-6.

Hamdan, A. R., Jiar, Y.K., Talib, R., Naim, H. A., Jaffri, H., Samah, N. A., Abu, B., Kosnin, A. M., Daud, K., and Xi, L. 2014. Lecture-Centred or Student-Centered: A Case Study in a Public University. Journal of Education and Practice. 5; 1-8.

Helmi, S. A., Yusof, K. M., and Hisjam, M. 2019. Enhancing the implementation of Science, Technology, Engineering and Mathematics (STEM) Education in the 21st Century: A simple and systematic guide. The 4th International Conference on Indsutrial, Mechanical, Electrical, and Chemical Engineering. https://doi.org/10.1063/1.5098172.

Hmelo-Silver, C. E. 2004. Problem-Based Learning: What and How Do Students Learn? Educational Psychology Review, 16(3), 235–266. Retrieved from http://.seattleimplementation.org/wp-content/uploads/2011/12/Hmelo-Silver-problem-based-learning-2004.pdf.

Jahnke, K., and Lindgren, S. 2021. You Teach Us: Peer Teaching in the Engineering Classroom. American Society for Engineering Education Annual Conference, 26-29th July 2021.

Japee, G. P., and Oza, P. 2021. Curriculum and Evaluation in Outcome-Based Education. Psychology and Education. 2; 5620-5625. ISSN: 00333077.

Mamat, M., Amran, N. N., Ismail, Z., Ibrahim, M., Ishak, H., and Baba, S. 2019. Service-learning in malaysia: Practice and implementation in four Public universties. International Journal of Civil Engineering and Technology (IJCIET). 10; pp. 1682-1691.

Marton, F., Dall'Alba, G., and Beaty, E. 1993. Conceptions of learning. Int J Educ Res, 19, 3; 277-300.

National Survey of Student Engagement. 2007. Experiences that matter: Enhancing student learning and success—Annual Report 2007. Bloomington, IN: Indiana University Center for Postsecondary Research.

Nawi, F. A. M., Tambi, A. M. A., Samat, M. F., and Mustapha, W. M. W. 2020. A review on the internal consistency of a scale: the empirical example of the influence of human capital investment on malcom baldridge quality principles in tvet institutions. Asian People Journal. 3; 19-29. https://doi.org/10.37231/apj.2020.3.1.121.

Oye, N. D., Iahad, A., Madar, M. J., and Ab.Rahim, N. 2012. The impact of e-Learning on students' performance in tertiary institutions. IRACST – International Journal of Computer Networks and Wireless Communications (IJCNWC), 2(2), 121–130.

Rivadeneira, J., and Inga, E. 2023. Interactive Peer Instruction Method Applied to Classroom Environments Considering a Learning Engineering Approach to Innovate the Teaching–Learning Process. Educ. Sci. 13; 301. https://doi.org/10.3390/educsci13030301.

Souppez, J-B. R. G., and Awotwe, T. W. 2023. The conceive design implement operate (cdio) initiative – an engineering pedagogy applied to the education of maritime engineers. Intl J Maritime Eng. vol 164. DOI: 10.5750/ijme.v164iA4.1187.

Syeed, M. M., Shihavuddin, A., Uddin, M. F., Hasan, M., and Khan, R. H. 2022. Outcome Based Education (OBE): Defining the Process and Practice for Engineering Education. IEEE Access PP(99):1-1. DOI:10.1109/ACCESS.2022.3219477.

Taber, K. S. 2018. The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. Res Sci Educ. 48;1273–1296. DOI 10.1007/s11165-016-9602-2.

Thomsen, B., Renaud, C., Savory, S., Romans, E., Mitrofanov, O., Rio, M., and Mitchell, J. 2010. Introducing scenario-based learning: Experiences from an undergraduate electronic and electrical engineering course. Paper presented at the Education Engineering (EDUCON), 2010 IEEE.

Ujang, Z. 2012. Akademia Baru – Memartabat UTM Berjenama Global (Siri Perutusan Tahun Baru Naib Canselor 2012). Penerbit UTM Press. ISBN: 798-983-52-0841-6.

UTMCdex, https://utmcdex.utm.my/wp-content/uploads/sites/64/2017/08/NALI_10_pages-1.pdf?external=1. Accessed on 08 February 2023.

Vladoiu, M. 2011. Open courseware initiatives - After 10 years. Proceedings - RoEduNet IEEE International Conference. doi:10.1109/RoEduNet.2011.5993712.

Warren, J. L. 2012. Does Service-Learning Increase Student Learning?: A Meta-Analysis. Michigan Journal of Community Service Learning, (Spring), 56–61.

Zitouniatis, A., Lazarinis, F., and Kanellopoulos, D. 2022. Teaching computational thinking using scenario-based learning tools. Education and Information Technologies. 28; 4017–4040.

Knowledge, Attitude, and Readiness to Practise among Malaysian Undergraduate Engineering Students Towards Disaster Management Preparedness

Article history
Received
1 May 2023
Received in revised form
4 June 2023
Accepted
5 June 2023

Faris Tarlochan[a,b]****, Mohamed Izham Mohamed Ibrahim***[b]***, Mohd Faris Khamidi***[d]***, Asan G.A. Muthalif***[a]
[a]*Department of Mechanical and Industrial Engineering , Qatar University, Qatar*
[b]*Technology Innovation and Engineering Education, Qatar University, Qatar*
[c]*College of Pharmacy, QU Health, Qatar University, Qatar*
[d]*Department of Architecture and Urban Planning, Qatar University, Qatar*
**faris.tarlochan@qu.edu.qa*

Abstract

Malaysian National Security Council (MNSC) defines disaster as an incident that occurs unexpectedly, resulting in the loss of lives and damage to properties, environment and daily activities of the local community. Disastrous events such as floods, earthquakes, terrorism, increase in population, cyber-attacks, pandemics, rising sea levels, economic recessions, urbanization, etc., have been increasing globally and also in Malaysia. The wellbeing of our Malaysian communities depends on a complex web of institutions, infrastructure and information. To reduce the disaster risk and impact, various efforts have to be in place to prepare and empower the community. As such, this paper is positioned at understanding this preparedness level among undergraduate engineering students in Malaysia. During emergencies, such undergraduate students should be able to rise and assist in national development from a disaster. In this study, we are focused to evaluate the engineering students in Malaysia in particular for knowledge (K), attitude (A) and readiness to practice (rP) regarding disaster preparedness. This is an exploratory study done through a questionnaire distributed among engineering undergraduate students in some selected public (one) and private universities (two) in Malaysia. Almost half of the participants understood that Malaysia is at risk of disasters and that these disasters come in many size and shapes. These participants also significantly understand the potential of risk of emergencies in Malaysia. However, the respondents indicated that they have not had real exposure or handling experience on this topic. There was a huge agreement that there is a lack of support from local officials in terms of organizational logistics and roles among local and national agencies in disaster response. This study has shown that the literature is scarce in terms of understanding the student agency for disaster preparedness. There is a need for relevant stakeholders like the Board of Engineers Malaysia to prepare engineering undergraduates for disaster management to strengthen the social fabric towards such risks.

Keywords: Attitude, Disaster management, Knowledge, Readiness to practice, Engineering students.

Introduction

Lately in the 20th and early in 21st century, disruptive events (disasters) such as floods, earthquakes, terrorism, political sanctions, increase in population, cyber-attacks, pandemics, rising sea levels, economic recessions, urbanization, etc., have been increasing globally. Beside this, there are Black Swan events, which are extremely rare but have severe impacts. Malaysian National Security Council (MNSC) defines disaster as an incident that occurs unexpectedly, resulting in the loss of lives and damage to properties, environment and daily activities of the local community. The wellbeing of our communities depends on a complex web of institutions, infrastructure and information. This wellbeing, however, is under a constant threat from such external or internal stresses and shocks. The COVID-19 pandemic and the 2008 global financial crisis are examples of Black Swan events that had taken the globe by surprise with catastrophic outcomes. Today, a great amount of risk also emerge in the digital sector. The cyber infrastructure has increased the connectivity and interdependencies between systems. All economic, environmental and social systems are interconnected through cyber infrastructure. Any cyber-attacks could bring devastation to a country due to the inter-connectivity of systems through the cyber infrastructures. Such stresses / shocks (internal or external) can result in significant damage to communities in terms of its environment (buildings, infrastructure systems, land, vegetation, etc.), economy, health and social fabrics. As such, understanding the multiple stress and shocks and their

Tarlochan, F., Mohamed Ibrahim, M.I., Khamidi, M.F., Muthalif, A.G.A. (2023), Knowledge, Attitude, and Readiness to Practise among Malaysian Undergraduate Engineering Students Towards Disaster Management Preparedness, *ASEAN Journal of Engineering Education*, 7(1), 12-19.

impacts on the social, economic and environmental systems is important for sustainability and human well-being (Berkes, 2013), (May, 2022), (Jinglu, 2022), (Birchall, 2022), (Melika, 2021). Besides understanding these stress and shocks, it is vitally important to understand the preparedness level of all residents in a geographic location. Disaster preparedness are measures put in place by authorities at various community scales to better respond and cope with the immediate aftermath of a disaster. This is important to predict the resilience level of a community to bounce back from the disaster. To reduce the disaster risk and impact, various efforts have to be in place to prepare and empower the community (Noraini, 2018). As such, this paper is positioned at understanding this preparedness level among undergraduate engineering students in Malaysia. During emergencies, such undergraduate students should be able to rise and assist in national development from a disaster (P Van, 2019).

Malaysia is a country with a relatively large population and is vulnerable to climate change- related disasters especially floods, landslides, and droughts (Alam, 2020). When comparing two period times (Period 1: 1985-1999; and Period 2: 2000-2014), the occurrence of natural disasters in Malaysia has risen close to 65% with an increase of death by 85% (Zairol, 2018). The reported economic damages also saw a rise of close to 120%. Such disasters in Malaysia, affected not only individuals, but also various economic sectors. For example, in Malaysia small medium enterprises (SMEs) contribute close to 37% to Malaysia's GDP and employment of 48% (https://www.dosm.gov.my/). Such SMEs take a heavy toll during disasters (Zairol, 2018). From an engineering perspective, critical engineering infrastructures (CEI) such as electricity, water supply and access to road transportation networks are crucial to be functioning to support disaster management and recovery. For example, the literature (Kirsch, 2010), (Rimfiel, 2017) has cited some examples on the failure of CEI and the consequences on hospitals. Kirsch et. al reported that due to loss of power and insufficiency of backup power, a hospital was inoperable of medical services. Some hospitals faced water contamination causing the cessation of activities.

The community in general is always the first layer to be affected by disasters. Rescue and support, in forms of job requirements and volunteering are important in forming the first defence line (Hoi, 2020). Engineering professionals are one of the key players in disaster risk management and relief (Cruz, 2007). In view of this, disaster engineering preparedness education and training should be integral parts of public awareness competencies development for undergraduate engineering students, such as training and education provided by Federal Emergency management Agency of USA (FEMA). Such modules from FEMA can be customized to create 1st year disaster management course to undergraduate students. Unlike the health education sector (Zhou, 2019), engineering education in general lacks such preparedness education. These undergraduate students are the future engineers and as such adequate knowledge, positive attitudes and readiness to practice must be acquired at the university level to enhance their skills. To date, scholarly work that focuses on the preparedness of undergraduate engineering students to handle disaster management is scarce. *The research question is the following: Are Malaysian engineering graduates prepared to respond to disasters?* There is almost no comprehensive reporting on engineering students in terms of their knowledge, attitudes and readiness to support the engineering fraternity in an event of a disaster. In this study, we are focused to evaluate the engineering students in Malaysia in particular for knowledge (K), attitude (A) and readiness to practice (rP) regarding disaster preparedness.

Materials and Methods

Study Design

This exploratory study was carried out in a Malaysian university among undergraduate engineering students. Selected students who completed the online survey were considered to have informed consent to participate in the study. The survey was distributed online, filled out by the respondents and returned to the research team. The data were collected electronically using Google Forms. Ethical approval for this study was obtained from Qatar University IRB (Approval Number: QU-IRB 1344-EA/20).

Population and sampling

The target population in the study was undergraduate engineering students. Students from postgraduate levels and non-engineering were excluded from the study. The sample size was calculated using a margin of error of 5%, a confidence level of 95%, and a response distribution of 50%. A minimum sample size of 373 students was required. The calculation was performed using Raosoft® online calculator http://www.raosoft.com/samplesize.html. Convenience non-probability sampling was applied to reach the respondents. Selected engineering institutions in Malaysia were invited to participate and were requested to share the online survey tool with their students. The approach was convenience sampling.

Study tool development and validation

The tool (KArP) was developed and adapted based on the previous studies (Li, 2022), (Rajaa, 2022), and changes were made according to the engineering discipline. Then a pretesting was done among four faculty members for face validity measure who are experts in engineering, health and disaster aspects. This was followed by a pilot study carried out among Qatar University College Engineering students for tool reliability measure using Cronbach's alpha. Forty-six students responded. A few minor changes were made to the items and the Cronbach's alpha measures are as the following: Knowledge (K) factor (21 items) = 0.620 (moderate – good), Attitude (A) factor (17 items) = 0.561 (moderate – good) and Readiness to practice (rP) factor (11 items) = 0.566 (moderate – good). The knowledge factor has 22 items (response: Yes or No) and the score ranged from 0 to 22; while the attitude factor has 17 Likert's scale items (5 response options: Strongly agree to Strongly disagree) and has a min-max score of 17 to 85; and the readiness to practice factor has 11 Likert's scale items (5 response options: Strongly agree to Strongly disagree) and has a min-max score of 11 to 55.

Data Analysis

Prior to conducting the survey, the tool had a page that explained disaster and relevant terms to support the understanding while answering the questions. The data collected for this research were compiled in Excel program and analysed using the Statistical Package for the Social Sciences v28. (Armonk, NY: IBM Corp.). The normality of the results was checked using the Kolmogorov–Smirnov test. Descriptive analysis, frequency (%) for non-continuous variables, and mean (SD) or median (IQR) for continuous variables were used. Because the data were not normally distributed, nonparametric tests (i.e., Chi-Square, Kruskal–Wallis, and Mann–Whitney) were used. Spearman rho's correlation test examined the correlation among the three parameters (K, A, and rP). Multiple linear regression was performed to predict the readiness to practice (dependent variable) from knowledge and attitude (independent variables). All tests were carried out at a priori alpha level of 0.05.

Results

The Cronbach's alpha i.e. internal consistency for the tool for the major study is reported as below (Table 1). High Cronbach's alpha values show consistency of response values for each respondent across a set of questions. The values are considered under moderate/acceptable level (Taber, 2018). Majority of the respondents indicated a moderate level of knowledge (56.4%), a moderate level of positive attitude (54.3%), and a moderate level of readiness to practice (64.3%). Less than one-forth of the respondents who showed a high level in all the three domains.

The profiles of the participants are shown in Table 2. The mean age (sd) was 21.5 (1.9) and ranged from 18 to 28 years. There were more male respondents than female respondents. The majority were from Mechanical Engineering. There is a fair distribution between the academic level 2-4 (years). All the respondents are undergraduate students working towards their bachelor's degree.

Table 1. Cronbach's alpha and average score for the KAPr tool

Factor	Cronbach's Alpha	Mean (SD)	Median (IQR)
Knowledge (K)	0.637	12.85 (3.35)	13.00 (10.00-15.00)
Attitude (A)	0.691	58.39 (7.26)	58.50 (53.00-63.00)
Readiness to practice (rP)	0.540	37.28 (4.40)	37.00 (34.00–41.00)

Table 2. Demographic profiles of the respondents

Profiles	Statistics
Gender	Female (n=14, 10.0%) Male (n=126, 90.0%)
Age (years): mean (sd)	21.5 (1.9) Range: 18 to 28
Engineering degree major	Civil/Architecture (n=8, 5.7%) Mechanical (n=115, 82.1%) Electrical/Electronics (n=17, 12.1%)
Academic level (year)	1st (n=7, 5.0%) 2nd (n=51, 36.4%) 3rd (n=47, 33.6%) 4th (n=31, 22.1%) 5th (n=4, 2.9%)
Degree conferred upon graduation	Bachelor (n=140, 100%)

Table 3 depicts the knowledge of the respondent regarding disaster preparedness. Majority (≥ 60%) of the respondents said "No" to 4 out of the 22 items. These items related to the following statements: *as an engineering student, I have previous exposure to this topic (64.3%); I read journal articles related to disaster preparedness (62.9%); Finding relevant information about disaster preparedness related to this country's needs is an obstacle to my level of preparedness (67.9%); I am unfamiliar with the organizational logistics and roles among local and national agencies in disaster response (i.e. taking decisions and measures) situations (62.1%).*

Looking at the "Yes" response, majority (≥ 60%) of the respondents said "Yes" to 11 out of the 22 items: *Disasters come in many shapes and sizes (type of disasters, intensity, effects, etc.)(91.4%); In general, I find that the research literature on disaster preparedness and management is easily accessible (63.3%); I find that the research literature on disaster preparedness is understandable (68.6%); I am aware of the potential risks of emergencies in this country (e.g: natural disaster, embargo, terror, war...etc.)(74.3%); I* *know how such emergencies or disasters can affect the engineering sector (power supply, water supply, transportation, manufacturing, etc.)(86.4%); I know the limits of my knowledge, skills, and readiness as a university student to act in disaster situations, and I would know when I exceed them (79.3%); In case of a disaster/crisis, I know how to overcome the situation by applying related engineering skills to benefit my society (63.6%); I am familiar with the accepted process of examining problems to decide which ones are the most serious and must be dealt with first in disaster situations (63.6%); Realistic on-scene training is vital to an efficient and effective disaster plan (84.3%); Disaster management is truly a systems-oriented specialty and involves multiple responding agencies (83.6%).*

Table 3. Knowledge assessment on disaster among respondents

Questions	Yes (1), n (%)	No (0) n (%)
As an engineering student, I have previous exposure to this topic (Disaster Preparedness).	50 (35.7)	90 (64.3)
	Average = 0.36	
As an engineering student, I have previous experience in dealing with disasters.	58 (41.4)	82 (58.6)
	Average = 0.41	
I think my country of residence (where you are studying currently) is at risk due to disasters (natural or human made).	76 (54.3)	64 (45.7)
	Average = 0.54	
Disasters come in many shapes and sizes (type of disasters, intensity, effects, etc.).	128 (91.4)	12 (8.6)
	Average = 0.91	
Is Engineering related disaster the sole responsibility of an engineering organization?	60 (42.9)	80 (57.1)
	Average = 0.43	
I read journal articles related to disaster preparedness	52 (37.1)	88 (62.9)
	Average = 0.37	
I am unaware of classes about disaster preparedness and management that are offered, for example, at either my college or community.	67 (47.9)	73 (52.1)
	Average = 0.48	
In general, I find that the research literature on disaster preparedness and management is easily accessible.	89 (63.6)	51 (36.4)
	Average = 0.64	
I find that the research literature on disaster preparedness is understandable.	96 (68.6)	44 (31.4)
	Average = 0.69	
Finding relevant information about disaster preparedness related to this country's needs is an obstacle to my level of preparedness.	45 (32.1)	95 (67.9)
	Average = 0.32	
I know where to find relevant research or information related to disaster preparedness and management to fill in gaps in my knowledge.	84 (60.0)	56 (40.0)
	Average = 0.60	
I know referral contacts in a disaster situation (e.g. public works authority department).	58 (41.4)	82 (58.6)
	Average = 0.41	
In a disaster situation, I think there is no sufficient support from local officials at the governance level.	77 (55.0)	63 (45.0)
	Average = 0.55	
I am aware of the potential risks of emergencies in this country (e.g: natural disaster, embargo, terror, war…etc).	104 (74.3)	36 (25.7)
	Average = 0.74	
I know how such emergencies or disasters can affect the engineering sector (power supply, water supply, transportation, manufacturing, etc.).	121 (86.4)	19 (13.6)
	Average = 0.86	
I know the limits of my knowledge, skills, and readiness as a university student to act in disaster situations, and I would know when I exceed them.	111 (79.3)	29 (20.7)
	Average = 0.79	
In case of a disaster/crisis, I know how to overcome the situation by applying related engineering skills to benefit my society.	89 (63.6)	51 (36.4)
	Average = 0.64	
I am familiar with the local emergency response system to initiate engineering procedures/solutions.	57 (40.7)	83 (59.3)
	Average = 0.41	
I am familiar with the accepted process of examining problems to decide which ones are the most serious and must be dealt with first in disaster situations.	89 (63.6)	51 (36.4)
	Average = 0.64	
I am unfamiliar with the organizational logistics and roles among local and national agencies in disaster response (i.e. taking decisions and measures) situations.	53 (37.9)	87 (62.1)
	Average = 0.38	
Realistic on-scene training is vital to an efficient and effective disaster plan.	118 (84.3)	22 (15.7)
	Average = 0.84	
Disaster management is truly a systems-oriented specialty and involves multiple responding agencies.	117 (83.6)	23 (16.4)
	Average = 0.84	

Table 4 depicts the attitudinal levels of the participants towards disaster preparedness. In terms of agreement, more than 50% of the respondents agreed (total of "strongly agree" AND "agree") that: *I would feel confident in my abilities as an engineering student in disaster situation (54.3%); I would be interested in educational classes on disaster preparedness that relate specifically to the country situation (85%); I would be willing to be a future member of an engineering facility/team in case of a disaster (81.4%); I would feel confident in providing engineering-related education in a disaster or emergency (59.3%); I need more workshops and simulated training to prepare for disaster situations (92.9%); Disasters can disrupt progress made towards achieving the sustainable development goals (SDGs) (89.3%). In terms of disagreement, (total of "strongly disagree" AND "disagree") there were no significant items to be reported*.

Table 4. Attitude assessment on disaster among respondents

Questions	Strongly Agree n (%)	Agree n (%)	Neutral n (%)	Disagree n (%)	Strongly Disagree n (%)
I consider myself prepared for the management of disasters.	16 (11.4)	43 (30.7)	49 (35.0)	26 (18.6)	6 (4.3)

	Average score: 3.26				
I would feel confident in my abilities as an engineering student in disaster situation.	19 (13.6)	57 (40.7)	46 (32.9)	14 (10.0)	4 (2.9)
	Average score: 3.52				
I would be interested in educational classes on disaster preparedness that relate specifically to the country situation	47 (33.6)	72 (51.4)	16 (11.4)	5 (3.6)	0
	Average score: 4.15				
In a disaster, I would be considered a key leadership figure in my community.	20 (14.3)	47 (33.6)	44 (31.4)	16 (11.4)	13 (9.3)
	Average score: 3.32				
I have personal/family emergency engineering plans for disaster situations (e.g. power supply, water supply, sanitary, food supply, etc.)	16 (11.4)	35 (25.0)	29 (20.7)	47 (33.6)	13 (9.3)
	Average score: 2.96				
I have an agreement with loved ones and family members on how to execute our personal/family emergency and disaster plans.	17 (12.1)	33 (23.6)	29 (20.7)	42 (30.0)	19 (13.6)
	Average score: 2.91				
I am able to describe my role in the response phase of a disaster in the context of my college, the general public, media, and personal contacts.	26 (18.6)	35 (25.0)	50 (35.7)	22 (15.7)	7 (5.0)
	Average score: 3.36				
I would not feel confident as a future manager or coordinator of an emergency engineering support facility.	13 (9.3)	40 (28.6)	34 (24.3)	42 (30.0)	11 (7.9)
	Average score: 3.01				
I would be willing to be a future member of an engineering facility/team in case of a disaster.	49 (35.0)	65 (46.4)	20 (14.3)	4 (2.9)	2 (1.4)
	Average score: 4.11				
I feel reasonably confident I can handle engineering-related problems independently without the supervision of an engineer in a disaster situation.	21 (15.0)	49 (35.0)	53 (37.9)	8 (5.7)	9 (6.4)
	Average score: 3.46				
I would not feel confident implementing emergency and disaster engineering plans and procedures.	5 (3.6)	37 (26.4)	42 (30.0)	36 (25.7)	20 (14.3)
	Average score: 2.79				
I would feel confident in providing engineering-related education in a disaster or emergency.	26 (18.6)	57 (40.7)	45 (32.1)	10 (7.1)	2 (1.4)
	Average score: 3.68				
As an engineering student, I consider myself prepared to manage disasters	16 (11.4)	45 (32.1)	42 (30.0)	29 (20.7)	8 (5.7)
	Average score: 3.23				
As an engineering student, I would not feel confident in my abilities as a future engineer and first responder in engineering-related disaster situation.	12 (8.6)	34 (24.3)	43 (30.7)	36 (25.7)	15 (10.7)
	Average score: 2.94				
There's enough awareness on "ways to stand wars and other humanity and natural emergencies among undergraduate students in my university	11 (7.9)	40 (28.6)	32 (22.9)	42 (30.0)	15 (10.7)
	Average score: 2.93				
I need more workshops and simulated training to prepare for disaster situations.	67 (47.9)	63 (45.0)	10 (7.1)	0	0
	Average score: 4.41				
Disasters can disrupt progress made towards achieving the sustainable development goals (SDGs)	64 (45.7)	61 (43.6)	13 (9.3)	2 (1.4)	0
	Average score: 4.34				

Table 5 illustrates the readiness to practice among the participants. More than 50% of the respondents agreed (total of "strongly agree" AND "agree") that*: I am willing to attend the emergency education incorporated in the undergraduate coursework (83.5%); Other extracurricular resources (e.g.: internet, TV, radio and newspapers) enable me with a sufficient degree of readiness to practice under disaster (59.3%); I'm ready to practice under disaster, knowing that some basic engineering tools may not be available because of the disaster situation (69.3%); I need to be more trained for disaster situations (91.4%); time and effort are barriers towards readiness to practice (86.4%). In terms of disagreement, (total of "strongly disagree" AND "disagree") the following statements are not barriers towards readiness to practice: Lack of knowledge about disaster (83.5%); engineering related disaster are unlikely to occur in my country (51.5%).*

Table 5. Readiness to practice assessment on disaster among respondents

Questions	Strongly Agree *n* (%)	Agree *n* (%)	Neutral *n* (%)	Disagree *n* (%)	Strongly Disagree *n* (%)
My role in disaster situations is clear.	19 (13.6)	34 (24.3)	59 (42.1)	20 (14.3)	8 (5.7)
	Average score: 3.26				
I am not ready to handle whatever potential risks of emergencies exist in the community.	11 (7.9)	33 (23.6)	38 (27.1)	52 (37.1)	6 (4.3)
	Average score: 2.94				
I am willing to attend the emergency education incorporated in the undergraduate coursework.	51 (36.4)	66 (47.1)	23 (16.4)	0	0
	Average score: 4.20				
I attended workshops/seminars about disaster, which is enough for me to practice in real situations.	16 (11.4)	34 (24.3)	30 (21.4)	42 (30.0)	18 (12.9)
	Average score: 2.91				
My undergraduate coursework enables me to be ready to practice in the settings of disaster (natural: eg- earthquakes and floods; or human-made: eg- embargo or wars)	16 (11.4)	46 (32.9)	42 (30.0)	27 (19.3)	9 (6.4)
	Average score: 3.24				
Other extracurricular resources (eg: internet, TV, radio and newspapers) enable me with a sufficient degree of readiness to practice under disaster.	21 (15.0)	62 (44.3)	47 (33.6)	9 (6.4)	1 (0.7)
	Average score: 3.66				
I'm ready to practice under disaster, knowing that some basic engineering tools may not be available because of the disaster situation.	20 (14.3)	77 (55.0)	32 (22.9)	7 (5.0)	4 (2.9)
	Average score: 3.73				
I need to be more trained for disaster situations.	79 (56.4)	49 (35.0)	12 (8.6)	0	0
	Average score: 4.48				
The following are barriers that reduce my readiness to practice:					
Lack of knowledge about disaster	0	7 (5.0)	16 (11.4)	79 (56.4)	38 (27.1)
	Average score: 1.94				
Engineering related disaster are unlikely to occur in my country	13 (9.3)	24 (17.1)	31 (22.1)	46 (32.9)	26 (18.6)
	Average score: 2.66				
It requires effort and time to be prepared.	65 (46.4)	56 (40.0)	12 (8.6)	5 (3.6)	2 (1.4)
	Average score: 4.26				

Mann-Whitney test was applied to find any significant difference between male and female respondents in terms of the total knowledge, attitude and readiness to practice scores; none was significant ($p > 0.05$). Further, Chi-square analysis was carried out to search for any significant association between gender and knowledge, attitude and readiness to practice categories; no significant difference was found ($p > 0.05$). Age was correlated with total knowledge, attitude and readiness to practice scores. Spearman rho correlation indicated only total knowledge score was significantly associated with age ($p = 0.008$, $r = 0.224$). The study also is interested to find for any significant differences of age of the respondents in terms of the knowledge, attitude and readiness to practice categories; no significant difference was found ($p > 0.05$). Both the covariates, age and gender did not influence the three main factors.

Spearman rho correlation indicated that there are significant associations between knowledge factor and attitude factor ($p<0.001$, $r=0.403$), knowledge factor and readiness to practice factor ($p<0.001$, $r=0.374$), and between attitude factor and readiness to practice factor ($p<0.001$, $r=0.648$). Further causality analysis was carried out using linear regression. It is shown that knowledge is a good predictor of attitude ($R^2 = 0.130$, $p<0.001$), and readiness to practice ($R^2 =$

0.1160, p<0.001) and attitude is a good predictor of readiness to practice ($R^2 = 0.418$, p<0.001).

Discussion

This study assessed the Malaysian engineering undergraduate students' knowledge (K), attitude (A), and level of readiness to practice (rP) regarding disaster preparedness. An overall summary would be that the participants had moderate levels of knowledge, attitude, and readiness to practice. The study goes to show that there are significant associations between knowledge factor and attitude factor, knowledge factor and readiness to practice factor, and between attitude factor and readiness to practice factor.

Almost half of the participants understood that Malaysia is at risk of disasters and that these disasters come in many size and shapes. These participants also significantly understand the potential of risk of emergencies in Malaysia (e.g.: natural disaster, embargo, terror, war…etc.). A huge percentage of them also acknowledge that disasters can affect the engineering sectors (power supply, water supply, transportation, manufacturing, etc.). The students also showed positive competencies (lifelong learning) in terms of identifying information sources and availability for materials related to disaster management and preparedness. However, the respondents indicated that they have not had real exposure or handling experience on this topic. There was a huge agreement that there is lack of support from local officials in terms of organizational logistics and roles among local and national agencies in disaster response (i.e. taking decisions and measures) situations. The study shows that the engineering students have a moderate knowledge in terms of disaster preparedness.

In terms of attitude, there was a moderate indication towards a positive attitude towards disaster preparedness. They feel confident in their abilities as an engineering student to assist in disaster situation and are willing to be a future member of an engineering facility/team in case of a disaster. They are also interested in educational classes on disaster preparedness that relate specifically to the country's situation. However, the students feel they are not well prepared for the management of disasters and would be happy to receive workshops and simulated training to prepare for disaster situations. Most of the participants are interested to practice and are willing to attend education and training programs. They have indicate this because they are not certain of their roles in such situation and do not have the required skills to handle the emergencies. The respondents also identified that the barrier for them in readiness is the effort and time for preparation.

What are the practical implication of this study? This study has shown that the literature is scarce in terms of understanding the student agency for disaster preparedness. This is a good prompt to support such studies, especially for ASEAN countries who are exposure to high risks. There is an urgent need to prepare engineering undergraduates on disaster preparedness. These students will be holding positions in the professional and community levels. As such, preparing undergraduates for disaster management will strengthen the social fabric towards such risks.

Limitation of Study

This study is an exploratory in nature, as such the sample size is not representative of the population. The other point is on social desirability bias i.e. the possibility of tendency of students to respond in a way that will be viewed favourably by others, rather than reply truthfully. The future step is to have more participants in this study and to conduct a mixed research method involving faculty members and stakeholders. The outcome of this study will then pave the way for proposing minor changes in the engineering education within the Malaysian context.

Conclusion

This study is to investigate the attitude, knowledge and readiness to practice among undergraduate engineering students in Malaysia during an event of a disaster. The survey was conducted among some private and public universities in Malaysia. In summary, it can be concluded that most engineering undergraduate have moderate level of knowledge and attitude. When it comes to readiness to practice, these students are ready and eager however state that they lack training and education on the "know-how". There was a huge agreement that there is lack of support from local officials in terms of organizational logistics and roles among local and national agencies in disaster response.

Acknowledgement

The authors would like to thank the public and private universities in Malaysia who had contributed towards the students being respondents to the study.

References

Felder, R.M., Brent, R., 2007. Cooperative learning. Active Learning: Models from the Analytical Sciences, vol. 970. ACS Symposium Series. 34–53.

Alam, A. S. A. Ferdous, Halima Begum, Muhammad Mehedi Masud, Abul Quasem Al-Amin, Walter Leal Filho., 2020 Agriculture insurance for disaster risk reduction: A case study of Malaysia, International Journal of Disaster Risk Reduction, 47, 101626.

Berkes, F. et.al. 2013. Community resilience. Towards an integrated approach. Society & Natural Resources, 26(1), 5-20

Birchall, S. J, Seghan MacDonald, Nicklas N. Baran., 2022. An assessment of systems, agents, and institutions in building community resilience to climate change: A case study of Charlottetown, Canada. Urban Climate, 41, 101062.

Cruz AM, 2007. Engineering contribution to the field of emergency management. Disciplines, Disasters and

Emergency Management: The Convergence and Divergence of Concepts, Issues and Trends from the Research Literature, CC Thomas, Springfield, IL. 49-60

Hoi Yen Chen, Che An Ahmad, Khatijah Lim Abdullah, 2020. Disaster relief work: The experiences of volunteers in Malaysia. International Journal of Disaster Risk Reduction. 43, 101414.

Jinglu Song, Rishikesh Pandey, Guanpeng Dong, Ayyoob Sharifi, Bhim Prasad Subedi, 2022. Urban-Rural Disparity in Community Resilience: A Multilevel Analysis of the Relief Progress after the 2015 Nepal Earthquake. Sustainable Cities and Society.79, 103698

Kirsch, T. D., Mitrani-Reiser, J., Bissell, R., Sauer, L. M., Mahoney, M., Holmes, W. T., Santa Cruz, N. and de la Maza, F, 2010. Impact on Hospital Functions Following the 2010 Chilean Earthquake. Disaster Medicine and Public Health Preparedness, Cambridge University Press, 4(2), pp. 122–128.

Li S, Gillani AH, Ibrahim MI, Omer S, Fang , 2022.. Should we focus more on teaching and training disaster management in health-care colleges? An insight into the students' knowledge, attitude, and readiness to practice. J Pharm Bioall Sci .14:147-56.

May Haggag, Ahmed Yosri, Wael El-Dakhakhni, Elkafi Hassini, 2022. Interpretable data-driven model for Climate-Induced Disaster damage prediction: The first step in community resilience planning. International Journal of Disaster Risk Reduction, 73.

Melika Amirzadeh, Naser Barakpour, 2021. Strategies for building community resilience against slow-onset hazards. International Journal of Disaster Risk Reduction, 66, 102599.

Mohammad Aghababaei, Maria Koliou, 2022. An agent-based modeling approach for community resilience assessment accounting for system interdependencies: Application on education system. Engineering Structures. 255.

Noraini Omar Chong, Khairul Hisyam Kamarudin, Siti Nurhuda Abd Wahid, 2018. Framework Considerations for Community Resilient towards Disaster in Malaysia, Procedia Engineering, 212, 165-172.

P Van Den Hazel, 2019. The role of youth in the climate change debate, European Journal of Public Health, 29 (4).

Rajaa A. Al-Qudah, Mohamed Izham Mohamed Ibrahim, 2022. Disaster Management and Preparedness among Future Jordanian Health Professionals: Exploring Knowledge, Attitude, and Readiness to Practice. Journal of Hunan University Natural Sciences, 49(9), 190-200.

Rimfiel Janius, Khalina Abdan, Zairul Ain Zulkaflli, 2017. Development of a disaster action plan for hospitals in Malaysia pertaining to critical engineering infrastructure risk analysis. International Journal of Disaster Risk Reduction. 21, 168-175.

Taber, K.S, 2018. The Use of Cronbach’s Alpha When Developing and Reporting Research Instruments in Science Education. Res Sci Educ 48, 1273–1296.

Zairol Auzzir, Richard Haigh, Dilanthi Amaratunga, 2018. Impacts of Disaster to SMEs in Malaysia, Procedia Engineering, 212, 1131-1138.

Zhou L, Zhang P, Zhang Z, Fan L, Tang S, Hu K, et al, 2019. A bibliometric profile of disaster medicine research from 2008 to 2017: A scientometric analysis. Disaster Med Public Health Prep; 13:165-72.

Canvas LMS Course Design: Create and Deliver Interactive Online Course on the Canvas Learning Management System : A Book Review

Article history
Received
23 February 2023
Received in revised form
11 June 2023
Accepted
15 June 2023

Zamrin Md Zin[a], Arman Shah Abdullah[b] , Mohd Hanafi Ahmad[c]
[ab]Department of Engineering Technology, Faculty of Technical & Vocational, Universiti Pendidikan Sultan Idris, 35900 Tanjung Malim, Perak, Malaysia.
[c]School of Industrial Logistic, Universiti Kuala Lumpur, 81750 Pasir Gudang, Johor, Malaysia.
**zamrinmz@gmail.com*

Abstract

As online education continues to grow in popularity, instructors are increasingly seeking ways to design effective and engaging online courses. "Canvas LMS Course Design: Create and deliver interactive online courses on the Canvas learning management system, 2nd Edition" by Ryan John is a comprehensive guide to designing online courses using the Canvas learning management system (LMS). The book is an excellent resource for instructors at all levels of experience, providing practical advice and examples to help them design engaging and effective courses that meet the needs of their students. The book focuses on the practical aspects of course design. John provides clear and concise guidance on topics such as multimedia integration, assessment strategies, and student engagement, and provides numerous examples and case studies to illustrate these concepts in action.

Keywords: learning management system, e-learning, online learning environment, interactive learning

Introduction

The importance of LMS as an online teaching aid has gained more attention worldwide since the outbreak of COVID-19 (Cavus et al., 2021). In fact, studies related to students' emotions in online learning have been conducted (Syafiqah Ahmad Termidi & Farhana Jumaat, 2022).

Other studies have also supported the acceptance of LMS in the higher education learning system (Camilleri & Camilleri, 2022). The book "Canvas LMS Course Design: Create and Deliver Interactive Online Courses on the Canvas Learning Management System, 2nd Edition" was written by Ryan John and published in 2021 (John, 2021).

This book is a comprehensive guide on how to produce online learning content using the Canvas LMS. Canvas LMS is a Learning Management System (LMS) platform designed to support online learning processes. It provides an easy and secure place to deliver, manage, and provide access to learning materials and activities for students and teachers.

Canvas LMS has features that allow students and teachers to interact directly and easily online, such as discussion forums, video discussions, online assignment delivery tools, and more. There are several other LMS platforms that have similarities in presenting learning modules to students, but the author chose to produce a comprehensive guidebook using CANVAS LMS because he has been directly involved for 3 years in introducing CANVAS LMS at Rider University.

Structure and Content

The book is divided into three sections and consists of eight chapters as follows:

Table 1. The Structure of Contents

Sections	Chapters
1. Designing and Creating Your Course	Chapter 1: Getting Started with Canvas Chapter 2: Building Your Canvas Course Chapter 3: Getting Ready to launch Your Course
2. Teaching and Enhancing Your Course	Chapter 4: Teaching Your Canvas Course Chapter 5: Exploring Special Feature Chapter 6: Utilizing and Integrating Apps
3. Practical Ideas and Resources	Chapter 7: Where to Go for Help Chapter 8: Now You're Ready!

Md Zin, Z., Abdullah, A.S., Ahmad, M.H. (2023), Canvas LMS Course Design: Create and Deliver Interactive Online Course on the Canvas Learning Management System : A Book Review, *ASEAN Journal of Engineering Education*, 7(1), 20-23.

It can be observed that this book provides highly detailed and easy-to-follow guidance on how to design and deliver online courses using Canvas LMS. Each step is clearly outlined and accompanied by case examples and images that help readers understand the concepts being discussed.

Summary of Book Chapters

Here is a chapter-by-chapter summary to provide a more detailed explanation in this book.

Chapter 1: Getting Started with Canvas. In this chapter, the initial steps to get started with Canvas is introduced. It covers creating an account, setting up profile, and navigating the Canvas interface. The different components and tools available within Canvas will also be explored.

Chapter 2: Building Your Canvas Course. This chapter focuses on the process of creating and organizing course in Canvas. It covers topics such as setting up course settings, creating modules, organizing content, and customizing the course layout. The structure of the course can be learned effectively for optimal student engagement.

Chapter 3 : Getting Ready to launch Your Course. This section allows the discovery of how to create engaging content for a Canvas course. The chapter explores various content creation tools within Canvas, such as the rich text editor, file uploads, and embedding multimedia elements. Readers will learn how to incorporate multimedia resources to enhance the learning experience.

Chapter 4 : Teaching Your Canvas Course . This chapter provides guidance and strategies to help effectively deliver a particular course content, engage with students, and facilitate a meaningful learning experience such as course navigation, content delivery, discussion and communication, assignments and assessments, and progress tracking.

Chapter 5 : Exploring Special Feature Engagement. This chapter aims to broaden your understanding of the capabilities and possibilities that Canvas provides such as Multimedia Integration, Learning Modules, Adaptive Learning, Tools, Virtual Meetings and Web Conferencing integration, Gamification and Interactive Elements.

Chapter 6 : Utilizing and Integrating Apps. This chapter equips the readers with the knowledge and skills to expand the functionality and possibilities of a course. It encourages them to explore a wide range of apps available in the App Center and select the ones that best align with their teaching goals and the needs of their students such as marketplace of pre-approved applications that can be integrated into the Canvas course.

Chapter 7 : Where to Go for Help. This chapter provides information on various resources and avenues available to address any issues or concerns that may arise such as Canvas Forum where instructors can share ideas and seek help from other Canvas experts.

Chapter 8 : Now You're Ready ! Finally, a trainer will be well-prepared to launch your Canvas course and facilitate a positive and engaging learning experience for his students. It consolidates the knowledge and insights gained throughout the book, helping him apply them effectively in practice.

Advantages of This Book

Step-by-step guidance: "Canvas LMS Course Design" excels in providing highly detailed and comprehensive step-by-step guidance for designing online courses using the Canvas Learning Management System. The book meticulously outlines each stage of the course design process, from initial planning to final implementation. This meticulous approach enables readers to navigate the complexities of course design with confidence and clarity.

Clear explanations: The author's ability to convey complex concepts and technical aspects related to the Canvas LMS in a clear and understandable manner is a notable strength of the book. The explanations are presented in a concise and straightforward style, ensuring that readers can easily grasp the underlying principles and apply them effectively in their own course design endeavors.

Practical examples: The inclusion of practical examples, case studies, and real-life scenarios further enhances the book's effectiveness. These illustrative examples demonstrate how the concepts and strategies discussed can be successfully implemented in real-world contexts. By showcasing concrete applications, readers are provided with practical insights and inspiration for designing their own engaging and interactive online courses.

Visual aids: Visual aids, such as diagrams, screenshots, and images, play a crucial role in enhancing the understanding of the Canvas LMS functionalities and course design concepts. The judicious use of visual elements not only reinforces the step-by-step guidance but also provides readers with a visual representation of key concepts, making them easier to comprehend and apply.

Structured organization: The book exhibits a well-structured organization, featuring a logical progression of topics. It begins with foundational concepts and gradually builds upon them, introducing more advanced techniques and strategies as the reader progresses. This systematic approach ensures that readers develop a solid understanding of each topic before moving on to more complex aspects of course design.

Comprehensive coverage: The book covers a wide range of topics that are pertinent to course design within the

Canvas LMS environment. From instructional strategies to multimedia integration and student engagement techniques, the book leaves no stone unturned in its comprehensive exploration of key elements and considerations in designing effective online courses. This comprehensive coverage equips readers with a holistic understanding of the subject matter and empowers them to create engaging and impactful learning experiences for their students.

By incorporating these advantages, "Canvas LMS Course Design" provides readers with a wealth of knowledge, practical guidance, and inspiration to effectively leverage the Canvas LMS for designing and delivering interactive online courses.

Areas for Improvement

The book presents several challenges associated with its content, particularly regarding the utilization of the Canvas Learning Management System (LMS). These challenges encompass:

1. *Learning Curve*: The use of Canvas LMS can pose a significant learning curve for individuals who lack prior experience with the platform. While the book provides step-by-step guidance, readers may require additional time to fully grasp the functionalities and interface of Canvas.
2. *Customization Limitations*: Despite offering some guidance on course design, the book falls short in addressing the extent of customization options within Canvas LMS. It may not adequately emphasize advanced customization possibilities or complex coding techniques to tailor the appearance and functionality of Canvas to meet individual or institutional requirements.
3. *Technical Issues*: Technology implementation is seldom flawless, and users of Canvas LMS may encounter technical problems while navigating the platform. The book may not sufficiently focus on providing comprehensive troubleshooting guidance for potential technical issues, such as server problems, device compatibility, or internet connectivity.
4. *Platform Updates*: Canvas LMS continuously updates its platform to enhance functionality and security. Since the book's publication date may precede these updates, it may lack the most up-to-date information and features. Consequently, readers should actively stay informed about the latest developments and consult Canvas's current documentation to ensure they are leveraging the newest features and comprehending system changes.
5. *Integration with Third-Party Tools*: The book may not adequately address the integration of Canvas LMS with external tools or web services that can complement its functionality. Readers seeking to integrate external tools like collaboration platforms, assessment tools, or registration systems may need to seek additional resources for more extensive guidance and insights into these integrations.

To tackle these challenges, readers are advised to take precautions by seeking technical support, engaging with the Canvas user community to share experiences, and augmenting their understanding of Canvas LMS through alternative accessible sources:

Conclusion

In conclusion, the review of the book "Canvas LMS Course Design: Create and Deliver Interactive Online Course on the Canvas Learning Management System" by Ryan John highlights several key points. The book serves as a comprehensive guide for educators and instructional designers looking to utilize the Canvas LMS for designing online courses. It provides step-by-step instructions and practical advice.

One of the main strengths of the book is its clear and easily understandable writing style, making it accessible for readers to follow and implement the discussed concepts. The author's extensive experience with Canvas LMS is evident, providing valuable insights and best practices throughout the book. The book covers various topics, including instructional strategies, multimedia integration, and techniques for enhancing student engagement.

However, there are areas that could be improved. The book could delve deeper into the analysis and evaluation of certain topics, such as assessment strategies and the integration of multimedia elements. Additionally, a more critical approach to examining assumptions and potential biases within the book would enhance its overall credibility.

Overall, "Canvas LMS Course Design" by Ryan John is a valuable resource for educators and instructional designers seeking guidance on utilizing the Canvas LMS for designing interactive online courses. Its strengths lie in its practicality, clarity, and comprehensive coverage of key topics. While there is room for improvement in terms of depth of analysis and critical evaluation, the book still offers valuable insights and recommendations for designing effective courses within the Canvas LMS.

This book is recommended for educators, instructional designers, and administrators who are new to using Canvas LMS or seeking practical guidance in course design. It serves as a helpful starting point for understanding the capabilities of the platform and implementing effective teaching strategies in an online learning environment. Additionally, experienced Canvas users may find value in the book's insights and best practices for enhancing their course design approaches.

References

Camilleri, M. A., & Camilleri, A. C. (2022). The Acceptance of Learning Management Systems and Video Conferencing

Technologies: Lessons Learned from COVID-19. *Technology, Knowledge and Learning*, *27*(4), 1311–1333. https://doi.org/10.1007/s10758-021-09561-y

Cavus, N., Mohammed, Y. B., & Yakubu, M. N. (2021). Determinants of learning management systems during covid-19 pandemic for sustainable education. *Sustainability (Switzerland)*, *13*(9). https://doi.org/10.3390/su13095189

John, R. (2021). Canvas LMS Course Design. In *Canvas LMS Course Design*.

Syafiqah Ahmad Termidi, N., & Farhana Jumaat, N. (2022). Assessments of Student's Emotions and Their Relevance in Online Learning. In *ASEAN Journal of Engineering Education* (Vol. 6, Issue 2).

Review on Chemical Engineering Capstone Design Teaching Model to Drive Continuous Improvement and Achieving Program Outcomes

Article history
Received
5 June 2023
Received in revised form
21 June 2023
Accepted
21 June 2023
Published online
30 June 2023

Aziah Pauzi[a,b], Farizul Hafiz Kasim[b]
[a]Science Department, Penang Matriculation College,
13200, Kepala Batas, Malaysia
[b]Faculty of Chemical Engineering & Technology, Universiti Malaysia Perlis,
Kompleks Pusat Pengajian Jejawi 3, 02600, Arau, Malaysia
**farizul@unimap.edu.my*

Abstract

Project-based Learning (PjBL) is a well-known paradigm for engineering design education, with numerous case studies published in the literature. Capstone is intended to provide students with an opportunity to demonstrate their readiness for professional practice. Consequently, this paper suggests a teaching and learning model as a new paradigm for capstone design projects in an effort to perpetually enhance engineering education, particularly in chemical engineering design courses. Rigorously assessing students' knowledge of the design process is essential for understanding how to best create learning environments to facilitate the development of such knowledge. Such assessment is also quite difficult and hence there is a lack of assessment tools capable of measuring the design process knowledge of every student. The model also intends to assess whether students can explain their tasks through PBL. Besides, it provides such a structure for aligning course learning outcomes, methods of teaching including teaching strategy and learning activity, and methods for assessing students' performance. Instead of prioritizing student outcomes and mapping them to direct metrics related to curriculum, the model is also used to highlight areas of engineering education where significant opportunities exist for improving the preparedness of our students for capstone and ultimately for professional practice. This paper also addresses an early stage of a study to seek the challenges in incorporating complex engineering problems during designing a capstone design model.

Keywords: Engineering education, Project-based learning, teaching, and learning model, Chemical engineering capstone design, complex engineering problems.

Introduction

This demanding global world needs engineers with many different skills and traits, and it is the role of engineering instructors to change the way engineering is taught. To compete in a world that is changing quickly, they must utilize their problem-solving skills to educate a new kind of engineer who can hit the ground running as soon as they graduate. As engineering education in the 21st century necessitates students to be prepared for a dynamic and complex work environment. The chemical engineering curriculum must therefore incorporate experiential learning that incorporates complexity, innovation, and knowledge application in the chemical engineering curriculum.

The development of capstone design courses is an effort to bring the practical side of engineering back to the engineering curriculum (Dutson et al., 1997). Capstone is intended to provide students with an opportunity to demonstrate their readiness for professional practice (Steiner & Kanai, 2016). A defining characteristic of an engineer is the ability to work with complexity and uncertainty while solving complex engineering problems. Industry leaders, academicians, and Accreditation Board for Engineering and Technology (ABET) standards have expressed renewed interest in teaching engineers to solve real-world and open-ended problems through design education in recent years.

When six of the outcomes use the phrase "solve complex engineering problems or activities," it shows how important it is for graduates to be able to do this. In fact, these outcomes are right in line with the engineering standards set by the Washington Accord, which all engineering accreditation signatory bodies that have signed it must also follow (Mohd-Yusof et al., 2014; Mohd-Yusof et al., 2015).

Program Outcomes (PO) or Graduates Attribute (WA) describe what students are expected to know and be able to perform or attain by the time of graduation. The transition to outcome-based education, particularly in engineering education, places emphasis on the requirement that all undergraduate engineers must be able to meet the POs as stated in the 2020 Engineering Programme Accreditation Manual (BEM,2020) as follow:

- *WA1. Engineering Knowledge* – Apply knowledge of mathematics, natural science, engineering fundamentals, and engineering specialization as

Pauzi, A. and Kasim F.H. (2023), Review on Chemical Engineering Capstone Design Teaching Model to Drive Continuous Improvement and Achieving Program Outcome, *ASEAN Journal of Engineering Education*, 7(1), 24-33.

specified in WK1 to WK4 respectively to the solution of complex engineering problems;
- *WA2. Problem Analysis* - Identify, formulate, conduct research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences (WK1 to WK4);
- *WA3. Design/Development of Solutions* - Design solutions for complex engineering problems and design systems, components, or processes to meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations (WK5);
- *WA4. Investigation* - Conduct an investigation of complex engineering problems using research-based knowledge (WK8) and research methods including the design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions;
- *WA5. Modern Tool Usage* - Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering problems with an understanding on the limitations (WK6);
- *WA6. The Engineer and Society* - Apply reasoning informed by contextual knowledge -to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions of complex engineering problems (WK7);
- *WA7. Environment and Sustainability* - Understand and evaluate the sustainability and impact of professional engineering work in the solutions of complex engineering problems in societal and environmental contexts (WK7);
- *WA8. Ethics* – Apply ethical principles and commit to the professional ethics, responsibilities and norms of engineering practice (WK7);
- *WA9. Individual and Team Work* - Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings;
- *WA10. Communication* - Communicate effectively on complex engineering activities with the engineering community and society at large such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions;
- *WA11. Project Management and Finance* - Demonstrate knowledge and understanding of engineering management principles and economic-decision making and apply these to one's own work, as a member and leader in a team, to manage projects in multidisciplinary environments.
- *WA12. Life Long Learning* -Recognize the need and have the preparation and ability to engage in independent and life-long learning within the broadest context of technological change.

Problem-based learning (PBL) is an educational strategy in which the problem serves as the learning process's beginning point. It is essential that the problem serve as the learning process's foundation. There is an argument that project work or project-based learning (PjBL) is by definition problem-based (Helle et al., 2006). PjBL is primarily motivated by the need to adapt to a changing world. The argument is that students should strive in an environment centered on learning instead of on teaching. PjBL aims to create a student-centered environment in which assignments are attempted and completed. The more the task reflects reality, the more the students feel motivated. Therefore, working on a project can be seen as a way of organizing various simultaneous and integrated learning processes. Through PjBL, especially in capstone design, engineering students should be able to come up with creative solutions to hard engineering problems that meet the specified needs. This is demonstrated in Figure 1, where it was discovered that Graduates Attributes, (WA3) requires engineering students to be able to provide design solutions for challenging engineering problems that satisfy the requirements (Alexa Ray Fernando, 2022).

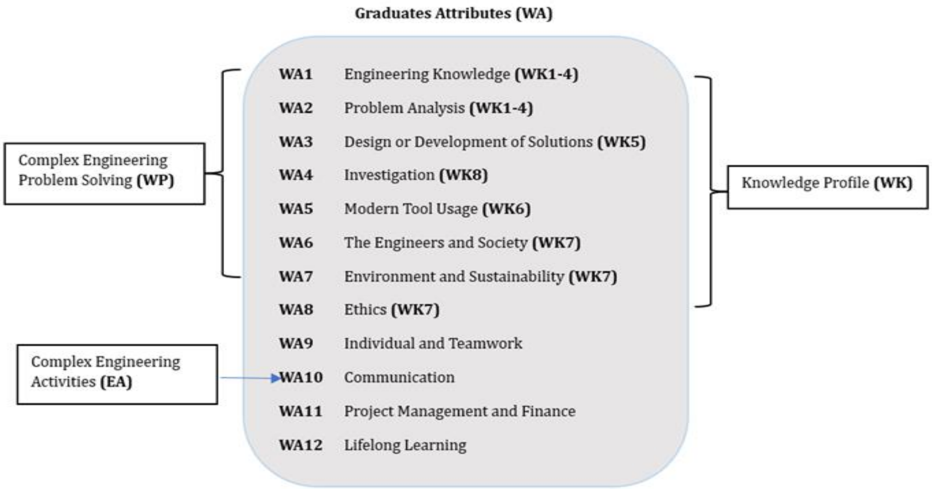


Figure 1. Complex Engineering Solving in WA's 12 Graduate Attributes

According to the IEA (2015), the range of complex problem solving is defined in Table 1.

Table 1. Definition of Complex Engineering Solving (WP)

No. & Attribute	**Complex problems** have characteristic WP1 and some or all of WP2 to WP7:
WP1 Depth of Knowledge Required	Cannot be resolved without in-depth engineering knowledge at the level of one or more of WK3,WK4,WK5,WK6 or WK8 which allows a fundamental-based, first principles analytical approach.
WP2 Range of conflicting requirements	Involve wide-range or conflicting technical, engineering and other issues.
WP3 Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.
WP4 Familiarity of issues	Involve infrequently encountered issues.
WP5 Extend of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering.
WP6 Extend of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs.
WP7 Interdependence	Are high level problems including many component parts or sub-problems

It is important to note that incorporating complex engineering problems, as described by IEA, to an engineering curriculum needs at least the first attribute and any of the attributes from WP2 to WP7.

The range of complex engineering activities (EA) is defined in Table 2.

Table 2. Definition of Complex Engineering Activities

No. & Attribute	**Complex activities** mean (engineering) activities or projects that have some or all of the following characteristic:
EA1 Range of resources	Involve the use of diverse resources (and for this purpose resources includes people, money, equipment, materials, information and technologies).
EA2 Level of interactions	Require resolution of significant problems arising from interactions between wide ranging or conflicting technical, engineering or other issues.
EA3 Innovation	Involve creative use of engineering principles and research-based knowledge in novel.
EA4 Consequences to society and the environment	Have significant consequences in a range of contexts, characterised by difficulty of prediction and mitigation.
EA5 Familiarity	Can extend beyond previous experiences by applying principles-based approaches.

A programme that builds this type of knowledge and develops the attributes listed below is typically achieved in 4 to 5 years of study, depending on the level of students at entry. The curriculum shall encompass the knowledge profile as summarised in Table 3.

Table 3. Definition of Knowledge Profile

No.	**Knowledge Profile**
	A systematic, theory-based understanding of the natural sciences applicable to the discipline.
WK2	Conceptually-based mathematics, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline.
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
WK5	Knowledge that supports engineering design in a practice area.
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.

WK7	Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability.
WK8	Engagement with selected knowledge in the research literature of the discipline.

Through capstone design projects, these attributes are extensively implemented to culminate the design experience of engineering students. Each institution of higher education has its own approach to designing and delivering capstone design projects, with the awareness that problem definition is a crucial phase of the design process that students must be properly educated and guided on.

Issues and Challenges

Additionally, according to a report on the future of engineering education in Malaysia (MOHE, 2006), employers believe that engineering graduates have the lowest level of proficiency in problem identification, formulation, and resolution and the highest level in theoretical engineering. This may indicate that students are able to fully comprehend theories but struggle to implement them practically, particularly when attempting to solve complex engineering problems through capstone design project. Kamaruzaman et al. (2018) reviewed that there are several issues and challenges to incorporate complex engineering problems during capstone design projects. Among those topics discussed are project irrelevance, faculty involvement, industrial involvement and conflict in assessment. On the other hand, research shows that learning by solving real-world problems can give context, leading to deep and meaningful learning and helping students to remember, transfer, or use their knowledge in other situations (Kamaruzaman et al., 2018). This research is necessary and should therefore be emphasized by engineering educators. Consequently, the model is used to emphasize the areas of engineering education where substantial opportunities exist for enhancing students' readiness for capstone projects and ultimately for professional practice.

In addition, varying interpretations or expectations from universities and industries make it more challenging to include complex engineering problems in capstone design projects. However, there are methods to accommodate both industry and universities in this circumstance. The first objective is to ensure that the industry understands the faculty's expectations and learning outcomes. For instance, this can be accomplished by providing vital information regarding the faculty-established learning outcomes. According to Phang et al. (2016), analysis of complex engineering challenges created by professors of engineering and reviewed by specialists, 58.5% of the issues were not deemed complex based on the characteristics listed in (ABET, 2009). Due to this circumstance, students have fewer opportunities to interact with difficult technical issues that real-world engineers encounter on a daily basis. Most projects assigned to undergraduate students are basic, unchallenging, limited, lack of real issues, well-structured, and incongruous with real-world work environments (Mohd-Yusof et al., 2014; Jamaludin et al., 2012). As a result, there is a mismatch between the needs of industry and students and what engineering education provides (Jonassen et al., 2006; J Heywood, 2005)

Mohd Yusof et al. (2014) and Phang et al. (2018) said that problems in the workplace are not the same as the problems that are often given to students in the classroom. Usually, projects at work are hard and have problems that aren't well-structured. On the other hand, projects in the school have problems that are well-structured. This can develop negative perception among students and make it hard for themselves to work in the real world once they realise how different what they learned in the classroom is from what they are experiencing. Cho and Jonassen (2002) agreed that being able to solve common classroom problems does not mean that a student will be able to solve real job problems.

To challenge students' critical thinking skills in capstone design, instructors in the industry should allow sufficient time for students to devise alternate solutions for their projects. Literature demonstrates that industrial participation in culminating design projects is always advantageous and valuable (Rasul et al., 2015; Uziak, 2016). Capstone design projects would benefit from collaboration with industry because their insights can aid in project development. The designed assignments should resemble those that students are likely to encounter in their professional careers. The stakeholders (students, faculty, all academic administrators, and the industry) must understand and identify the attributes and characteristics of complex engineering problems to incorporate them into the engineering curriculum via capstone design projects. In addition, the faculty should prepare and train engineering graduates to be capable of completing a capstone design project while taking into account other aspects of life. As an industry, engineering professional organizations, and accreditation bodies place a greater emphasis on the solution of complex engineering problems, and students need to be able to identify and define complex engineering problems. As a result, the purpose of this research is to develop a teaching and learning model for the capstone class among final-year students and hope that is simple enough for students to comprehend. Developing appropriate and effective teaching methods, techniques, and strategies is essential for a successful teaching process.

Learning Theory applied in capstone project

McHenry et al. (2005) introduced constructivism as a learning theory that facilitates the growth of engineers' competencies for engineering practice and through graduate education. As far as engineering education at the undergraduate level is concerned, the teaching and learning approach focuses on the development of specific actual knowledge that, when intellectually combined, enables the understanding of engineering principles, scientific laws, and mathematics applications required to conceptualize and execute design-oriented solutions to problems.

The cognitive learning theory of cognitivism supports this approach. As long as engineers apply their knowledge to real-world situations, an engineering education based on cognitive processes is sufficient for preparing engineering graduates. Therefore, educators must implement this theoretical constructivist learning approach because it will be able to challenge or encourage students' metacognitive and cognitive thinking skills in the context of solving complex engineering problems via capstone design projects. Moreover, through this method, students will reflect on their own experiences to construct their worldview. This implies that they will develop their own norms and mental models to comprehend their own experiences.

Figure 2 is an example of a constructivist illustration of such a process model through constructivism.

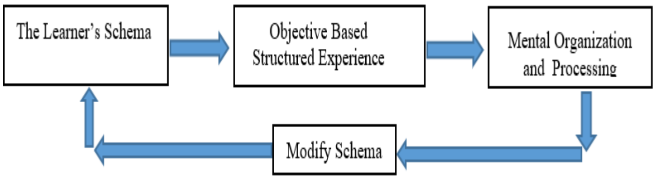


Figure 2. The process model of constructivism

This process model demonstrates that constructivism encourages the mental construction of the student's reality (experiences) and that the student generates new understanding through the mental processing of each new experience about existing knowledge. In addition, constructivism influences the learning process through curriculum, instruction, and assessment, but this will not be elaborated upon in this paper. To manage and evaluate capstone design assignments, a model is utilized.

Literature Review

New labor market demands driven by industry 4.0 advancements necessitate a transformation in engineering education. According to M. Krsmanovic (2019), UNESCO's concern is to train engineers to satisfy the labor market demands of modern labor. This demonstrates that STEM occupations have increased dramatically in recent years. This study is being undertaken concerning the existing situation and future developments to develop engineers who can address the great problems of the moment in real life. In an age of growing globalization, engineering education must emphasize transferable abilities and allow STEM graduates to develop cross-capacity, making them more marketable and flexible in their working environment. Furthermore, because tertiary education as a public good foster a high level of trust among graduates and businesses, there is a need to introduce a more holistic approach to engineering education, with the possibility of reorganizing current practices in the curriculum to better prepare engineers for future challenges.

In addition, in capstone design, it is essential to equip future engineers with these skill sets to meet the industry's current demand. Interactive methods are needed to be introduced to chemical engineering students as most elements of Industry 4.0 such as augmented reality (AR) and virtual reality (VR) and internet things become important nowadays (Oveissi & Ghadi, 2021). The successful implementation of this initiative has prompted us to investigate the possibility of converting some of our traditional teaching techniques to 4.0 versions as prospective hands-on activities. According to Chandrasekaran et al. (2013**)**, they stated that improving students' knowledge and facilitating their transition into the workforce requires effective collaboration between educational institutions and industry partners. Globally, project-based learning (PBL) is well-developed and implemented in the majority of engineering institutions and departments. Universities are thought to be the location where new information is identified, and industry is thought to be the setting where knowledge is put into practice.

Practicing design is one of the fundamental processes in engineering and all other related engineering activities. In one way or another, accreditation bodies such as the Accreditation Board for Engineering and Technology (ABET), Engineers Australia (EA), and the European Accreditation of Engineering Programmes (EUR-ACE) stipulate that the ability to identify, formulate, and solve engineering problems are essential skills in an engineering program. Steiner & Kanai (2016**)** has proposed a new progress model for capstone, which highlights its unique role in the engineering education curriculum for continuous improvement. The basic assumption is students should be prepared and able to work on an open-ended real-world project and show that they can use the knowledge and abilities they've acquired so far to address a problem in the real world.

Campbell et al. (2015) have defined a generation as a group of people born around the same time who grow up in the same cultural environment and then shape that culture. Generation Z students are viewed as risk-averse and distinct, and universities must be prepared to meet the challenge of educating this new generation (Moore et al., 2017). As a result, educators of engineering are challenged to adjust to these changes.

Capstone Teaching and Learning Model

The addition of capstone into the curriculum by ABET 2000 forced many engineering programs across the nation to address the need for providing a new form of experiential learning for students (Steiner & Kanai, 2016). Instead of focusing on the knowledge of abstract principles, analysis, and engineering fundamentals, the introduction of the capstone course meant that educators also needed to address synthesis and consider the skills needed for engineering graduates to actually use their newfound knowledge in practice (Froyd et al., 2012). To obtain outcomes, the teaching and learning environment which is applied in this capstone design model is an interactive process that requires the participation of both teachers and students. Constructionist theory (Case & Light, 2011) and collaborative learning (Mills J.E., and Treagust, 2003) are the foundations of active learning. Moreover, McHenry et al. (2005b) stated that constructivism is the most effective learning theory and process for the development of professional competence. This theory's central premise is that knowledge is not transmitted from teacher to pupil, but rather actively constructed. This is crucial in the context of engineering knowledge based on theoretical foundations (Taajamaa & Holvitie, 2018). This supports by Freeman et al. (2014), he stated that active learning and problem-based learning have been demonstrated to increase performance in STEM classes and develop the ability to solve complex problems. This is crucial for the development of successful engineers through capstone design projects.

Gomez-del Rio & Rodrigue (2022) assert that constructivist learning theory, which holds that learning is centered on understanding and creating meaning, provides the basis for the project-based learning paradigm. Nevertheless, capstone design project should be embedded with the elements of complex engineering problems to make the project more similar to the industrial world. Todd and Magleby (2005) stated that students become more interested to participate and learn well if the given projects are relevant and can help them to be successful engineers later. Modification and simplification of real-world projects would be beneficial for capstone design projects. Jin et al. (2015) made an instrument to test and improve design skills. He said that identifying and defining problems, which are the stages of design problems, are the most important design skills. In this phase, students are expected to possess the knowledge and abilities necessary to solve complex engineering problems. Therefore, students undertaking a capstone design assignment must first identify and define their engineering complex. As a result, to address this challenge, educational innovators have created a model with learning techniques such as inquiry learning, collaborative learning, flipped classrooms, project-oriented problem-based learning, team teaching, and digital environments for education (Hutchings & Quinney, 2015). The majority of these approaches are student-centered, with lecturers facilitating student interaction with information and peers. Due to the requirement to solve complex and multiparametric difficulties, the rapidly changing employment market is now calling for engineering graduates with a more comprehensive set of abilities (Ballesteros et al., 2021).

Up to this point in time, the majority of our efforts as instructors have gone into building a strong capstone course. There hasn't been a lot of effort made into exploring and using the intelligence gained from capstone projects as a way to close the knowledge and skill gap between what students need to be successful and what they really have (Steiner & Kanai, 2016). Our experience indicates that it may be possible to use capstone to assess the preparedness of graduating engineering students for professional practice and in turn use this as feedback to the curriculum to affect change. The earlier progressive model proposed for capstone in the engineering curriculum showed that capstone in the new model serves as the ‘final exam’ for all POs which is mapped to direct measures from assignment in the capstone course. Figure 3 is a model for Capstone in Relation to the Engineering Curriculum.

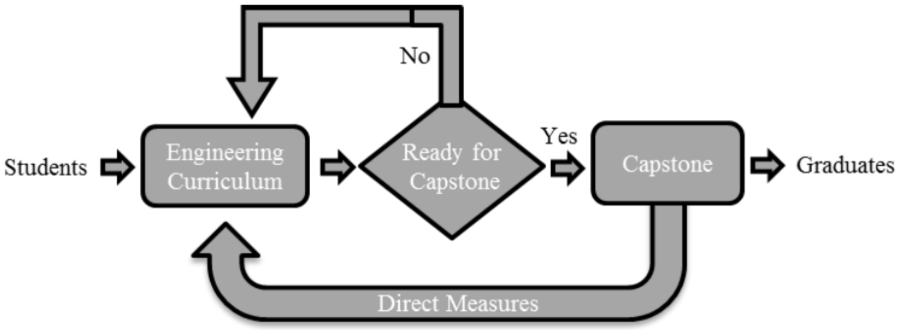


Figure 3. A model for Capstone in Relation to the Engineering Curriculum (Steiner & Kanai, 2016).

This model mapping direct measures of student outcomes to knowledge and skills. In general, engineering programmes should not rely exclusively on capstone for all direct measures of student outcomes. Rather, direct and indirect measures should be monitored from a variety of perspectives, including coursework (direct measures) and post-graduate surveys (indirect measures). This model demonstrates that it is possible to monitor all ABET student outcomes (PO) at the capstone level. The model presented shows that it possible to monitor student progress throughout the curriculum in order to ensure that students are indeed prepared for the capstone project and are consequently better prepared for professional practice.

On the other hand, the concept of the Project-based learning (PjBL) model that was proposed by Qattawi et al. (2021) covers more ground than previous models. The learning model that is utilized by senior-level engineering students participating in design-based learning may be seen in Figure 4.

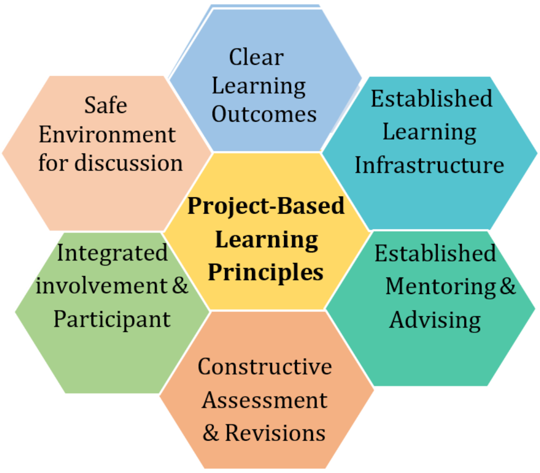


Figure 4. Project-based Learning model (Qattawi et al., 2021)

The design principles of PjBL model which can be adapted to Design-based Learning (DBL), must convey the learning objectives and ensuring the effectiveness of the model. Darling-Hammond et al. (2015) discussed the main four principles necessary for the success of PBL: those are (1) specific learning outcomes that translate into project goals and objectives, the essential questions the project will handle, and the connections between the design activities and the learning purposes the faculties are seeking; (2) learning resource that supports both student and instructor learning; and (3) revision and assessment plans. The evaluation process can be any of the form of self, peer, student to faculty, and faculty to student assessments. But it must ensure that the learning objectives are met; (4) promoting participation and involvement through the proper social organization of the students' groups, faculty, and public community.

One of the strengths of this model is that it includes (1) a learning resource that is beneficial to the learning of both students and instructors; (2) revision and assessment plans; and (3) specific learning outcomes that translate into project goals and objectives. Other strengths of this model include the essential questions that will be addressed by the project, as well as the connections between the design activities and the learning purposes that the faculties are seeking. In addition, the students' groups and forums should function to encourage participation. The structure for the necessary roles and interaction needed for project completion should be provided. These roles may include mentoring roles of faculty, mentoring, and advising from industry professionals and even students' groups. Ayas and Zeniuk (2001) proposed two additional components for the PjBL model. They highlighted the importance of (5) leader role models. The attitude for learning and monitoring the behavior and results are set by the role models. They also emphasized on (6) the necessity of creating a psychologically safe learning environment, which promotes and encourages design creativity and offers a platform for constructive discussions and feedback.

Furthermore, Jamieson & Shaw (2020) proposed a situational model in Figure 5 which this model is compared to the capstone process design course community of practice environment, where innovation can be more narrowly defined and measured based on objective improvement in the performance of a process or a product. The embedded aspect of the learning space within a community of practice adds value to this paradigm, and the larger innovation ecosystem is situational. Engineers are introduced to the community and given a practicing environment in which to solve the problem utilizing this model method.

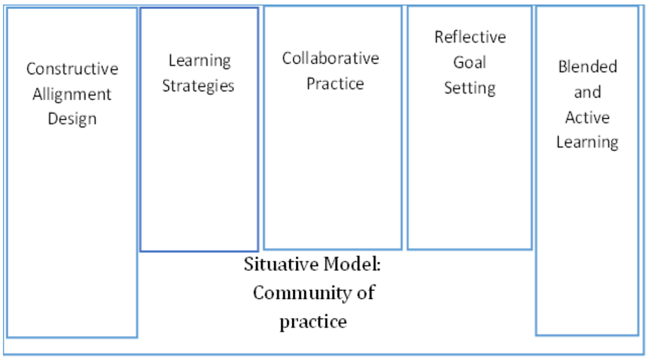


Figure 5. Experiential learning environment for capstone design supporting design, innovation, and leadership development in a community of practice (Jamieson & Shaw, 2020)

Undergraduate engineering curricula should provide ample opportunities for students to learn, practice, and demonstrate development of graduate attributes. In addition, planned opportunities for feedback on both technical and professional task performance combined with active reflection on their progress is required. This teaches students how to identify their strengths, their weaknesses, and to target their next steps to continue to learn and to develop effectively. The "ability to work as an effective team member or leader" does not develop merely by listening to a lecture on either subject! Knowledge of the principles of effective leadership does not necessarily make one an effective leader. Equally applicable to becoming an effective innovator or designer. Changing only the assessment method to one that requires performance demonstration without offering the chance to develop a skill through feedback is similarly ineffective.

The embedded nature of the learning space within a community of practice and the larger innovation ecosystem is situative (Ito et al., 2014; Jamieson, 2016) in nature and Situativity Theory (Greeno et al., 2013) is the framework and context for this study and capstone course design. The construction of learning by students in an environment where the learning objectives of a program of study are consistent with the required assessments and outcomes are central to the theory of constructive alignment (Biggs, 2012). Through this model students are introduced to and taught about team, design, and innovation processes through learning about learning, thinking, and reflective skills. A blended and active learning environment engages students in processes and encourages reflection and sense making (Jamieson, 2016). A community of practice provides students with mentors and models of the innovation process, as well as an environment for the development of engineering design, innovation, and leadership skills. Working in teams on goal-oriented tasks earlier and more frequently in their programme of study was also cited as potentially advantageous for developing skills necessary for the capstone design course. These student suggestions reflect a desire for earlier learning experiences that would help them develop engineering practice-related skills in addition to engineering knowledge. The intended learning outcome of the described pedagogical intervention was to provide students with opportunities to practise leadership, creativity, and innovation as contributors to open-ended capstone design projects. In conclusion, this model has a positive impact on both instructors and pupils.

Discussion

Capstone design is used by many engineering programs throughout the world to help students get ready for real-world engineering work. This literature study highlighted the significance of chemical engineering students' preparation for the capstone design course. The proposal of a suitable model for usage as a learning and teaching approach among senior project students is intriguing from a pedagogical perspective. At this point, an integrated approach has emerged by combining all elements in the past capstone design model. This perhaps the effective teaching and learning model through the PjBL strategy can be prepared for the future engineers. Besides, the direct measurement process consists of a set of instruments and actions. This instrument used to monitor student's performance. The design and development of the model is carried out by experienced instructors who have participated in capstone design. A section could be added in the instruments for reflection. Compilation of the results from all experts in the course will provide invaluable insights for continuous improvement. The feedback may include a combination of qualitative and quantitative feedback from students and instructors. Students reflective have an important role in monitoring what individual students have learned from the course and its applicability to professional practice.

The outcomes of graduating students in this design course may benefit from this strategy. It is envisaged that the inclusion of design-based courses in engineering curricula will help bridge the gap between engineering graduates' abilities and the certifications or skills needed in the industry. Capstone design courses are highly considered valuable learning activities because they give students the chance to work on real-world engineering projects. Moreover, engineering programs are revising their curricula to better equip graduates for future problems, as they are aware of this necessity. This culminating experience allows professors to gauge the efficacy of their students' undergraduate education as a whole and to identify problem areas for remediation. This may point to a place of growth in a certain capstone design course.

Summary, Limitation, and Future Work

In conclusion, this article has gone over the crucial aspects that students need to grasp to better their performance in the capstone course that they take during their last year of study for their engineering degree. Nevertheless, project-based learning that includes a design component is very difficult and has the potential to give students quick feedback to continue to improve their performance. It is expected of engineers to find solutions to difficult technical challenges, as this is a need from the industry as well as a requirement from professional organizations and accrediting agencies. As a result, educational establishments of a higher level need to take part in this initiative to raise the number of engineers capable of resolving difficult issues in Malaysia. Education in design should be given sufficient emphasis within the engineering curriculum to reflect the fact that complex problems are most likely to be solved via the process of design. Therefore, students should work on improving their capstone design project to become better engineers for future difficulties. The major culminating design experience requires students to have knowledge and expertise to succeed. They will become more marketable to potential employers and flexible in the environments in which they operate as a result of this. It has been suggested that the fundamental ideas taught in engineering classes should be rethought to incorporate a more holistic perspective, particularly in the capstone design class. This would make engineering education more relevant to the setting of Industry 4.0.

References

ABET, "Criteria for Accrediting Engineering Programs, "www.abet.org/wp-content/uploads/2015/04/criteria-eac-2010-2011.pdf , 2009.

Alexa Ray Fernando, J. G. U. V. and C. A. D. C. (2022). Work in progress: Perception of complex engineering problem among capstone design students. *IEEE*, *0*, 14–16.

Ballesteros, M. Á., Sánchez, J. S., Ratkovich, N., Cruz, J. C., & Reyes, L. H. (2021). Modernizing the chemical engineering curriculum via a student-centered framework that promotes technical, professional, and technology expertise skills: The case of unit operations. *Education for Chemical Engineers*, *35*, 8–21. https://doi.org/10.1016/J.ECE.2020.12.004.

Campbell, W. K., Campbell, S. M., Siedor, L. E., & Twenge, J. M. (2015). Generational differences are real and useful. *Industrial and Organizational Psychology*, *8*(3), 324–408. https://doi.org/10.1017/iop.2015.43.

Case, J. M., & Light, G. (2011). Emerging methodologies in engineering education research. *Journal of Engineering Education*, *100*(1), 186–210. https://doi.org/10.1002/j.2168-9830.2011.tb00008.x.

Chandrasekaran, S., Stojcevski, A., Littlefair, G., & Joordens, M. (2013). Project-oriented design-based learning: Aligning students' views with industry needs. *International Journal of Engineering Education*, *29*(5), 1109–1118.

Cho, K. L., & Jonassen, D. H. (2002). The effects of argumentation scaffolds on argumentation and problem solving. *Educational Technology Research and Development*, *50*(3), 5–22. https://doi.org/10.1007/BF02505022.

Dutson, A. J., Todd, R. H., Magleby, S. P., & Sorensen, C. D. (1997). A Review of Literature on Teaching Engineering Design Through Project-Oriented Capstone Courses. *Journal of Engineering Education*, *86*(1), 17–28. https://doi.org/10.1002/j.2168-9830.1997.tb00260.x.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111.

Froyd, J. E., Wankat, P. C., & Smith, K. A. (2012). Five major shifts in 100 years of engineering education. *Proceedings of the IEEE*, *100*(SPL CONTENT), 1344–1360. https://doi.org/10.1109/JPROC.2012.2190167.

Gomez-del Rio, T., & Rodriguez, J. (2022). Design and assessment of a project-based learning in a laboratory for integrating knowledge and improving engineering design skills. *Education for Chemical Engineers*, *40*, 17–28. https://doi.org/10.1016/J.ECE.2022.04.002.

Greeno, J. G., Collins, A. M., & Resnick, L. B. (2013). Cognition and learning. In *Handbook of Educational Psychology* (pp. 15–46). https://doi.org/10.4324/9780203053874-8.

Helle, L., Tynjälä, P., & Olkinuora, E. (2006). Project-based learning in post-secondary education - Theory, practice and rubber sling shots. *Higher Education*, *51*(2), 287–314. https://doi.org/10.1007/s10734-004-6386-5.

Hutchings M and Quinney A "The Flipped Classroom, Disruptive Pedagogies, Enabling Technologies and Wicked Problems: Responding to 'the Bomb in the Basement'" *The Electronic Journal of e-Learning* 13(2) 2015, (pp106-119).

Jamaludin, M. Z., Mohd.Yusof, K., Harun, N. F., & Hassan, S. A. H. S. (2012). Crafting Engineering Problems for Problem-Based Learning Curriculum. *Procedia - Social and Behavioral Sciences*, *56* (ICTLHE), 377–387. https://doi.org/10.1016/j.sbspro.2012.09.666.

Jamieson, M. V., & Shaw, J. M. (2020). Teaching engineering innovation, design, and leadership through a community of practice. *Education for Chemical Engineers*, *31*, 54–61. https://doi.org/10.1016/j.ece.2020.04.001.

Jamieson, M. V. (2016). *Application of Blended and Active Learning to Chemical Engineering Design Instruction*. 1–260.

Jin, S. H., Song, K. Il, Shin, D. H., & Shin, S. (2015). A Performance-Based evaluation rubric for assessing and enhancing engineering design skills in introductory engineering design courses. *International Journal of Engineering Education*, *31*(4), 1007–1020.

Jonassen, D., Strobel, J., Lee, C., Technologies, L., Programme, E. T., Sciences, L., & Group, T. A. (2006). Everyday Problem Solving in Engineering : *Journal of Engineering Education*, *9*(2), 139–151. http://onlinelibrary.wiley.com/doi/10.1002/j.2168-9830.2006.tb00885.x/abstract.

Kamaruzaman, F. M., Hamid, R., & Mutalib, A. A. (2018). A review on issues and challenges in incorporating complex engineering problems in engineering curriculum and proposed solutions. *Proceedings - 2017 7th World Engineering Education Forum, WEEF 2017- In Conjunction with: 7th Regional Conference on Engineering Education and Research in Higher Education 2017, RCEE and RHEd 2017, 1st International STEAM Education Conference, STEAMEC 201*, *November*, 697–701. https://doi.org/10.1109/WEEF.2017.8467167.

M. Krsmanovic, I. (2019). "STEMANITIES"' as a Future Fit Scholarship:Trends and Challenges in Engineering Education for Industry 4.0. *Emerging Trends in Industrial Engineering*, *November*, 0–6. https://doi.org/10.21428/92f19a8b.594c147f.

McHenry, A. L., Depew, D. R., Dyrenfurth, M. J., Dunlap, D. D., Keating, D. A., Stanford, T. G., Lee, P., & Deloatch, G. (2005). Constructivism: The learning theory that supports competency development of engineers for engineering practice and technology leadership through graduate education. *ASEE Annual Conference and Exposition, Conference Proceedings*, *January 2015*, 2263–2268.

Mills J.E., and Treagust, D. (2003). *Engineering education-Is problem-based or project-based learning the answer? Cite this paper*. http://www.aaee.com.au/journal/2003/mills_treagust03.pdf

Mohd-Yusof, K., Helmi, S. A., Phang, F. A., & Mohammad, S. (2015). Future Directions in Engineering Education : Educating Engineers of the 21st Century. *ASEAN Journal of Engineering Education*, *2*(1), 8–13.

Mohd-Yusof, K., Phang, F. A., & Helmi, S. A. (2014). *How to develop engineering students' problem solving skills using cooperative problem based learning (CPBL)*. https://doi.org/10.5339/qproc.2014.wcee2013.30.

Moore, K., Jones, C., & Frazier, R. S. (2017). Engineering Education For Generation Z. *American Journal of Engineering Education (AJEE)*, *8*(2), 111–126. https://doi.org/10.19030/ajee.v8i2.10067

Oveissi, F., & Ghadi, A. E. (2021). Preparing Chemical Engineers for Industry 4.0: An Interactive Education Approach. *9th Research in Engineering Education Symposium and 32nd Australasian Association for Engineering Education*

Conference, REES AAEE 2021: Engineering Education Research Capability Development, *1*, 65–73. https://doi.org/10.52202/066488-0008.

Phang, F. A., Anuar, A. N., Aziz, A. A., Yusof, K. M., Syed Hassan, S. A. H., & Ahmad, Y. (2018). Perception of complex engineering problem solving among engineering educators. *Advances in Intelligent Systems and Computing*, *627*(January), 215–224. https://doi.org/10.1007/978-3-319-60937-9_17.

Qattawi, A., Alafaghani, A., Ablat, M. A., & Jaman, M. S. (2021). A multidisciplinary engineering capstone design course: A case study for design-based approach. *International Journal of Mechanical Engineering Education*, *49*(3), 223–241. https://doi.org/10.1177/0306419019882622.

Rasul, M. G., Lawson, J. J., Howard, P., Martin, F., & Hadgraft, R. (2015). Learning and teaching approaches and methodologies of capstone final year engineering projects. *International Journal of Engineering Education*, *31*(6), 1727–1735.

Steiner, M. W., & Kanai, J. (2016). Using capstone to drive continuous improvement in the curriculum. In *ASEE Annual Conference and Exposition, Conference Proceedings* (Vols. 2016-June). https://doi.org/10.18260/p.27134

Taajamaa, V., & Holvitie, J. (2018). *Co-creative engineering curriculum design* –.

Uziak, J. (2016). A project-based learning approach in an engineering curriculum. *Global Journal of Engineering Education*, *18*(2), 119–123.

Knowledge Requirement of Incorporating Artificial Intelligence in Engineering Education through TPACK

Article history
Received
14 June 2023
Received in revised form
21 June 2023
Accepted
21 June 2023
Published online
30 June 2023

Nurzal Effiyana Ghazali[a*], Nor Farahwahidah Abdul Rahman[b]
[a,b]Centre for Engineering Education
University Teknologi Malaysia, 81310 Johor Bahru, Malaysia
[a]Faculty of Electrical Engineering
University Teknologi Malaysia, 81310 Johor Bahru, Malaysia
[b]Faculty of Social Science and Humanities
University Teknologi Malaysia, 81310 Johor Bahru, Malaysia
**nurzal@utm.my*

Abstract

It is believed that Malaysians have no interest in the field of engineering education. Engineering curriculum development and educator development are neglected. As a result, most of engineering educators deliver the contents lack or without pedagogical knowledge. It becomes worst when they incorporate artificial intelligent applications in their classrooms without pedagogical knowledge. Therefore, this work is to create awareness among engineering educators about the knowledge that they need before using artificial intelligence in their classroom. The first author describes her experienced incorporating technology/artificial intelligence in engineering education. She discussed initial knowledge that engineering educators need before they are capable to teach a subject using artificial intelligence based on Technological, Pedagogical and Content Knowledge (TPACK) framework. However, this knowledge alone may not be translated into quality teaching. Therefore, the first author discussed Community of Inquiry (CoI) and she believes that CoI is a venue for engineering educators to simulate the knowledge. As a conclusion, TPACK can be modelled as engineering educators' professional knowledge and CoI as assessment method.

Keywords: Technology Knowledge, Pedagogy Knowledge, Content Knowledge, Engineering Education, Community of Inquiry.

Engineering Program in Malaysia

Engineering program in Malaysia are offered at both undergraduate and graduate levels that covers a wide range of topics. The quality of engineering programs controlled by Engineering Accreditation Council (EAC) and Board of Engineers Malaysia (BEM). The accreditation is carried out to ensure that the program produce competent and skilled engineers who met worldwide standards.

EAC standard is the foundation for the creation of engineering curricula. According to EAC Standard 2020 (Engineering Accreditation Council, 2020), an engineering program should have a minimum of 135 Student Learning Time (SLT) credits based on a semester of instruction that lasts 14 weeks. These credits should be divided into:

a) At least 90 SLT credits must be in engineering, including engineering sciences and projects relevant to the student's field of study.
b) The remaining SLT credits must have enough general education material to support the technical curricula material.

Figure 1 is a general description of the Malaysian engineering program.

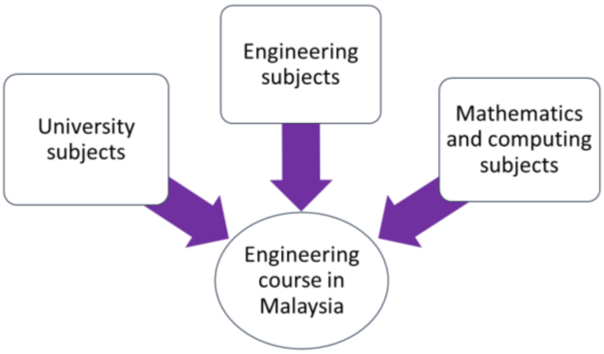


Figure 1. General description of the Malaysian Engineering Program

The components can be divided into three parts: university subjects with often general content, core subjects relevant to the student's area and computing and mathematics subjects. As a result of this structure, the curriculum is designed for students to obtain plenty chances with analytical critical, constructive, creative and evidence-based thinking within engineering complex problems. The sophisticated engineering activities, knowledge profile and problem-solving components of the curriculum are all taken seriously by EAC.

Ghazali N.E. & Abdul Rahman N.F (2023), Knowledge Requirement of Incorporating Artificial Intelligence in Engineering Education through TPACK, *ASEAN Journal of Engineering Education*, 7(1), 34-40.

Artificial Intelligence in Engineering Education

Artificial Intelligence (AI): What it is? John McCarthy provides the following definition: *"It is the science and engineering of creating intelligent machines, particularly clever computer programs. Although it is related to the related to the related job of utilizing computers to comprehend human intellect, AI should not be limited to techniques that can be observed by biological means"* (Mccarthy, 2007). There are many applications of AI build for academic purposes. It is commonly seen in speech recognition, customer service, computer vision, healthcare, personal assistant and e-commerce are some of the more typical uses.

AI has the ability to enhance student learning and support engineering educators in the field of engineering education. Jose L. Martin Nunez & Andres Diaz Lantada introduced the concept of "artificial intelligence-aided engineering education" to describe the use of AI techniques and resources to enhance the entire teaching-learning process in higher education. Therefore, it has a big impact on engineering education, from curriculum planning and development to teaching and learning (T&L) strategies, teaching methods, assessment and on learning outcomes.

The most well-liked AI applications that currently used in engineering education is a generative pre-trained transformer model (GPT) called ChatGPT. It creates content in response to an interaction with a prompted query and order. On March 14, 2023, OpenAI released the latest ChatGPT, ChatGPT4. It is more collaborative and innovative than ever. When working with users on creative and technical writing activities like songwriting, screenwriting or figuring out a user's writing style, it can generate, edit and iterate with them.

According to ChatGPT features, engineering education can benefit from personalized learning, the development of critical thinking and problem-solving skills, the promotion of active learning, and the ability for students to receive rapid feedback on their works. Besides that, it can benefit students in researching new engineering topics, cutting-edge research and industry trends and can be used as a resource for strengthening engineering principles.

The application of AI in teaching and learning comes with debates. Most debates surround ChatGPT for concern on plagiarism and students' cheating (Anders, 2023). Yet, the potential of using ChatGPT for teaching and learning has been actively discussed in literatures for its potential to aid deep learning for users. Looking at this opportunity, this paper discussed the potential usage of ChatGPT within teaching and learning theory.

Incorporating Technology in Engineering Education Classroom

It takes more effort to integrate technology than just picking an application and utilizing it in class. The first author is passionate in incorporating technology into engineering lessons. The subjects she has taught are listed in Table 1.

The first author has been assigned to various topics each year, as seen in Table 1. Despite having only a few weeks to prepare before the start of the semester, she is extremely motivated to use technology into her teaching and learning activities (T&L). Therefore, according to her experience, there are challenges arose: (a) "what should be delivered?," (b) "how can be delivered?" and (c) "in what way technology can be incorporated? There often time which teaching engineering courses and university courses is not within her research area, making it an issue with teaching delivery. Later she discovered question on "how can be delivered" is actually related to the topic matter. Inability to digest the subjects' content for teaching, has directly affects how content is presented in lectures.

She begins experimenting with numerous technology applications that are available online or shared by colleagues. Table 1 shows how she made an effort to include technology into her lessons. ChatGPT is the recent technology aid adopted for teaching purposes. Regardless of the intention, the enthusiasm, however it does not count for the classroom design and effectiveness of delivery.

Table 1. List of subjects that has been assigned to the first author

Year	Semester	Course	Technology Used
20222023	2	Data Communications and Networks	Cisco Packet Tracer – Networking Simulation Tool, Wireshark, ChatGPT, UTM eLearning, Discord
		Extra-Curricular Experiential Learning (University Subject)	Google Form, Google Sheet, UTM eLearning, Discord
	1	Capstone Project	Google Form, Jamboard, Discord
		Network Programming	Python, UTM eLearning, Discord
		Graduate Attribute (University Subject)	Jamboard, Coggle, UTM eLearning, Discord
20212022	2	Data Communications and Networks	Cisco Packet Tracer – Networking Simulation Tool, Discord, Wireshark, Zoom, UTM eLearning

		Graduate Attribute (University Subject)	Padlet, Discord, UTM eLearning
		Computer & Communication Networks	Zoom, UTM eLearning, Discord, UTM eLearning
	1	Signals & Systems	Explain Everything, Zoom, Jamboard, Discord, UTM eLearning
		Capstone Project	Google Form, Jamboard, Miro, Discord
		Graduate Attribute (University Subject)	Padlet, Discord, UTM eLearning
20202021	2	Electromagnetic Field Theory	edpuzzle, CMap, Zoom, Discord, UTM eLearning
	1	Introduction to Scientific Programming	MATLAB, Discord, UTM eLearning
		Capstone Project	Google Form, Jamboard, Miro, Discord
		Graduate Attribute (University Subject)	Padlet, Discord, UTM eLearning
20192020	2	Introduction to Scientific Programming	MATLAB, UTM eLearning
		Digital Electronic	Kahoot, UTM eLearning
	1	Signals & Systems	MATLAB, UTM eLearning
		Capstone Project	Miro
		Graduate Attribute (University Subject)	Google Form, UTM eLearning
20182019	2	Network Programming	Python, Sketchboard, UTM eLearning
		Broadband & Multimedia Networks	Network Simulator 3 (NS3), UTM eLearning
	1	Signals & Systems	Padlet, Schoology, MATLAB, UTM eLearning
		Capstone Project	Miro, UTM eLearning
20172018	2	Digital Electronic	Jigsaw Planet, Quartus II, UTM eLearning
	1	Signals & Systems	Padlet, MATLAB, UTM eLearning
		Capstone Project	Miro, UTM eLearning
20162017	2	Electronic	UTM eLearning
		Electronic Circuit	UTM eLearning
	1	Signals & Systems	Padlet, MATLAB, UTM eLearning
		Capstone Project	Miro, UTM eLearning

One of her major entry points to make the delivery theoretically driven is keynote lecture on Technological, Pedagogical, and Content Knowledge (TPACK). Coincidentally, the keynote speaker at one of the conferences she was attending had discussed the TPACK framework. She then realized that picking and implementing technology in the classroom is more complicated than she had previously thought.

Having this conversation reflectively allow existing practice to be continuously questions for further improvement. With strong commitment for engineering education, attending engineering education conferences and publishing articles is meaningful as part of professional growth in becoming good engineering educator.

Technological, Pedagogical and Content Knowledge (TPACK) Framework

A theory of knowledge is necessary for engineering educators in order to help them make sense of what they are doing and to give them control over their own inquiry processes. The theory of knowledge can be characterized as the practical knowledge of engineering educators, which refers to knowledge that has mostly been acquired through educator's professional experience. By examining the "what, how, and why" of information, engineering educators' knowledge can be evaluated. The "what" are the contents, the "how" are the methods of delivery and the "why" explain why the contents and methods of delivery should be adapted to particular disciplines.

Sadly, there is a dearth of pedagogical and philosophical understanding among engineering educators (Ghazali et al., 2021). Making things getting worse when engineering educators lack the experience to use technology. Talking about technology, many of engineering educators received their degrees at a time when educational technology was not as advanced as it is now. As a result, engineering educators lack the knowledge and confidence to integrate technology in T&L. However, to remain relevant as educator in a higher education institution, engineering educators must adapt to the contemporary environment, which includes the existence of AI in the education sector.

Several works used TPACK to enhance engineering education when integrate technology in T&L. (Fahadi & Khan, 2022; Khalid et al., 2023; Maria Moundridou &

Kyparisia A. Papanikolaou, 2017; Mutanga et al., 2018). The TPACK framework was introduced by Punya Mishra and Mathew Koehler in 2005. It is an extension from Schulman's proposed pedagogical content knowledge (PCK) in 1986 (Koehler & Mishra, 2009). The basis of PCK was that pedagogy and knowledge are two different types of knowledge that can intersect to produce new types of knowledge, such as information about how to teach content in a given subject area. Another new dimension of knowledge is introduced in TPACK through the use of technology in T&L as shown in Figure 2. The technology is referred to as AI implementation in a classroom environment in the discussion context of this paper.

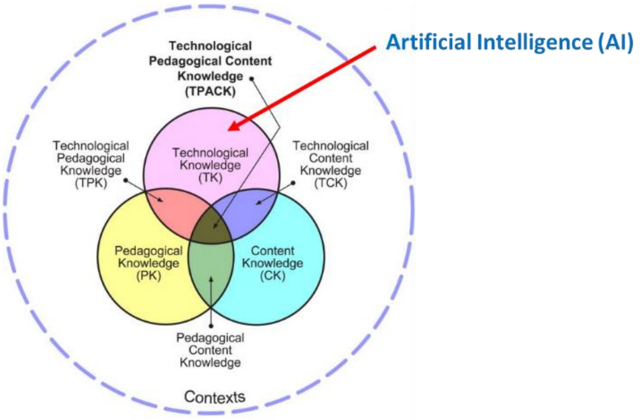


Figure 2. TPACK (Koehler & Mishra, 2009)

A. *Content Knowledge (CK)*

Going back to "what", "how" and "why" in the first paragraph, content knowledge (CK) represents "what", which this is seen from engineering educators' subject-specific knowledge. The material that must be covered in university subject is distinct from the material that must be covered in engineering core subjects. For instance, Graduate Success Attributes course. This domain specific knowledge would comprise understanding of concepts, theories, ideas, organizational frameworks, understanding of evidence and proof as well as understanding of established processes and methods for acquiring such information, as mentioned by Shulman (1986).

Knowing the deeper knowledge principles of the subjects that engineering educators need to teach is important for engineering educators because knowledge and the nature of research vary widely throughout fields. For instance, in the context of engineering, this would entail familiarity with engineering facts and ideas, the engineering method and evidence-based reasoning. Lack of solid foundation in subject matter knowledge can be costly; for instance, educators may give lectures that are shallow (read from slides alone), convey inaccurate information and worst-case lead to student misconceptions.

B. *Pedagogical Knowledge (PK)*

Pedagogical knowledge (PK), which refers to educators' knowledge of the T&L procedures, methods, and strategies, provided the solution to the "why" question. This encompasses broader educational concepts, principles, and objectives. Teachers should be able to understand how students acquire knowledge, develop skills, establish learning routines, and foster positive learning attitudes. Therefore, understanding cognitive, social and developmental theories of learning as well as how to apply them in the classroom is a requirement for engineering educators.

C. *Pedagogical Content Knowledge (PCK)*

Pedagogical content knowledge (PCK) is overlapping between content and pedagogy that creates a new knowledge that involves teaching and learning methods, curriculum, assessment and reporting, circumstances that foster learning, as well as connections between pedagogy, curriculum and assessment. Effective instruction links students' prior knowledge to alternative teaching strategies that accommodate common misconceptions and strategies for addressing them. Additionally, engineering educators that have PCK will have T&L approaches that are flexible and take into account different perspectives on the same problem or idea.

D. *Technology Knowledge (TK)*

Technology knowledge (TK) cannot be defined due to its shifting nature (Koehler & Mishra, 2009). Technology advancements happen quickly. Thus, engineering educators must adapt to these changes in order to stay relevant throughout a lifetime of open-ended involvement with telecommunication technology.

E. *Technological Content Knowledge (TCK)*

Technological content knowledge (TCK) outlines the interactions between technology and content. It is important to know which technology is better suited to conveying the content of any discipline. Technology might limit the types of delivery method that are feasible, but it can also make it possible to create newer and more diversified delivery method.

Engineering educators should master more than the subject matter that they teach; they also need to be aware of the particular technology that are the most effective for addressing subject-matter learning in their fields as well as how the technology may very depend on the content.

F. *Technological Pedagogical Knowledge (TPK)*

Technological pedagogical knowledge (TPK) discusses how engineering educators understand the usage of particular technologies that can affect T&L. It includes being aware of the pedagogical possibilities and constraints provided by various technology tools, taking into account how well they connect with suitable pedagogical designs and techniques within particular disciplinary contexts and developmental contexts.

Engineering educators must understand how various technologies might help or hurt students' learning outcomes and how to successfully incorporate them into lesson plans. With this knowledge, engineering educators may decide how best to employ technology to improve the teaching and learning process.

G. Technological Pedagogical Content Knowledge (TPACK)

The term "TPACK," or technological pedagogical content knowledge, refers to a broad and integrated body of knowledge that combines content, pedagogy and technology. It results from the interplay between these three fundamental components.

Engineering educators must comprehend how concepts can be represented using technology, how pedagogical methods can use technology to effectively teach content and how technology can address students' learning obstacles if they are to possess TPACK. Engineering educators also need to understand students' prior knowledge, epistemological ideas and how technology can help reinforce epistemologies.

Engineering educators should incorporate TPACK because every teaching circumstance comes across mixes material, pedagogy and technology in a different way. There isn't a single technology answer that works for all lecturers, subjects or teaching styles. The ability of engineering educators to navigate the intricate interactions between curriculum, pedagogy and technology within particular situations leads to effective solutions.

Oversimplified solutions or failure might result from disregarding the complexity of any knowledge component or the relationships between them (Koehler & Mishra, 2009). Engineering educators must therefore acquire fluency, cognitive flexibility and a nuanced awareness of the relationships between content, pedagogy and technology in various contextual contexts. Consideration of TPACK as a professional knowledge construct requires this in-depth knowledge of teaching using technology.

Community of Inquiry (CoI) Framework

Upon reviewing TPACK literatures, she made an attempt to take part in pedagogy and technology-related training. Community of Inquiry (CoI) complements TPACK framework, where TPACK examines the theory, while CoI examines the implementation of the technology. She published a papers discussing online class design using CoI (Ghazali, 2021). The framework of CoI is illustrated in Figure 3.

As described above, the relationship between TPACK and existing practices is seamless. One reasons for that is the clear relationship between TPACK components to be modelled by engineering educators as their professional knowledge. Holding this knowledge may not be translated into quality teaching. This is how, the first author experience frustration when realizing activities designed for students is disengaging. Since TPACK can be considered as cognitive pre-requisite for engineering educator, CoI on the other hand has its role as venue for educators to simulate the knowledge.

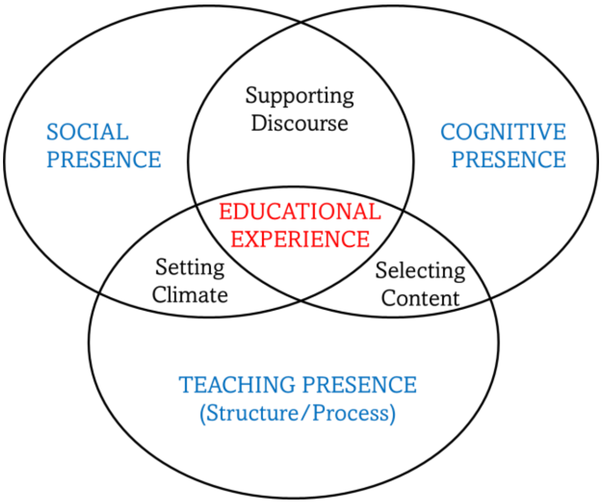


Figure 3. Community of Inquiry (CoI) Framework

CoI consists of three essential elements which are social presence, cognitive presence, and teaching presence that develop educational experience. Social presence creates open communication, group cohesion, and a trusted environment. Cognitive presence relates to learners who are able to construct and confirm meaning through the developmental phases of inquiry – a triggering event, exploration, integration, and resolution. The third element, teaching presence is linked with the design facilitation and direction of a community of inquiry. In summary, CoI is where “students listen to one another with respects, build on another’s ideas, challenge one another to supply reasons for otherwise unsupported opinions, assist each other in drawing inferences from what has been said, and seek to identify one another’s assumptions” (Lipman, 2003). CoI framework is based on the collaborative and individually constructivist learning experience.

Discussion

Based on her experienced, she would like to make a few suggestions to improve the quality of engineering students because they are output of the program. The ideas have been divided into two categories: faculty management and engineering educators.

Faculty Management

According to the TPACK framework, engineering educators must be knowledgeable about the subject, pedagogy, the technology he plans to employ, and knowledge of how all of these relate before they can begin teaching. Therefore, if the management wants the engineering educators to teach something that is not in the field, support such as holding training that will be conducted by someone in engineering education field not from education and pairing the engineering educators with engineering educators who is an expert in the subject will help the 'new' engineering educators to develop themselves before they start to teach. Furthermore, allowing engineering educators especially who are just started the career to teach for at least three semesters before being changed to a new subject. The goal of this is to give the engineering educators to make reflection of their lessons and improve them.

Engineering Educators

Engineering educators themselves must reflect on their own teaching methods and work with an education specialist to create their reflection, which must then be published. The T&L activities are actually greatly improved by this way.

Conclusion

As mentioned earlier, incorporating technology or in this case we are focusing on AI, is not just picking the application. It is beyond that. It is actually a process, where it involves input to the engineering educators, processing of the input and assessment of the process as shown in Figure 4.

Engineering educators should aware that they need input that is mentioned in TPACK framework. The results obtained by this TPACK framework becomes input to the implementation in the class. The input is processed during the implementation in the classroom. From the implementation, assessment can be done using CoI frameworks, to check either planning from TPACK is worked or not. If it does not work, the reason of it should be identified either from input or process of the input.

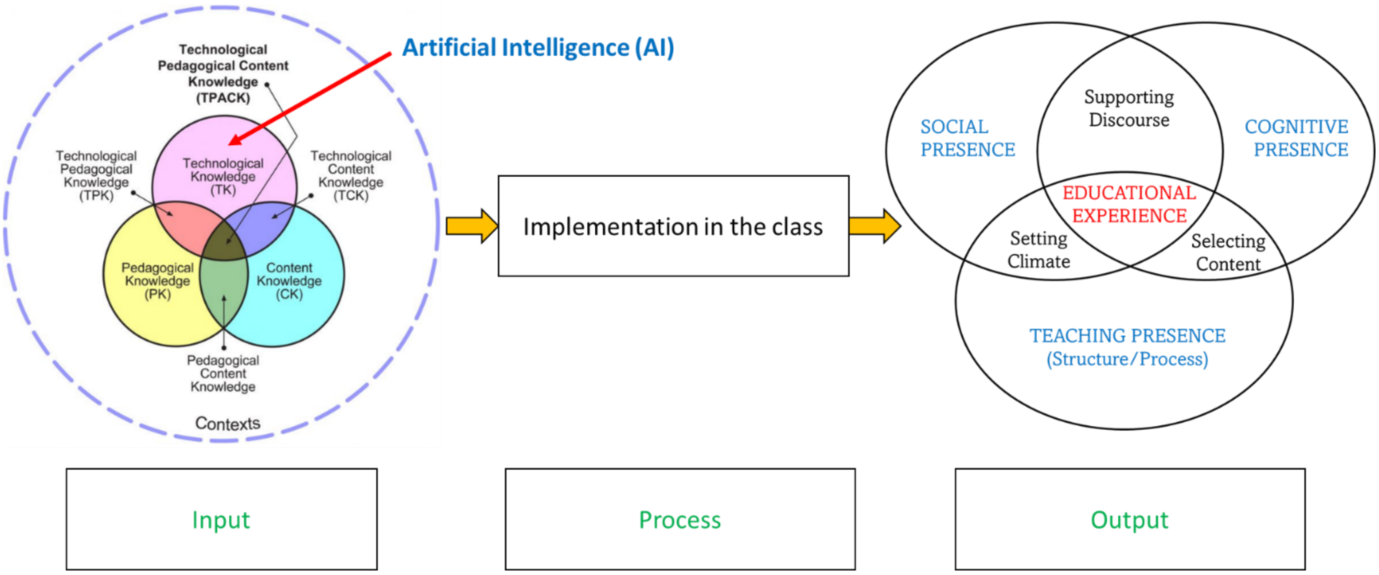


Figure 4. Knowledge requirement for engineering educators

References

Anders, B. A. (2023). Is using ChatGPT cheating, plagiarism, both, neither, or forward thinking? *Patterns*, *4*(3), 100694. https://doi.org/10.1016/j.patter.2023.100694

Engineering Accreditation Council. (2020). *EAC-Standard-2020*.

Fahadi, M., & Khan, M. S. H. (2022). Technology-enhanced Teaching in Engineering Education: Teachers' Knowledge Construction Using TPACK Framework. *International Journal of Instruction*, *15*(2), 519–542. https://doi.org/10.29333/iji.2022.15229a.

Ghazali, N. E. (2021). Designing Online Class using Discord based on Community of Inquiry Framework. *Asean Journal of Engineering Education*, *5*(2), 46–52.

Ghazali, N. E., Bakar, Z. A., Shafie Bakar, M., Nur, T., Tengku, Z., Busu, M., Farahwahidah, N., Rahman, A., Effiyana Ghazali, N., & Abu Bakar, Z. (2021). Epistemology in Engineering Education: An Overview. In *ASEAN Journal of Engineering Education* (Vol. 5, Issue 2).

Jose L. Martin Nunez, & Andres Diaz Lantada. (2020). Artificial Intelligence Aided Engineering Education State of the Art, Potential and Challenges. *International Journal of Engineering Education*, *36*(6), 1740–1751.

Khalid, M., Hossain Khan, M. S., & Gregory, S. (2023). Contextual variation on teachers' conceptions of ICT-enhanced teaching in engineering education. *Heliyon*, e14531. https://doi.org/10.1016/j.heliyon.2023.e14531

Koehler, M. J., & Mishra, P. (2009). *What is Technological Pedagogical Content Knowledge? 9*(1), 60–70. http://www.tpck.org/.

Lipman, M. (2003). *Thinking in Education*. Cambridge University Press.

Maria Moundridou, & Kyparisia A. Papanikolaou. (2017). Educating Engineering Educators on Technology Enhanced Learning based on TPACK. *2017 IEEE Global Engineering Education Conference (EDUCON)*, 1243–1250. https://doi.org/10.1109/EDUCON.2017.7943007

Mccarthy, J. (2007). *What is Artificial Intelligence?* http://www-formal.stanford.edu/jmc/

Mutanga, P., Nezandonyi, J., & Bhukuvhani, C. (2018). Enhancing Engineering Education through Technological Pedagogical and Content Knowledge (TPACK): A Case Study. In *International Journal of Education and Development using Information and Communication Technology (IJEDICT)* (Vol. 14).

The Making of Green Engineers: Sustainable Development and the Hybrid Imagination (Synthesis Lectures on Engineering): A Book Review

Article history
Received
17 June 2023
Received in revised form
21 June 2023
Accepted
21 June 2023
Published online
30 June 2023

Mohamad Syahrul Nizam Ibrahim*
Faculty of Agricultural Science and Forestry, Universiti Putra Malaysia
Bintulu Campus, 97008 Bintulu, Sarawak, Malaysia
**mohamadsyahrulnizamibrahim@gmail.com*

Abstract

“Green engineer” is a connotation that needs to be worked so that the public is more aware that engineers nowadays are humanistic in implementing any related projects and it in line with the Sustainable Development Goals 2030. *The Making of Green Engineers: Sustainable Development and the Hybrid Imagination (Synthesis Lectures on Engineering)* emphasizes the intersection of sustainable development and engineering education, focusing on the formation of "green engineers." It delves into the role of imagination, creativity, and interdisciplinary thinking in preparing engineers to address environmental and sustainability challenges. The book also examines how engineering education can foster a hybrid imagination, combining technical expertise with a deep understanding of social, environmental, and ethical dimensions. It explores pedagogical approaches, curriculum design, and educational practices that nurture sustainability-oriented mindsets among engineering students. The book emphasizes the importance of interdisciplinary collaboration, systems thinking, and a holistic approach to engineering education. It offers insights into the integration of sustainability principles into engineering curricula and the development of green engineering professionals who can contribute to a more sustainable future. The book is highly recommended as a resource for engineers, students, researchers, or professionals seeking to deepen their understanding of sustainable development and the role of green engineering within it.

Keywords: Green engineer, quality education, ecocentrism, humanistic, sustainability.

Jamison, A. (2022). *The Making of Green Engineers: Sustainable Development and the Hybrid Imagination.* Switzerland: Springer International Publishing. ISBN: 9783031793547, 3031793544

Introduction

The Making of Green Engineers: Sustainable Development and the Hybrid Imagination (Synthesis Lectures on Engineering) is authored by Prof. Dr. Andrew Jamison, professor of Technology, Environment and Society at Aalborg University in Denmark since 1996 who has taught in a wide range of science and engineering programs. Before coming to Aalborg, he taught a course in science and society for many years for natural science students at the University of Copenhagen and served as founding director of a graduate program in science and technology policy at Lund University in Sweden.

The book has been written as part of the Program of Research on Opportunities and Challenges in Engineering Education in Denmark (PROCEED), funded by the Danish Strategic Research Council, for which Prof. Dr. Jamison has served as coordinator. The book consists of seven chapters which are (i) Turning Engineering Green; (ii) Contending Approaches to Engineering Education; (iii) The Emergence of Green Engineering; (iv) Educating Green Engineers; (v) Fostering Hybridity; (vi) A Case Study: The Alley Flat Initiative in Austin, Texas; and (vii) Conclusion.

In the book, the author discusses and exemplifies three contending response strategies on the part of engineers and engineering educators: a commercial strategy that links scientists and engineers into networks or systems of innovation; an academic strategy that reasserts the traditional values of science and engineering; and an integrative strategy that aims to combine scientific knowledge and engineering skills with cultural understanding and social responsibility by fostering what the author terms a "hybrid imagination." The author combines scholarly analysis with personal reflections drawing on over forty years of experience as a humanist teaching science and engineering students about the broader social, political, and cultural contexts of their fields.

Even though there are seven chapters in this book, I am most interested in the first, fifth and forth chapters because these explain the book's uniqueness in the context of the creation of "green engineer" better than the other chapters.

Ibrahim, M.S.N. (2023), The Making of Green Engineers: Sustainable Development and the Hybrid Imagination (Synthesis Lectures on Engineering): A Book Review, *ASEAN Journal of Engineering Education*, 7(1), 41-44.

Summary and opinions

Turning Engineering Green

In the first chapter, it highlights the "Turning engineering green" where in the context of cultural transformation it refers to the shift in engineering practices, values, and norms towards sustainability and environmental consciousness. It involves reorienting engineering culture to prioritize environmental considerations, embrace sustainable design principles, and foster a mindset of responsible stewardship of natural resources.

Cultural transformation in engineering requires a collective change in attitudes, beliefs, and behaviours within the engineering community. Here are some key aspects involved in turning engineering green through cultural transformation:

1. Environmental Awareness: Cultural transformation starts with raising awareness about environmental issues among engineers.

It involves educating engineers about the impacts of engineering activities on the environment and promoting an understanding of the interconnectedness between engineering and sustainability.

2. Values and Ethics: Shifting engineering culture involves re-evaluating values and ethics to incorporate environmental considerations.

This includes recognizing the intrinsic value of the environment, adopting a long-term perspective, and embracing the ethical responsibility of engineers towards sustainable practices.

3. Interdisciplinary Collaboration: Cultural transformation requires fostering collaboration between engineers and professionals from other disciplines, such as environmental science, social sciences, and humanities.

By working together, engineers can gain a broader perspective on environmental challenges and benefit from diverse insights and expertise.

4. Sustainable Design and Innovation: Transforming engineering culture involves integrating sustainable design principles into engineering practices.

This includes considering life cycle assessments, minimizing resource consumption, promoting renewable energy solutions, and incorporating eco-friendly materials and technologies.

5. Education and Professional Development: Cultural transformation requires rethinking engineering education and professional development programs.

This includes incorporating sustainability-focused courses, promoting interdisciplinary learning, and providing training on sustainable engineering practices and technologies.

6. Systems Thinking and Holistic Approaches: Turning engineering green involves adopting systems thinking and holistic approaches to problem-solving.

Engineers need to consider the broader environmental, social, and economic implications of their projects, and seek solutions that optimize multiple dimensions of sustainability.

7. Collaboration with Stakeholders: Cultural transformation requires engaging with stakeholders, including communities, policymakers, and non-governmental organizations.

By involving diverse perspectives and considering local context, engineers can develop solutions that align with societal needs and environmental goals.

8. Leadership and Advocacy: Transforming engineering culture involves fostering leadership and advocacy for green engineering practices.

Engineers can take a proactive role in promoting sustainability within their organizations, advocating for sustainable policies, and serving as role models for future generations of engineers.

It can be summarised that cultural transformation towards turning engineering green is an ongoing process that requires commitment, collaboration, and continuous learning. By embracing sustainability and environmental consciousness, engineers can play a crucial role in addressing global environmental challenges and building a more sustainable future.

Fostering Hybridity

The fifth chapter of this book is of particular interest to me because it emphasises that engineering education can foster a hybrid imagination by incorporating multidisciplinary approaches and emphasising the integration of technical expertise with social, environmental, and ethical concerns. It appears to be filled with the primary content of this book. Here are some keyways to achieve the hybridity through interdisciplinary curriculum:

1. The engineering programs can offer courses and projects that bridge the gap between technical disciplines and other fields such as social sciences, environmental studies, ethics, and policy.

In my opinion, the argument expressed by the author regarding bridging the engineering with other disciplines is very important in accordance with this industry 4.0 era. Furthermore, by exposing students to diverse perspectives and knowledge domains, they can develop a broader understanding of the interconnectedness between engineering and society.

2. Case studies and real-world projects can be implemented by integrating case studies and real-world projects into engineering education allows students to explore complex problems that require

technical solutions while considering the social, environmental, and ethical implications.

I agree that this approach encourages critical thinking and helps students recognize the broader context in which their technical expertise is applied.

3. Ethics and professional responsibility should be emphasised. Engineering programs can include dedicated courses or modules on ethics and professional responsibility.

In general, these courses may cover topics like codes of conduct, environmental stewardship, social justice, and the ethical considerations involved in decision-making processes. It is commendable that the author emphasised these values where educators should encourage students to consider the societal impact of their work and make ethical decisions throughout their careers in engineering.

4. In terms of collaboration and teamwork, it should be emphasised in engineering education that helps students develop the skills to work effectively in multidisciplinary teams.

By collaborating with individuals from different backgrounds and expertise, students can learn to appreciate diverse perspectives and integrate technical knowledge with social and environmental considerations. In my view, the gap between developed and developing countries can still be seen in this context.

5. Engineering education can emphasize the importance of sustainability and systems thinking.

This involves considering the entire lifecycle of engineering projects, including resource consumption, waste generation, and long-term environmental impacts. Students can learn to design solutions that optimize not only technical efficiency but also social equity and environmental sustainability.

6. Furthermore, encouraging community engagement and service-learning experiences allows students to apply their engineering skills in real-world settings while addressing social and environmental challenges.

This hands-on approach fosters a deeper understanding of the impacts of engineering on communities and the importance of considering social and environmental factors in problem-solving.

By incorporating these approaches into engineering education, students can develop a hybrid imagination that combines technical expertise with a deep understanding of social, environmental, and ethical dimensions. This prepares them to tackle complex challenges and contribute to a more sustainable and socially responsible future.

Educating Green Engineers

In the context of engineering education, the fourth chapter discusses pedagogical approaches, curriculum design strategies, and educational practises. Compared to the fifth chapter, which focuses on the quality of the future green engineer, this chapter places a greater emphasis on the effective delivery methods employed by educators in the production of green engineers.

The author highlights nurturing sustainability-oriented mindsets among engineering students involves adopting pedagogical approaches, curriculum design, and educational practices that promote awareness, knowledge, and engagement with sustainability principles. Active learning and experiential education are one of key aspects that need to be considered (Smith et al., 2020). The educators should engage students in hands-on, experiential learning opportunities that allow them to directly interact with sustainability challenges. This can include field trips, laboratory experiments, project-based learning, and internships that focus on real-world sustainability issues. By actively participating in problem-solving and critical thinking, students develop a deeper understanding of sustainability and its relevance to engineering. By considering the broader context, students can identify sustainable solutions that address multiple dimensions of a problem. Incorporate sustainable design principles throughout the engineering curriculum. Teach students to prioritize energy efficiency, resource conservation, waste reduction, and life cycle thinking when designing engineering solutions. Emphasize the importance of renewable energy, circular economy concepts, and sustainable materials in the design process (Garcia et al., 2022). Encourage students to reflect on the ethical and social implications of engineering decisions. Incorporate discussions on social justice, equity, and inclusivity within engineering projects. Address the potential impacts on marginalized communities and promote responsible and equitable engineering practices. Foster collaboration and interdisciplinary approaches by integrating coursework and projects with other disciplines such as social sciences, environmental studies, and policy. This enables students to understand and appreciate diverse perspectives and develop holistic solutions to sustainability challenges.

Next, offer elective courses or specializations that specifically focus on sustainability within engineering disciplines. This allows students to explore sustainability concepts in-depth and develop specialized knowledge and skills in areas such as renewable energy, green infrastructure, sustainable transportation, or water management. It is crucial to provide research opportunities that allow students to investigate sustainability-related topics. Encourage undergraduate and graduate students to work on research projects that contribute to sustainable engineering practices. This can foster innovation and promote deeper engagement with sustainability challenges. Next, it should promote sustainability engagement beyond the classroom by organizing sustainability-focused events, workshops, and guest lectures. Encourage students to participate in sustainability-related clubs, organizations, and community service activities. This helps create a culture of sustainability on campus and fosters a sense of responsibility and activism among engineering students.

Through the implementation of these pedagogical approaches, curriculum design strategies, and educational practises, engineering programmes can foster in students a commitment to sustainability. I believe these author’s highlighted strategies can equip them to become accountable engineers who can integrate sustainability principles into their professional work and contribute to a more sustainable and equitable world.

Conclusion

To sum up, the book is highly original and thought-provoking, and it reminds me that people must not simply predict a future they do not know, but instead attempt to create a future they should know. It is a required reading for everyone, not just engineering educators and those who wish to design engineering education. The exploration of “green engineering" and its relationship with sustainable development is likely intended for an audience interested in engineering, sustainability, and related fields. It offers insights into the integration of sustainability principles into engineering curricula and the development of green engineering professionals who can contribute to a more sustainable future. It may serve as a resource for engineers, students, researchers, or professionals seeking to deepen their understanding of sustainable development and the role of green engineering within it.

References

Garcia, M. R., Smith, K. P., & Chen, L. (2022). Life cycle assessment of sustainable building materials in green engineering projects. Journal of Sustainable Engineering, 15(3), 112-128. doi:10.xxxxx/jseng.2022.15.3.112

Smith, J. A., Johnson, R. B., & Davis, C. D. (2020). Sustainable design principles in green engineering. Journal of Environmental Engineering, 28(2), 45-58.hjh

From Childhood Dream to University Journey: My Path to Becoming a Chemical Engineer

Article history
Received
19 May 2023
Received in revised form
22 June 2023
Accepted
23 June 2023

Anas Abdulqader Alshaikh
Faculty of Chemical and Energy Engineering,
Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, Malaysia
anasalshaikh6@gmail.com

Abstract

From an early age, children harbor vivid dreams of their ideal future professions, fueling their aspirations and shaping their journey toward fulfilling careers. A dream that starts prior to school and grows along the journey. In this paper, I delve into the intricate factors that shaped my aspiration to become an engineer and how they molded my professional engineering identity. I adopted autoethnography and narrative inquiry approaches, delving into personal experiences and employing qualitative research methods. Through this exploration, I uncover the profound impact of societal perception theory and social learning theory on shaping my career aspirations from an early age. Reflecting on my own journey as a chemical engineering student, I trace my fascination with science back to my childhood and unveil the pivotal decision to pursue chemical engineering. Within this paper, I extensively discuss the educational environment, teaching methods, and familial influences that played crucial roles in shaping my chosen path. Furthermore, I tackle the challenges encountered throughout my university education, encompassing academic hardships, technical assessments, and the abrupt transition to online learning necessitated by the COVID-19 pandemic. Despite these obstacles, my unwavering passion for chemical engineering was revitalized through hands-on application and interdisciplinary courses. This study places great emphasis on the significance of comprehensive engineering education in fostering the development of essential professional skills, critical thinking prowess, and problem-solving abilities. It serves as a testament to the multifaceted nature of engineering education and its profound influence in shaping an individual's engineering identity. Through this meticulous exploration, I aim to provide valuable insights into the underlying dynamics that drive individuals towards engineering as a profession and contribute to the broader understanding of engineering education's transformative power.

Keywords: Chemical engineering identity, Engineering education, narrative inquiry, self-study.

Introduction

In today's rapidly evolving world, learning has become an indispensable part of our lives. It not only provides us with new knowledge and skills but also significantly impacts our well-being. Learning is a continuous process that allows individuals to expand their knowledge and develop new skills. It enables individuals to have intelligent conversations with others, and if one has learned the necessary business skills, they can be a great asset to a company. Engineering, in particular, is a field that plays a critical role in the development of countries. The importance of engineering in developed countries cannot be overstated. The development of advanced technologies, infrastructure, and transportation systems are all dependent on the expertise of engineers. Therefore, learning engineering has become increasingly important for the continued growth and progress of developed countries.

Engineering education plays a crucial role in shaping our world by addressing global challenges such as climate change, renewable energy, and healthcare. Through engineering, new technologies and systems can be developed that can make our lives easier, healthier, and more sustainable. Thus, engineering education is vital for preparing future generations of professionals who can solve complex problems and lead us to a better future.

Engineering education is important in shaping the engineering identity of an engineer. It provides individuals with a foundational understanding of engineering principles, theories, and practices, and equips them with the skills and knowledge necessary to solve complex problems. Through education, engineers learn to approach problems systematically and systematically assess different solutions, which helps to shape their engineering identity. Engineering education also exposes individuals to various subfields within engineering, allowing them to explore different areas and develop a sense of where their interests and strengths lie. This exploration can help shape an individual's engineering identity by allowing them to identify their passions and pursue their goals.

However, compared to most majors, engineering students have a higher attrition rate. In fact, according to some estimates, 50% of engineering majors switch their majors or leave school early (Belasco, 2021). Additionally, some engineering graduates may choose to pursue careers in fields unrelated to engineering,

Alshaikh, A.A. (2023), From Childhood Dream to University Journey: My Path to Becoming a Chemical Engineer, *ASEAN Journal of Engineering Education*, 7(1), 45-52.

while others may face difficulty finding employment in their field of study.

As a developed country, Sustainable development is a major goal for Saudi Arabia, as reflected in its Vision 2030 plan, which aims to achieve sustainability goals and accelerate the energy transition (UN, 2023). Saudi Arabia is a country that heavily relies on the oil and gas industry, making chemical engineering a vital field in the country's economy. Chemical engineering has been an integral part of the country's development plans, and the Saudi government has made significant investments in the field, including the establishment of world-class universities and research centers. In recent years, the Saudi government has also been working to diversify its economy, and chemical engineering has played a crucial role in achieving this goal.

Engineering students embark on a learning journey that involves navigating various challenges and complexities. Throughout this journey, they encounter obstacles in both their academic pursuits and interactions within society. These various issues as shown in Figure 1 significantly affect and shape their choices and decisions in developing their engineering identity. In this paper, I will delve into my personal journey as a chemical engineer where I began my education in elementary school in Saudi Arabia and went on to pursue a degree in chemical engineering in Malaysia including the differences in educational systems and the pursuit of professional development.

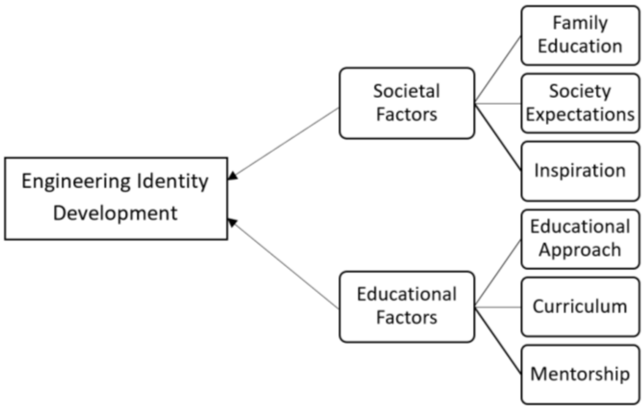


Figure 1. Conceptual framework for the relation between different factors and engineering identity development.

Methods

The primary objective of this paper is an attempt to answer the question “what are the factors that influence the person to have the desire to be an engineer and how it translates to developing a professional engineer identity”. The paper discusses the factors starting from the society’s dictations to the classroom experiences. The methodology employed in this study is divided into two parts, autoethnography approach to analyse the background and societal factors and the narrative inquiry approach to analyse the learning journey from high school to graduating from university. Both methods fall under the qualitative research paradigm.

Autoethnography, a relatively new research paradigm, uses reflective narratives to illuminate the researcher's personal experiences in order to examine cultural ideas, practices, and the social experiences that shape our identities (Wall, 2008). In order to demonstrate their understanding and the significance of using autoethnography as a valid and significant research technique, the writers use their own stories throughout their study. However, the analysis of experience as understood through a narrative is the focus of narrative inquiry, a relatively new qualitative methodology. It is a means of contemplating and researching experience. Throughout the course of the inquiry, narrative inquirers reflect on experience narratively (Clandinin et al., 2010).

In narrative inquiry, stories are useful in guiding the researcher towards a deeper comprehension of phenomena. When engaging with narrative inquiry, we take on the role of co-participants to co-create the knowledge with the participants across specific locations and times (Pino Gavidia et al., 2022).The story is how we make sense of the world, and narrative research allows us to understand, describe, and act within the context of the storyteller's experiences (Ntinda, 2019). Thus, the study of narrative focuses on how people live in the real world. This idea is expanded upon in educational research to see education and research as the creation and reconstruction of stories, either from personal experiences or through group participation. Thus, learners, teachers, and researchers are all storytellers and characters in their own or other people's stories (Zakaria, 2021).

To write this paper, I have reflected on my own journey from elementary school to university to my short experience in the industry discussing all factors and the turning points in order to find an answer for this research question “what are the factors that influence the person to have the desire to be an engineer and how it translates to developing a professional engineer identity”. I review my experiences through the lenses of autoethnography, narrative inquiry tracing the effects and changes in my performance in university and the projects I was involved in. I also referred to my diaries through the years, reflection reports at the end of each course, learning portfolio, and internship logbook in order to analyse my overall engineering identity development.

The significance of my study lies in its exploration of the intricate relationship between societal and educational factors in shaping engineering identity. By delving into my journey, this paper sheds light on the complex influences that contribute to an individual's development as an engineer, thus providing valuable insights and effective engineering education and professional growth.

Findings and Discussions

Growing up

Being a leader in the petroleum industry, Saudi Arabia has gone through a lot of changes and revolutionary developments through the years. From the early days of the huge petroleum sea discovery in the eastern area in 1938, engineering passion has grown among people living in the country. As a child of an educated family, my interest in science and pursuing a medicine or engineering dream came from an early age. The first question I was asked on my first day in first grade was “what do you want to become in the future?”, all the class said one of these three answers, a pilot, a doctor, and an engineer, and I remember my answer was “a pilot” which changed immediately after my unpleasant first flight. Societal Perception Theory is evident in the early perceptions of careers such as being a pilot, doctor, or engineer that the students in the first-grade class mentioned. The societal perception and prestige associated with these jobs influenced the answers given by the students, despite not having a deep understanding of the fields at such a young age. This reflects how societal norms and perceptions can shape one's early career aspirations (Aronson et al., 2010).

I grew up in a family where education is a priority and I was taught the first verse in Quran revealed to prophet Muhammed -peace be upon him- was “Read, ⌜O Prophet,⌝ in the Name of your Lord Who created” (Quran 96:1). My grandfather was a doctor in Islamic studies and had a huge influence on my father and uncles to pursue masters and doctorate in Islamic studies too. My father graduated from a highly reputed Islamic university, so I was surrounded by books and in a research and learning environment for many years growing up and that was my first trigger to consider education as a path of my life and a must. The Social Learning Theory is shown by the influence of the family environment on my future plan and decisions (Bandura, 1971). Throughout my fathers’ tremendous library, there was not any science-related book to read since it is not related to his field except an old organic chemistry book. This enthusiasm to discover the unknown of science was enough for me to establish my passion and voice out my desire to become an engineer.

> *“Acquire knowledge, and learn tranquillity and dignity.”*
>
> — Umar ibn Al Khattab

As I reflect on my journey, I can see how Societal Perception Theory and Social Learning Theory have played a role in shaping my choices. The societal perception and lack of exposure to science-related education during my primary and secondary school years have influenced my path. The aura and perceptions associated with subjects like physics and chemistry initially sparked my curiosity and desire to learn more about these fields, as evidenced by my questions to neighbours about these subjects before entering high school. However, the limited availability of science-related education in my early schooling years weakened my passion and desire for engineering. This serves as a reminder of the impact that societal perception and educational environment can have on shaping our career choices.

The high school education system in Saudi Arabia is the first and major station for a student to decide the direction of his future education. During my days in high school, two paths were the choices for all students. The first path is for students with theoretical study preferences like philosophy and language education, and the other path is for students with practical education preferences like medicine or engineering.

The second path was my choice where I picked my first tools for my following engineering education venture. The tools of an engineer are acquired through the years. The analytical and critical mindset is something from an early age. However, practical and technical skills are acquired through education and school. Engineering accreditation agencies are united in their opinion that engineering education must support the development of professional skills in addition to technical and scientific skills (Picard et al., 2022). My first class in chemistry in high school was the pivotal point that decided my future. The chemistry teacher followed a direct teaching method by writing the full lesson as nested points and titles. The chemistry lesson was written down while being explained in a very clear and understandable fashion. Scientific teaching involves active learning strategies to engage students. Active participation in lectures and discovery-based laboratories helps students develop the habits of mind that drive science (Handelsman et al., 2004).

This start of high school made chemistry class my favourite and got the complex details of chemistry ahead of the fascinating concepts of physics. The education method was the main reason as it combined the explanation – mental aspect- with the writing – physical aspect – and the combination of these two eased the learning journey. This method illustrates the Science Writing Heuristic (SWH) which is a framework developed by Carolyn Keys, Brian Hand, Vaughan Prain and Susan Collins that promotes critical thinking and scientific inquiry in the classroom (Keys et al., 1999). It is a structured approach to engage students in the process of scientific inquiry through writing. This method is effective because it includes initial engagement, exploratory talk, pre-writing, inquiry, and potentially discussion and revision (Stephenson et al., 2016).

> *“Writing in science is not only for communicating with others; it is also a tool for learning that supports scientists and students alike in clarifying thinking, synthesizing ideas, and coming to conclusions.”*

— Karen Worth et al., The Essentials of Science and Literacy

As we get closer to graduation from high school, my desire to continue my study in the chemistry field has grown, but at that time my concern was that I would end up being a lecturer and that is not something as prestigious as being an engineer as I feel in my society. However, I came to the decision of pursuing chemical engineering since it combines both chemistry and engineering as I expected from the name. but I was not sure 100% about what I will learn chemical engineering and if that is my best choice.

University journey

As I graduated from high school, there were no doubts or clouds about my future goal as I was confidently choosing to be a chemical engineer. Although it is true that chemical engineers are comfortable with chemistry, they use their understanding of the subject for much more than merely creating chemicals. However, my understanding of chemistry and the joy of the followed teaching method combined were the reason behind my growing love for chemistry and immature decision at that time, which might be not the case for others.

I started looking for reputed universities in chemical engineering and I ended up enrolling at Universiti Teknologi Malaysia (UTM). My diary for the first day in college says *"Today was my first day as a chemical engineering student at university. I felt a mix of excitement and nervousness as I stepped onto campus, eager to embark on this new chapter of my academic journey. Yeah, I am living my dream. Let's rumble"*.

During my first year in college as a chemical engineering student, I encountered numerous challenges that impacted my academic journey. One significant hurdle was the level of hardship I faced, as I had started in the second semester and was unable to fully follow the academic plan. This created difficulties in catching up with the coursework and adjusting to the new environment. Additionally, the unprecedented technicality of the tests and assessments caught me off guard, resulting in lowered confidence in my abilities as a student. The complex and rigorous nature of the chemical engineering curriculum compounded with the technical challenges posed by the assessments, which made it challenging to keep up with the pace of the coursework. Despite these obstacles, I persevered and sought support from professors and peers to overcome the difficulties and build my confidence as a chemical engineering student.

The transition between being a "mostly-receiving" student in high school to a "mostly-searching" student in college was an enormous shock personally that led to a drastic change in my learning mindset. Even though going to college is normally the next step following high school, there are instances when they couldn't be more different. High school gives you a glimpse of what being an adult will be like from childhood to adulthood. Conversely, college gives you the opportunity to totally take control of your time, responsibilities, and future (Randolph, 2022).

The mindset transition produced some important skills a chemical engineer should have, like responsibility and accountability. These two traits are the foundation of the work of a chemical engineer's personality who works on dangerous projects and deals with harmful materials at times. In my first year, my experience in chemical engineering was not pleasant as I was shocked with the difficulty of some courses which made me rethink and question my choice. My confidence in my ability to ride the waves coming my way was diminished and I was low to 20% confident to be a chemical engineer.

The challenges faced during my first year as a chemical engineering student have taught me valuable lessons. I have learned the importance of perseverance in overcoming hardships, the significance of seeking support from professors and peers to navigate the unfamiliar environment and technical assessments, and the need for adaptability in adjusting to the fast-paced coursework. Taking responsibility and being accountable for my own learning journey has empowered me to develop essential skills. Through self-reflection, I have grown personally and recognized the value of resilience, seeking guidance, and embracing change. These lessons will continue to guide me as I progress in my academic and professional endeavors in the field of chemical engineering.

In my second year of college, I had the opportunity to study a more diverse range of courses in different fields, such as analytical chemistry, numerical methods, and material engineering. These courses played a crucial role in boosting my confidence as a chemical engineering student. However, it was the transport process course that truly ignited my passion for the field. For the first time, I felt like I was learning about real-life phenomena and seeing the direct application of chemical engineering principles. This connection to the practical aspects of the field made me fall in love with chemical engineering all over again which embodies the self-efficacy theory (Gallagher, 2012). It was a turning point that helped me regain my confidence and reaffirmed my commitment to pursuing my passion in chemical engineering.

Unfortunately, during my second year in college, the COVID-19 pandemic struck, leading to a sudden shift in the learning methods from in-person classrooms to completely online. This transition had a significant impact on my academic experience as a chemical engineering student. I found it challenging to adapt to the virtual learning environment, which hindered my understanding of some courses. The absence of face-to-face interactions with professors and peers, as well as the limitations of online learning tools, made it difficult to fully engage and participate in class discussions which can be explained by transactional distance theory (Weidlich et al., 2018).

The theory states that this separation causes unique learner and instructor behavioral patterns. The separation between students and teachers has a significant impact on both teaching and learning. Separation creates a psychological and communicative barrier that must be crossed, creating a chance for miscommunication between the learner's and instructor's inputs. The transactional distance is this area of psychology and communication (Moore, 1993). As a result, my passion for learning, which was previously fueled by the dynamic classroom environment, was affected. Despite the challenges, I persevered and adapted to the new normal of online learning, seeking additional resources and support to overcome the obstacles posed by the pandemic and continue my academic journey in chemical engineering.

The reflection for numerical methods and optimization course which was one of the main courses in my second year gives a brief of the unusual experience of learning transition during the pandemic. "*Reflecting on my experience learning numerical methods in person for a few weeks before transitioning to online teaching, I found the shift to be both challenging and transformative. The in-person sessions allowed for engaging discussions and hands-on practice, fostering a deeper understanding of the subject. However, the online format presented unique hurdles, requiring adaptability and self-discipline to navigate the virtual lectures and complete assignments effectively. Despite the initial difficulties, I learned valuable skills in independent learning and digital collaboration, proving that resilience and determination are crucial in the face of unexpected circumstances.*"

By my third year, I was introduced to a wide range of courses that expanded my understanding of the role of chemical engineering beyond the technical aspects. Courses such as chemical reaction engineering, engineering economics, entrepreneurship, unit operation, electrical technology, separation, and plant design provided me with a comprehensive knowledge of the field. As I progressed through these courses, I began to see the connections between different concepts and how they applied to real-world situations.

This newfound understanding translated into a successful internship experience during the summer of my third year, where I was able to apply the knowledge and skills I had gained in practical engineering projects. Internship was the shifting point in my journey that made me sure and 100% confident to follow the practical and industry and become a chemical engineer. I managed to land a job as a chemical engineering intern in a polymers company in Saudi Arabia named "Saudi Top Plastic Factory". The internship journey was the measuring point of the learning journey in chemical engineering and the checkpoint for the possessed and lost skills. I started to feel confident in my abilities as a chemical engineer and began to see the bigger picture of how my education was preparing me for a future career in the field.

My third-year journey have imparted several valuable lessons. Through exposure to a diverse range of chemical engineering courses, I expanded my understanding of the field beyond its technical aspects. This broadened perspective allowed me to see the real-world applications of the concepts I learned, reinforcing the practical relevance of my education. A transformative internship experience provided me with hands-on opportunities to apply my knowledge and skills, instilling a sense of confidence and certainty in pursuing a career in chemical engineering. This industry exposure highlighted the practicality of the field and solidified the connection between my education and future career aspirations. Overall, I have learned the importance of comprehensive understanding, practical application of knowledge, gaining confidence through experience, appreciating industry exposure, and establishing a clear link between education and career goals. These lessons have shaped my academic journey and fueled my passion for excelling in the field of chemical engineering.

In my fourth and final year of college, I was determined to pursue my passion for chemical engineering and further develop my skills and knowledge. I recognized the importance of continual growth and skill development, which led me to take elective courses in polymers and downstream processing to expand my expertise in different areas of the field. These courses not only boosted my confidence but also assured me that I possess the capabilities to adapt to a rapidly evolving field. Additionally, I understood the value of specialization within chemical engineering, realizing that honing in on specific areas of interest can set me apart and enhance my career prospects.

The highlight of my college journey was the completion and presentation of my plant design project, which showcased my ability to integrate various concepts and apply them to a real-world engineering problem. This experience reinforced my belief in the power of interdisciplinary thinking and solidified my passion for chemical engineering. Furthermore, by participating in the undergraduate research conference and presenting my final year project, I had the opportunity to enhance my technical and soft skills, adding to my sense of accomplishment and readiness for a future career in the field. Overall, these experiences and lessons have provided me with the necessary building blocks to confidently pursue a fulfilling and successful career in chemical engineering.

Internship Journey (practical experience)

My first day as a chemical engineering intern was a typical day starting a new job where I had to finish paperwork and was introduced to the safety manager who took me around the factory and explained the facilities. From the first day, I was faced with the reality in the first meeting where I had to read the daily schedule of the factory and the instructions for me as a practicing engineer. It was fascinating walking around machines and equipment I have been studying for five semesters. Not long until the industrial manager came and took me to the production line and was asking me a few questions during our chat I was able to answer them, and that was a moment of confidence boost that set the optimistic tune for my practical experience.

The instant increase in my confidence after answering the questions is related to the self-awareness theory which provides insights into the relationship between answering questions and confidence. According to this theory, when we compare ourselves against our standards of correctness and find alignment between ourselves and our standards, we experience a sense of validation and self-affirmation that can boost our confidence. Answering questions correctly can provide such a sense of validation and affirmation, leading to increased confidence (Carden et al., 2022).

During the 12 weeks of my internship, I was responsible for few tasks. Daily production management, laboratory assistance, and process engineering. The diversity of the tasks was a key to applying a wide range of my knowledge I learnt in university classrooms. The management subjects are well used in production management where details of imports and exports are recorded and the track of weekly production must meet customers' needs. This aspect of chemical engineering is the furthest field from the technical practices and is more related to management and business departments. However, it ignites the sense of responsibility and builds my manager character as a practicing chemical engineer. Many times, I was called by the management where I was asked about the track of production and an update must be provided to keep the work and production going. Figure 2 (b) shows me performing the TGA analysis for a raw material before processing.

Figure 2. (a) my first week in my internship. (b) performing TGA analysis.

The production work was the easiest in my internship since it is done from a comfortable office without moving around the production area most of the time. However, the other tasks are more challenging and require pure chemical engineering skills and knowledge. Until this point, I did not have any idea about the range where I operate and how I can implement my knowledge but the daily routine and the discipline it requires were enough to hook me up and make me an enthusiastic intern in a routine work environment.

The practical experience during my internship can be related to Kolb's learning cycle which describe the process of my learning in all projects and experiments. Kolb's learning cycle is a model describes the experiential learning process and involves four interrelated modes: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Figure 3)(McLeod, 2017).

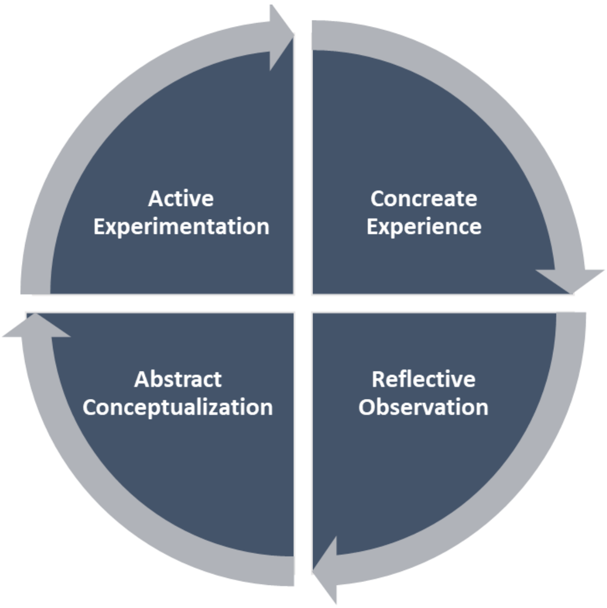


Figure 3. Kolb's learning cycle

To clearly demonstrate the Kolb's learning cycle in my internship, I selected the first practical experiment I did in the laboratory. the experiment was to measure qualitatively and quantitatively the emissions from a material that will go through heating and melting process. The first stage of Kolb's learning cycle is "concrete experience". Prior to my internship in university, my experiences with heating materials were in green experiments where the materials used are safe. So, the sense of danger had not been experienced dealing with such materials and the objective of the heating processes were to for the sake of heating only. Adding a new measured factor to a familiar experiment created the sense of the first time. As a result, I was more conscious of the details of the experiment due to the unfamiliarity of the objective and the caution because of the precise and accurate data that must be acquired.

Next is the reflecting observation. After finishing the task, I would record the observations and the new findings for personal knowledge or further research. Every time after the experiments I recall what I have learned and refer to the logbooks of my laboratory courses and discuss with my colleagues in order to get more explanation for the experiment. For example, during the emission experiment, I faced an issue with setting the heater to get a specific temperature and there was a fluctuation in the temperature measured. This affects the accuracy of the data. Fortunately, my supervisor helped me fixing this issue with a brief explanation. However, I remember calling a friend who had more experience regarding laboratory procedures and he was aware of my problem and gave me instructions and on the other hand I described to him the device I am using from another company. So, the reflection and discussion led to the two of us exchanging knowledge and learning new things.

The third stage of Kolb's learning cycle is Abstract Conceptualization, and this is when I attempt to interpret what happened. I accomplish this by using what I already know, by using concepts I'm already familiar with, or by talking with my colleagues about potential theories, concepts, hypotheses, or approaches in an effort to make a conclusion about my experience. I will write the concepts I learned and connect it to the potential outputs and the scenarios of different cases and what can be controlled and modified for a preferred output. As I do the experiments repeatedly, the concepts become more understood and the divergence from the expected output decreases. The analysis, discussion and recommendations as documented will help with further improvements and better understanding. For example, in this experiment I faced the issue of me being unexperienced in recording and analysing the data instantly in a systematic manner. The reason is because I need to use my own ideas in forming the files and recording the data where in university you need to record the data in a pre-prepared files which makes you unaware of this part of the whole process.

Finally, the Active Experimentation stage. In this stage, learner tries out new approaches to solve problems or achieve goals based on the insights and knowledge gained from the previous stages. This stage involves taking risks, testing hypotheses, and making adjustments based on feedback and evaluation of results. In view of this, I repeated the experiments many times and conducted different experiments where I applied the knowledge I gained. So, a noticeable improvement in my performance with new knowledge and a different window of critical thinking and problem-solving skills.

Reflecting on my days in the internship, many skills I acquired in classrooms were the reason to have a successful and motivating experience to pursue practicing chemical engineering. Technical and communication skills, time management, and adaptability helped me to indulge and dive in the practical field. The key to solve the challenges I faced were through applying these skills efficiently and have the self-confidence where it can be built through the daily tasks and integration and application of previous knowledge.

After 12 weeks, I left the company to continue my study. This eye-opening experience really served me positively and charged me through the remaining of my learning journey. The next semester I started working on my final year project with completely different view and passion due to the practical experience I had during my internship. My final year project was in biodiesel production from palm fatty acid distillate using sulfonated sago pith waste catalyst. I put a lot of work and my time doing the experiments was enjoyable since my aspiration to get more knowledge and learn more about chemical engineering have gone to different highs. I worked hard in this project and I managed to achieve the best undergraduate research award in the undergraduate research conference 2022.

Conclusion

Looking back through my journey from being a dreaming kid to being a chemical engineer, it can be concluded that there are many societal to personal factors that dictated my aspirations. and the stations I went through and the two complete different parts of the world that I lived in and learnt from shaped me the way I am now. However, developing an engineering identity involves a combination of personal traits, education, and practical experience. Seeking out engineering experiences, such as internships, research projects, or volunteer work, can provide a better understanding of what engineers do and allow for applying knowledge to real-world problems. Ultimately, constructing an engineering identity involves a lifelong commitment to learning and growing as an engineer, staying up to date with the latest advancements in the field, and striving to make a positive impact on society through engineering. I am grateful for the journey and hope that sharing my professional development as an engineer might at least help other aspiring engineers.

References

Aronson, E., Wilson, T. D., & Akert, R. M. (2010). Social psychology (7th ed ed.). Upper Saddle River, NJ: Prentice Hall.

Bandura, A. (1971). Social learning theory. Morristown, N.J.: General Learning Press.

Belasco, A. (2021). So You Want to Be an Engineer... Retrieved from https://www.collegetransitions.com/blog/so-you-want-to-be-an-engineer/#:~:text=The%20attrition%20rate%20for%20engineering,drop%20out%20prior%20to%20graduation.

Carden, J., Jones, R. J., & Passmore, J. (2022). Defining Self-Awareness in the Context of Adult Development: A Systematic Literature Review. Journal of Management Education, 46(1), 140-177. doi:10.1177/1052562921990065

Clandinin, D. J., & Huber, J. (2010). Narrative Inquiry. In P. Peterson, E. Baker, & B. McGaw (Eds.), International Encyclopedia of Education (Third Edition) (pp. 436-441). Oxford: Elsevier.

Gallagher, M. W. (2012). Self-Efficacy. In V. S. Ramachandran (Ed.), Encyclopedia of Human Behavior (Second Edition) (pp. 314-320). San Diego: Academic Press.

Handelsman, J., Ebert-May, D., Beichner, R., Bruns, P., Chang, A., DeHaan, R., Wood, W. B. (2004). Scientific Teaching. Science, 304(5670), 521-522. doi:doi:10.1126/science.1096022

Keys, C. W., Hand, B., Prain, V., & Collins, S. (1999). Using the Science Writing Heuristic as a Tool for Learning from Laboratory Investigations in Secondary Science. Journal of Research in Science Teaching, 36(10), 1065-1084. doi:https://doi.org/10.1002/(SICI)1098-2736(199912)36:10<1065::AID-TEA2>3.0.CO;2-I

McLeod, S. (2017). Kolb's learning styles and experiential learning cycle. Simply psychology, 5.

Moore, M. G. (1993). Theory of transactional distance In D Keegan (ed) Theoretical Principles of Distance Education pp. 22–38 Routledge. New York.

Ntinda, K. (2019). Narrative Research. In P. Liamputtong (Ed.), Handbook of Research Methods in Health Social Sciences (pp. 411-423). Singapore: Springer Singapore.

Picard, C., Hardebolle, C., Tormey, R., & Schiffmann, J. (2022). Which professional skills do students learn in engineering team-based projects? European Journal of Engineering Education, 47(2), 314-332. doi:10.1080/03043797.2021.1920890

Pino Gavidia, L. A., & Adu, J. (2022). Critical Narrative Inquiry: An Examination of a Methodological Approach. International Journal of Qualitative Methods, 21, 16094069221081594. doi:10.1177/16094069221081594

Randolph, K. K. (2022). 20 Differences Between High School & College Life. Retrieved from https://www.fastweb.com/student-life/articles/the-20-differences-between-high-school-college-life

Stephenson, N. S., & Sadler-McKnight, N. P. (2016). Developing critical thinking skills using the Science Writing Heuristic in the chemistry laboratory. Chemistry Education Research and Practice, 17(1), 72-79. doi:10.1039/C5RP00102A

UN. (2023). Our Work on the Sustainable Development Goals in Saudi Arabia. Retrieved from https://saudiarabia.un.org/en/sdgs

Wall, S. (2008). Easier Said than Done: Writing an Autoethnography. International Journal of Qualitative Methods, 7. doi:10.1177/160940690800700103

Weidlich, J., & Bastiaens, T. (2018). Technology Matters – The Impact of Transactional Distance on Satisfaction in Online Distance Learning. International Review of Research in Open and Distance Learning, 19. doi:10.19173/irrodl.v19i3.3417

Zakaria, I. D. Z. Y. (2021). Seeing With New Eyes: My Professional Development Expedition as an Engineer: Submitted Manuscript. Asean Journal of Engineering Education, 5(1), 58-66. doi:10.11113/ajee2021.5n1.65

Institutional Practice for Engineering Students Employability: Automate Offline Employability Tracking Instrument with Data Mining

Article history
Received
6 June 2023
Received in revised form
23 June 2023
Accepted
23 June 2023

***Nor Farahaida Abdul Rahman*[a]**, Nor Farahwahidah Abdul Rahman*[b]**
*[*a]School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA 40450 Shah Alam, Selangor Darul Ehsan. Malaysia*
[b]School of Education, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia
[b]Centre for Engineering Education, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia
** farahaida@uitm.edu.my*

Abstract

The analysis of graduate employability is substantial to interpret Higher Education Institutions (HEIs) capability to produce career-ready graduates. Therefore, data gathering related to employment and employability to assess the current trends is crucial. However, developing a fast and accurate programming language for analysing enormous data is a challenging task. This paper presents an Automate Offline Employability (AOE) data analysis using a spreadsheet program; it reduces the time consumption in analysing lots of data and increases data analysis accuracy. The system utilises various Excel formulas and functions to execute multitasking algorithms simultaneously. The instrument can sort the data according to various study fields, matching the initial and current data, analysing them based on employability attributes, and generating multiple interpretable graphs. It can also extract the Uniform Resource Locator (URL) of email and WhatsApp of graduate. Additionally, it has a desktop layout to help the user retrieve any information with a single click. All functions provided by the instrument has successfully executed and verified to achieve the design objectives. Using the instrument, the user can only gather 211 data within 12 days. The instrument provides various information such as the percentage of employment status, field of work, salary, and entrepreneurship.

Keywords: career development; employability analysis tool graduate employability; learning analytic; spreadsheet program.

Introduction

In recent years, graduate employability has become one of the Higher Education Institutions (HEIs) priorities, especially in Malaysia. As a result, all undergraduate programs' design must be in line with the Ministry of Higher Education of Malaysia (MoHE) vision. According to MoHE, every HEI should produce competent graduates to fulfil national and international human resources needs; they should work in their relevant fields within six months after their graduation (Mohamad, Rose, Azlin & Puvanasvaran, 2012).

According to Belen, Gemma & Thelma (2018), employability is the probability of getting a job or the ability to be employed. Nevertheless, authors in (Lee, 2001) stated that employability is the proportion of graduates from an institution that secured job placement after graduation.

The study outcomes are essential to support the development of strategies and employment policies for universities (Michavila et al., 2015). A study about the correlation between graduate employability skills and previous work experiences was conducted by Dershem, (2016). From the findings, graduates who had past work experiences have a better chance to be hired. According to Pažur Aničić & Divjak (2020), both individual and institutional factors usually affect graduates' employability potential.

In Malaysia, researchers are focusing on employability issues such as unemployment problems, graduate skills (hard and soft skills) or attributes (Hashim, Chang & Abdul Rahman, 2016), (Tahir at el., 2018), (Shahrifudin, 2018). According to Misni, Mahmood & Jamil (2020), there was a direct correlation between curriculum design and employability competency. A study about the effect of training certifications in increasing the employability rate was conducted by Shariff & Abdul Aziz (2019). The findings recommended that other factors such as industrial training, work activities in industry and soft skills should be in the syllabus, to enhance students' competence and marketability. Nevertheless, no study focuses on developing tools to acquire, manage, and analyse graduate employability data to date. The dominant discourse in graduate employability has tended to centre on the prediction for employability

Abdul Rahman N.F.A. & Abdul Rahman N.F. (2023), Institutional Practice for Engineering Students Employability: Automate Offline Employability Tracking Instrument with Data Mining, *ASEAN Journal of Engineering Education*, 7(1), 53-64.

trend, which reflects HEIs' capacity to nurture graduate for the labour market. This paper reviews the graduate employability concept's application to establish a link between graduate employability and students who are at risk of unemployment. Furthermore, a new instrument named Automate Offline Employability (AOE) using a spreadsheet program is introduced to reduce data collection time and increase data analysis accuracy.

Engineering Graduate Early Transition in Employability

Students are projected to seek career objectives via early-career mobility rather than working in various jobs. The concept of early-career mobility emphasises mobility in which employability often reflects the role of degree obtained when entered the industry. The supporting view of employability in early-career mobility represents students' ability to transition knowledge and skills gained from university to industry and within the industry. The most notable terminologies used for this scope of the study is graduate employability and early career mobility. Employability is defined as the self-sufficient to move self within the labour market for sustainable employment (Rothwell & Rothwell, 2017). The concept of career mobility begins with occupational mobility by Sicherman & Galor in 1990. The underlying assumption for this concept is to understand the knowledge transition or transferability between fields. Early-career mobility allows HEIs to determine the possibilities of educational return investment to human capital (Sicherman & Galor, 1990).

There are two types of career mobility known as an intra-firm career (move ladder by promotion) and interfirm career (uncertain direction) (Sicherman & Galor, 1990). In Lindberg (2009), the authors situated the mobility as the transition between higher education-to-work transitions and relation with labour markets. Instead, the authors in (Tolkach & Tung, 2019) recognised career mobility as a prominent human resource management topic. Previous studies looked at occupational patterns (Sicherman & Galor, 1990), career projection and career trajectories (Jacob & Klein, 2019) as part of the determining factors that contribute to career mobility. When considering the difference in the mobility definition for a graduate's career, the contras can be either the study focus on career development after graduating or looking at students' mobility when they are still in the university.

Previous studies focus on earning or salary (Sicherman & Galor, 1990; Jacob & Klein, 2019) as an indicator to come out with a theoretical explanation about the pattern that existed in early career development among graduates. We identify the literature gap on lack of emphasis as students make a transition from higher education to work, which is early-career mobility. It is essential to note this phase of transition because the national degree organising requires input to inform the higher education policy on modularity and transferability of degree for students' mobility (Lindberg, 2009).

The early career transition explained how students perceived graduate employability with the university's degree and its inter-linkage with the labour market (Kenneth & Gary, 2018). The debates circulated on employability among engineering educators due to persistent news from labour markets pointing at higher education for compromising quality over quantity. By looking at this matter, early-career mobility often discussed from the labour market's perspective, and not much explanation can be obtained from a higher institution (Lindberg, 2009).

As regards employment addressed earlier, the concept of employability is extended to early-career mobility. According to the authors Inge et al., (2020), there is no consensus on the definition of employability among researchers. It is because there were different approaches used to represent the quality of being employed. However, the narrations focus on employability as a set of skills that graduates must acquire or develop. Thus, these qualities must be supported by the faculty members during teaching and learning and their employers (Education Policy Planning and Research Division, 2019). Hence, movements along the employability studies suggest looking at the transition phase to look at students' ability to differentiate themselves and stand apart when applying for specific job outcomes like engineering. Employability outcomes for early career mobility are resourceful to explain cases like lower-earning degree course or capture the complexities of career-oriented focus as students graduated from university. Employability and early career mobility are used interchangeably throughout the paper to assert our paper's essential contribution in representing students' career transition. Since this study's focus is on graduates, we gravitate to the concept of early-career mobility by looking at where students end up after completing their degrees. Career is conceptualised as the series of jobs that graduates hold in their work-life (Inge et al., 2020). In Inge et al. (2020), the authors use motivation as the premise for career mobility and identified motivation to change careers as one of the crucial factors. In this study, a career change may imply and the engineering degree holders might not end up in the engineering industry as an engineer. Most studies described the disappearance of young engineering graduates from entering the labour market as the leaking pipeline between academia and industry. However, the analysis that seeks an understanding of educational background's career trajectories is mostly unknown among faculty members. As engineering educators, questions like what happened to the students once they completed their degree, are the students are being employed, or self-employed or moving to another type of career that is unrelated to the degree have their roots in preparing students for employment.

Therefore, this type of information is required with the current urbanisation era to make higher education remain relevant for career mobility. This study is a significant determinant of graduates' labour market outcomes for curriculum developers and faculty members at a higher education institution.

To understand the persistent gap between graduating and job shopping among graduates, the shortcoming and barriers in early-career mobility transition may be able to assist the university with career crafting. Managing the transition from HEIs to the labour market has highlighted the increasing pressure experienced by graduates to get employed. Therefore, the graduate's individualisation employability map increasingly received attention among HEIs to come out with astute planning, preparation, and foresight.

The present study aims to contribute to a more elaborated understanding of early-career mobility by mapping individual early-career mobility. In defining early-career mobility that represents HEIs' social structure, this study considers how data mining can be used to provide resources for this purpose. Hence, the following questions shall be addressed:

- Can data mining become an algorithm in an assessment model for early-career mobility?
- How to identify structural circumstances that influenced early-career mobility?

Research Method

The effectiveness of the assessment instrument is later deployed as a survey to students. Hence, each item asked in the survey should be designed to reach the assessment instrument's aim. In this work, the questionnaires are constructed based on the criteria highlighted in the official employability reports produced by the Ministry of Education Malaysia (Science Po Graduate Employability, 2019) and the Science Po Graduate Employability (Gauckler & Körner, 2016). According to the reports, the survey should gather information about the graduate education field, employment status, type of employment, type of position, type of employment sector, salary and contribution to the economic sector. According to (Gauckler & Körner, 2016), the questionnaire's task is to translate what the researcher wants to know into a language that the respondent understands.

The Participants

For the preliminary study, the questionnaires focus on defining employability and identify suitable constructs that may benefit the faculty members' decision making. The first questionnaire involved 211 final year students Semester March 2019 – July 2019 in the Faculty of Electrical Engineering. The online survey was conducted before the end of the final semester. The sampling strategy is purposive because this preliminary study is aimed at improving the instrument. Within six months after the end of the final semester, the same students must answer the second questionnaire. The link for the survey was posted to the email or WhatsApp app. For the nonresponsive graduates, their information was gathered through a phone call. Without a proper instrument, the time consumption to gather the second questionnaire's responses took weeks to complete. Furthermore, several staffs were needed to help the coordinator to collect the data.

Application Modelling and Development

Data mining and data analytics are essential in evaluating data of graduate employability effectively (Belen, Gemma & Thelma, 2018). Data mining is an educational tool to enhance learning quality from a different perspective. By using the technique, HEIs can identify students' prospective ability by predicting the present performance through earlier period performance and awareness to ensure the student starts the career and moves ahead in the right path for better quality (Misni, Mahmood & Jamil, 2020). Meanwhile, data analytics is the science of discovering and communicating meaningful patterns in data and developing actionable plans (Inge et al., 2020). It also provides insights into what has already happened (Michavila et al., 2015; John, 2014).

An online observatory instrument had been developed referring to previous work by Michavila et al. (2015). By using the instrument, they can track the graduates and provide counselling to improve their employability. The instrument utilised a data analytics approach to evaluate all data. Nevertheless, online has some limitations such as internet reliance, speed, security, and browser support. Hence, an offline instrument should be considered to overcome the limitations of the online instrument.

This paper examines employability among graduates at the Faculty of Electrical Engineering, UiTM Shah Alam. To trace graduate employment, the faculty members decide to develop an instrument to trace graduates' employment. The development of the proposed instrument undergoes two phases. The first phase involves constructing an employability questionnaire for the final year students, and the second phase includes data management and analysis. Figure 1 shows the flowchart of developing the Automate Offline Employability (AOE) instrument.

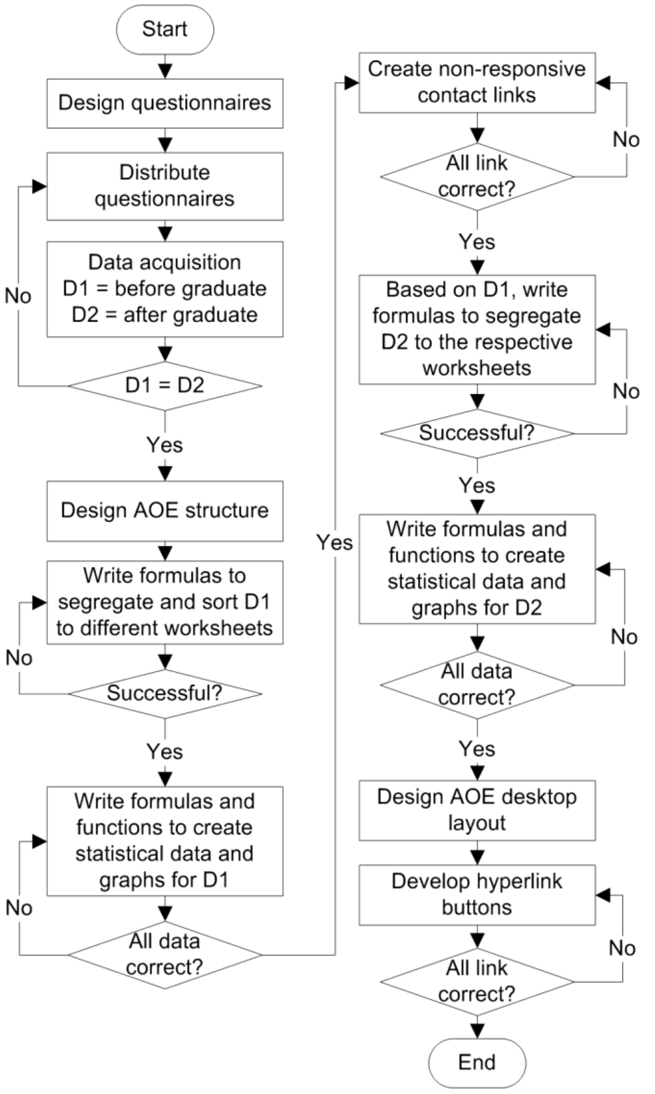


Figure 1. Flowchart to develop AOE system

To comply with the ministry requirement, the faculty initiates a tracking instrument to engage with the graduates six months after they graduate from UiTM. The instrument adopted the employability framework proposed by Defillippi & Arthur (1994). They define employability as graduates' capability to get hired or develop a personal career; it refers to graduates' career mobility. Therefore, the questionnaires applied various classification algorithms on the data set that classifies graduate employability.

The questionnaire consists of demographic and career mobility parts. The demographic section obtained information such as name, email address, mobile phone number and current employment status. For employment status, the students will be clustered into five categories: employed (full time), employed (part-time), self-employed, students/trainee, and none of the above. From here, students further proceed into section two, in which the questions focus on the type of industry, job position, job title, type of industry, salary, company's name, industrial linkage with training and entrepreneurship details.

The platform of the questionnaires is a Google Form. It is a user-friendly, stable, and safe medium for online collecting data. The first questionnaire (D1) aims to gather personal and academic information to create an initial database for students who will complete their study in the current semester. Additionally, the questionnaire collects information related to the job application activities and status, entrepreneurship involvement and future planning. The final year students need to answer the questionnaire upon their final semester. Typically, they must complete the questionnaire before the submission of the Final Year Project (FYP) report; the FYP coordinators supervise the students to complete this task. Finally, based on the graduate status declared in the questionnaire, the graduate employability coordinator can filter out the information of the students who are not yet completing their study. Their information will save in the next batch initial database.

Meanwhile, the second questionnaire (D2) goal is to obtain updated information about the students' current employment details and entrepreneurship involvement within six months after graduation. Thus, it creates another database. Usually, on the first day of the sixth month, the graduate employability coordinator sends a notification email for answering the questionnaire. If the students do not reply after the third reminder, the notification is forwarded to their private WhatsApp account. Lastly, if the students are still not responding, the coordinator will personally call them. The coordinator will know who is not completing the questionnaire by screening the personal information in both databases. Therefore, it is crucial to have an automatic instrument to monitor the students' feedback to reduce the time consumption in monitoring much information simultaneously. Moreover, the instrument is essential to match, sort and analyse the information from both databases.

Data Processing

The AOE instrument aims to execute multitasking operation simultaneously using various Microsoft Excel formulas and functions. The algorithm of these formulas and functions depends on how the instrument should interact with the databases. It started with processing the initial database and followed with the second database. The work involves four processes: (1) to sort, match and extract data from both databases into different worksheets, (2) to generate statistical data and informative graphs, (3) to produce clickable WhatsApp links and a list of emails of the nonresponsive students, and (4) to provide a user-friendly desktop function. Hence, the AOE instrument can systematically process many data and promptly increase the accuracy of data analysis.

First, each name will transfer to different worksheets under various study fields (Sheet 1, Sheet 2, …). There are five study fields in the Faculty of Electrical Engineering, UiTM: electronics, system, communication, computer and power. Before the sorting process begins, each worksheet should count the total number of students for the respective study fields using the 'COUNTIF' function. The number acts as a reference to halt the cataloguing process. Then, the 'IF' function checks whether the student names belong to the study field. Later, the 'INDEX' function retrieves the name from the database and transfers it into the worksheets. A mathematical equation using the 'AGGREGATE' function stops the sorting process. Finally, based on the student names, the 'VLOOKUP' function transfers other information in the initial database to each worksheet. Once completed, the second database's information is sorted into their respective study field using the 'IF' and 'VLOOKUP' functions.

The AOE instrument generates the statistical data and informative graphs of both databases in four separate worksheets. Two worksheets tabulate the statistical data, while another two display the informative graphs. For the initial database, the instrument produces information about the percentage of students who applied for jobs, received, and attended job interviews, secured a job position, and was involved in entrepreneurship during the final year. Nevertheless, for the second database, the instrument shows information related to the percentage of graduate marketability, job status and category, basic salary, and entrepreneurship. These processes utilise many 'IF', 'COUNTIF' and 'charts' functions.

When the students do not respond to the second questionnaire, the instrument will flag the students' names in each study field worksheet. Based on the flag and the study field, the 'IF', 'INDEX' and 'AGGREGATE' functions transfer the students' contact information into another five worksheets. Next, a 'HYPERLINK' function combines the phone number and the Uniform Resource Locator (URL) link of WhatsApp messengers. The length of the URL link should be less than 255 characters. It is the maximum length allowed by Excel. Eventually, another one worksheet used the 'TEXTJOIN' function is created to assemble all emails from the five worksheets. Table 1 presents several formulas and functions employed in the instrument.

Table 1. Microsoft excel formulas and functions utilized in the AOE instrument

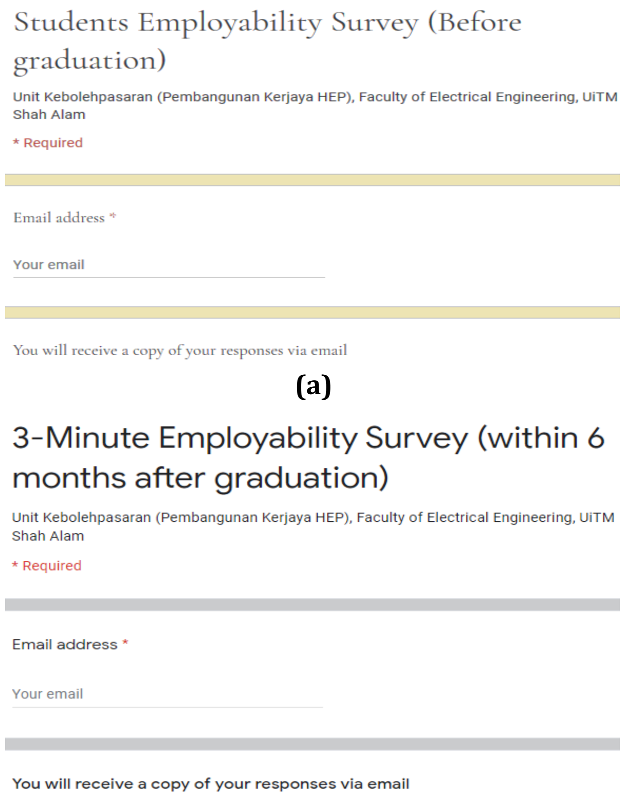
Operation	Formulas and functions
Count students for each study field	=COUNTIF('(BEFORE) INFO'!$A$10:$A$1009,'D1'!$B$3)
Sort, match and extract data from D1 to multiple worksheets based on the study fields	=@IF(ROWS('D1'!$A$6:A6)<=$A$3,INDEX('(BEFORE) INFO'!$E$10:$E$1009,AGGREGATE(15,3,('(BEFORE) INFO'!$A$10:$A$1009='D1'!$B$3)/('(BEFORE) INFO'!$A$10:$A$1009='D1'!$B$3)*(ROW('(BEFORE) INFO'!$A$10:$A$1009)-ROW('(BEFORE) INFO'!$A$9)),ROWS('D1'!$A$6:A6))),"")
Retrieve reminding data from D1 to multiple worksheets	=IF(ROWS('D1'!$A$6:A6)<=$A$3,VLOOKUP(B6,'(BEFORE) INFO'!$B$10:$AN$1009,5,FALSE),"")
Sort, match and extract data from D2 to multiple worksheets based on information in D1	=IF(ISERROR(VLOOKUP(C6,'(AFTER) INFO'!$A$10:$AN$1009,4,FALSE)),"",(VLOOKUP(C6,'(AFTER) INFO'!$A$10:$AN$1009,4, FALSE)))
Extract and calculate number and percentage for D1 statistical data	1) =COUNTIF('D1'!$N$6:$N$205,$D$6) 2) =COUNTIF('D1'!$O$6:$O$205, "Yes") 3) =COUNTIFS('D1'!$N$6:$N205,"Yes",'D1'!$P$6:$P205,"Yes",'D1'!$O$6:$O205,"Less than 5")+COUNTIFS('D1'!$N$6:$N205,"Yes",'D1'!$P$6:$P205,"Yes",'D1'!$O$6:$O205,"Between 5 to 10")+COUNTIFS('D1'!$N$6:$N205,"Yes",'D1'!$P$6:$P205,"Yes",'D1'!$O$6:$O205,"Between 11 to 15")+COUNTIFS('D1'!$N$6:$N205,"Yes",'D1'!$P$6:$P205,"Yes",'D1'!$O$6:$O205,"Between 16 to 20")+COUNTIFS('D1'!$N$6:$N205,"Yes",'D1'!$P$6:$P205,"Yes",'D1'!$O$6:$O205,"More than 20") 4) =COUNTIFS('D1'!$O$5:$O204,"Yes",'D1'!$P$5:$P204,Q6,'D1'!$Q$5:$Q204,"Yes")
Extract nonresponsive contact info to multiple worksheets based on various study fields.	=@IF(ROWS(C_D1!$A$6:A6)<=$B$3,INDEX('D1'!$J$6:$J$205,AGGREGATE(15,3,('D1'!$BX$6:$BX$205="NO")/('D1'!$BX$6:$BX$205="NO")*(ROW('D1'!$BX$6:$BX$205)-ROW('D1'!$BX$5)),ROWS(C_D1!$A$6:A6))),"")
Create WhatsApp links	=IF(B6<>"",HYPERLINK(F6&G6&H6&I6,"CONTACT"),"")
Merge emails	=TEXTJOIN(",",1,C_D1!$B$6:$B$205,C_D2!$B$6:$B$205,C_D3!$B$6:$B$205,C_D4!$B$6:$B$205,C_D5!$B$6:$B$205)

The verification and troubleshooting of all formulas and functions are using the existing data from the previous batch. Once completed, the last stage of the instrument design is to build a user-friendly desktop layout. From this page, the user can retrieve any essential data by clicking the 'HYPERLINK' functions. Hence, it eases the user to browse the comprehensive data in the instrument with a single click. Furthermore, the user can change the title of each graph in the instrument through the desktop only.

Findings and Discussion

This section presents the results of both phases mentioned in previous section. The discussion will correlate the outcomes of the first and second phases in terms of the AOE instrument's role in reducing time consumption for gathering the information from the second questionnaire. Furthermore, it includes elaborating the instrument capability to generate functions and data analyses elaborated in the previous section.

Figure 2 shows screenshots of the first and second questionnaires designed for the AOE instrument. Since there is no significant difficulty in collecting the initial data from the first questionnaire; hence, the form does not have an eye-catching headline to attract students' attention. Without completing the form, students cannot submit their FYP report. Time taken to gather all data was one to three days only. Nevertheless, an eye-catching headline is crucial for the second questionnaire.



Students Employability Survey (Before graduation)

Unit Kebolehpasaran (Pembangunan Kerjaya HEP), Faculty of Electrical Engineering, UiTM Shah Alam

* Required

Email address *

Your email

You will receive a copy of your responses via email

(a)

3-Minute Employability Survey (within 6 months after graduation)

Unit Kebolehpasaran (Pembangunan Kerjaya HEP), Faculty of Electrical Engineering, UiTM Shah Alam

* Required

Email address *

Your email

You will receive a copy of your responses via email

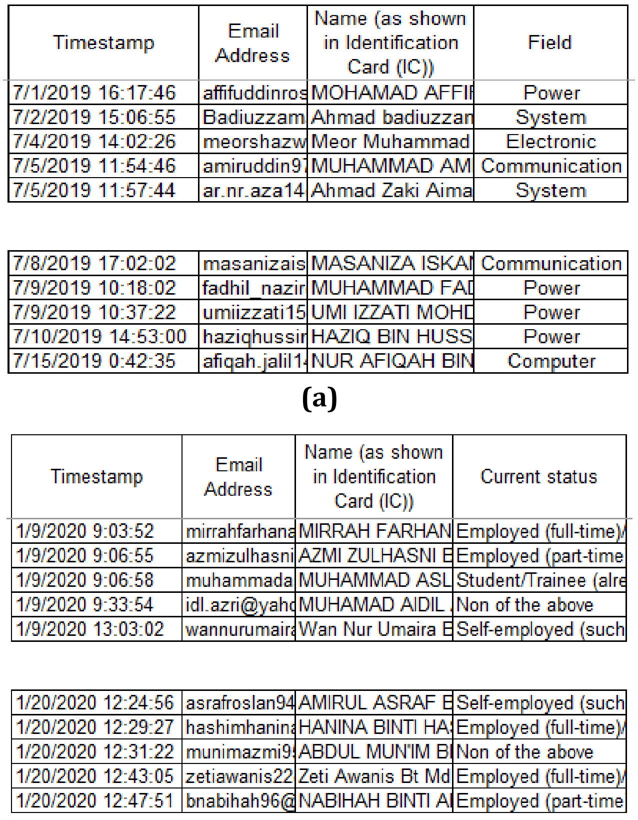
(b)

Figure 2. The (a) first and (b) second questionnaires.

The form title depicted in Figure 2(a) was highlighting the time needed to answer the questionnaire. Due to the short time frame, students or graduates are more likely to answer the questionnaire on the spot. Other than that, some graduates do not consider their part-time job as a real job. This claim is in line with the finding in Gauckler & Körner (2016), where small and informal jobs are likely to be overlooked in household surveys. For them, the actual job should be in the area of electrical engineering.

Thus, it is difficult to obtain accurate data on their employment status. Thus, the second questionnaire consists of a question related to the source of their monthly income. From the answer, the coordinator can verify whether they are currently working or not.

Figure 3 displays samples of responses from the D1 and D2 questionnaires. According to the timestamp shown in Figure 3(a), the initial database was completed in the middle of July 2019. The first questionnaire gathered 211 data from the students. Table 2 presents the distribution of the data according to the specific study field.



Timestamp	Email Address	Name (as shown in Identification Card (IC))	Field
7/1/2019 16:17:46	affifuddinros	MOHAMAD AFFI	Power
7/2/2019 15:06:55	Badiuzzam	Ahmad badiuzza	System
7/4/2019 14:02:26	meorshazw	Meor Muhammad	Electronic
7/5/2019 11:54:46	amiruddin9	MUHAMMAD AM	Communication
7/5/2019 11:57:44	ar.nr.aza14	Ahmad Zaki Aima	System
7/8/2019 17:02:02	masanizais	MASANIZA ISKA	Communication
7/9/2019 10:18:02	fadhil_nazir	MUHAMMAD FA	Power
7/9/2019 10:37:22	umiizzati15	UMI IZZATI MOH	Power
7/10/2019 14:53:00	haziqhussi	HAZIQ BIN HUSS	Power
7/15/2019 0:42:35	afiqah.jalil1	NUR AFIQAH BIN	Computer

(a)

Timestamp	Email Address	Name (as shown in Identification Card (IC))	Current status
1/9/2020 9:03:52	mirrahfarhana	MIRRAH FARHAN	Employed (full-time)
1/9/2020 9:06:55	azmizulhasni	AZMI ZULHASNI	Employed (part-time
1/9/2020 9:06:58	muhammada	MUHAMMAD ASL	Student/Trainee (alre
1/9/2020 9:33:54	idl.azri@yah	MUHAMAD AIDIL	Non of the above
1/9/2020 13:03:02	wannurumair	Wan Nur Umaira	Self-employed (such
1/20/2020 12:24:56	asrafroslan94	AMIRUL ASRAF	Self-employed (such
1/20/2020 12:29:27	hashimhanin	HANINA BINTI HA	Employed (full-time)
1/20/2020 12:31:22	munimazmi9	ABDUL MUN'IM B	Non of the above
1/20/2020 12:43:05	zetiawanis22	Zeti Awanis Bt Md	Employed (full-time)
1/20/2020 12:47:51	bnabihah96@	NABIHAH BINTI A	Employed (part-time

(b)

Figure 3. Samples of responses in the (a) first (D1) and (b) second (D2) questionnaires

Table 2. Microsoft excel formulas and functions utilized in the AOE instrument

Study field	Number of students
Electronic	46
System	29
Communication	17
Computer	4
Power	115

Subsequently, the data collection of the second questionnaire happened in early of January 2020. The period between both questionnaires is six months. Fig. 3(b) presents the first and the last five responses of the second questionnaire. By referring to the timestamp, it shows the duration of gathering the data is only 12 days. This time frame includes the waiting time for three emails, one WhatsApp message and phone calls. The time interval of dispatching emails and messages is three days per reminder. Using the AOE instrument, the process's speed increases, and the execution involves only single personnel.

Table 3 tabulates the total number of graduates that answering the second questionnaire. In overall, only 98.59% of graduate had answered the questionnaire. The contributing factors of 1.41% nonresponsive students are invalid email addresses and phone numbers. Figure 4 depicts the percentage of responders and the WhatsApp links and emails of the nonresponsive students generated by the AOE instrument.

Table 3. Total students responded to second questionnaire

Study field	Number of students
Electronic	45
System	28
Communication	17
Computer	4
Power	114

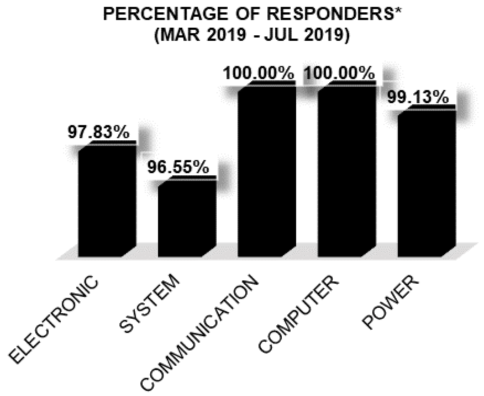
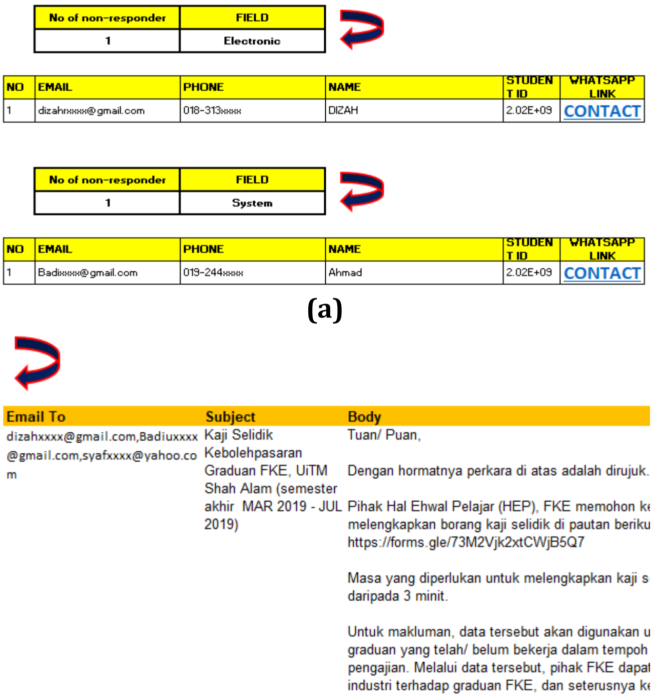


Figure 4. The responders' percentage for D2 questionnaire.

As mentioned, the AOE instrument can segregate and sort all raw data according to various study fields. The sorted data then transferred to different worksheets: electronic, system, communication, computer and power. Figure 5 presents data in the Excel worksheet. According to the fifth column in Figure 6(a), we can see that all students came from the power course only. Hence, it verifies the AOE instrument's capability to segregate the first questionnaire's raw data based on the study fields. Meanwhile, Figure 6(b) shows the sorted data from the second questionnaire. All data in Figure 6(b) matched the data in Figure 6(a).



No of non-responder	FIELD
1	Electronic

NO	EMAIL	PHONE	NAME	STUDENT ID	WHATSAPP LINK
1	dizahrxxxx@gmail.com	018-313xxxx	DIZAH	2.02E+09	CONTACT

No of non-responder	FIELD
1	System

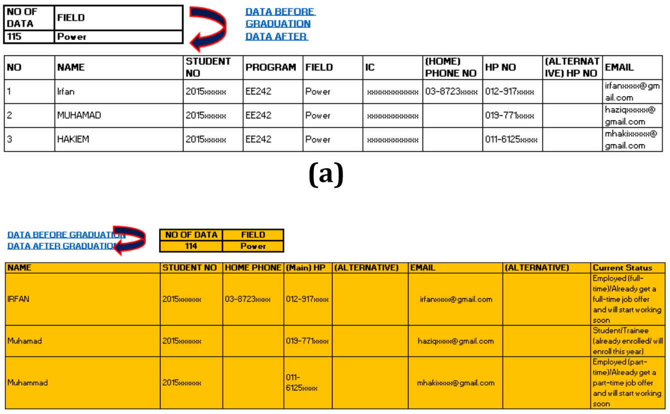
NO	EMAIL	PHONE	NAME	STUDENT ID	WHATSAPP LINK
1	Badixxxx@gmail.com	019-244xxxx	Ahmad	2.02E+09	CONTACT

(a)

Email To	Subject	Body
dizahxxxx@gmail.com,Badiuxxxx@gmail.com,syafxxxx@yahoo.com	Kaji Selidik Kebolehpasaran Graduan FKE, UiTM Shah Alam (semester akhir MAR 2019 - JUL 2019)	Tuan/ Puan, Dengan hormatnya perkara di atas adalah dirujuk. Pihak Hal Ehwal Pelajar (HEP), FKE memohon ke melengkapkan borang kaji selidik di pautan beriku https://forms.gle/73M2Vjk2xtCWjB5Q7 Masa yang diperlukan untuk melengkapkan kaji s daripada 3 minit. Untuk makluman, data tersebut akan digunakan u graduan yang telah/ belum bekerja dalam tempoh pengajian. Melalui data tersebut, pihak FKE dapat industri terhadap graduan FKE, dan seterusnya ke

(b)

Figure 5. The (a) WhatsApp links and (b) email addresses of nonresponsive students



NO OF DATA	FIELD
115	Power

DATA BEFORE GRADUATION
DATA AFTER

NO	NAME	STUDENT NO	PROGRAM	FIELD	IC	(HOME) PHONE NO	HP NO	(ALTERNATIVE) HP NO	EMAIL
1	Irfan	2015xxxxx	EE242	Power	xxxxxxxxxxxx	03-8723xxxx	012-917xxxx		irfanxxxx@gmail.com
2	MUHAMAD	2015xxxxx	EE242	Power	xxxxxxxxxxxx		019-771xxxx		haziqxxxxx@gmail.com
3	HAKIEM	2015xxxxx	EE242	Power	xxxxxxxxxxxx		011-6125xxxx		mhakixxxxx@gmail.com

(a)

DATA BEFORE GRADUATION
DATA AFTER GRADUATION

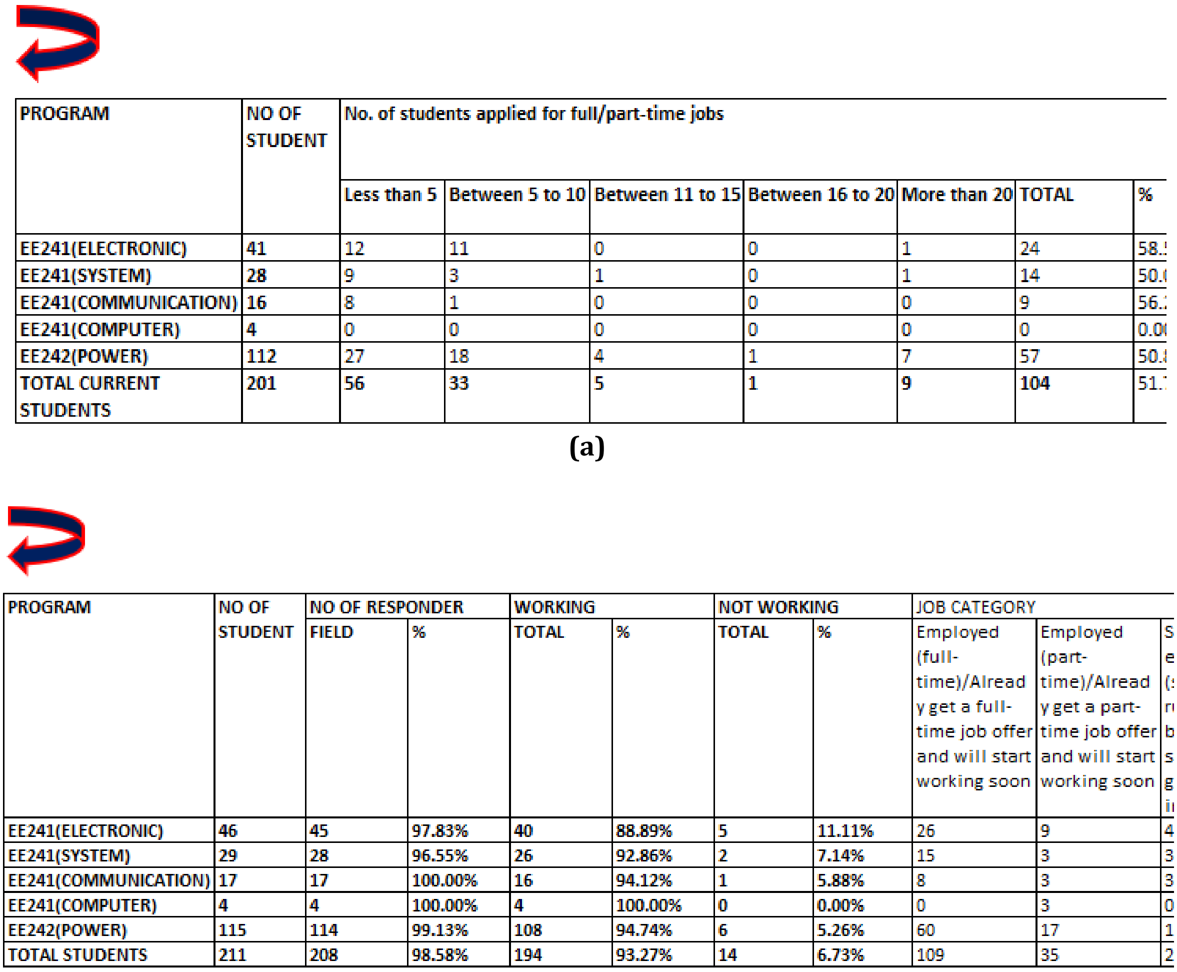
NO OF DATA	FIELD
114	Power

NAME	STUDENT NO	HOME PHONE	(Main) HP	(ALTERNATIVE)	EMAIL	(ALTERNATIVE)	Current Status
IRFAN	2015xxxxxx	03-8723xxxx	012-917xxxx		irfanxxxx@gmail.com		Employed (full-time)/Already get a full-time job offer and will start working soon
Muhamad	2015xxxxxx		019-771xxxx		haziqxxxx@gmail.com		Student/Trainee (already enrolled/ will enroll this year)
Muhammad	2015xxxxxx		011-6125xxxx		mhakixxxx@gmail.com		Employed (part-time)/Already get a part-time job offer and will start working soon

(b)

Figure 6. Sorted data from the (a) first and (b) second questionnaires in the Excel worksheet.

Eventually, Figure 7 shows some of the statistical data generated by the AOE instrument. Using the instrument, the user can retrieve various statistical data such as the number of students who apply for jobs and receive job offers during the final semester and the employment status of students after graduation. To get the percentage of selective information, the user can refer to the graphical data. These data are valuable to study the trend of applying for jobs among the final semester students and employability among the graduate. To obtain these data by a single click, the user can use the desktop layout buttons. Figure 8 shows the desktop layout of the AOE instrument.



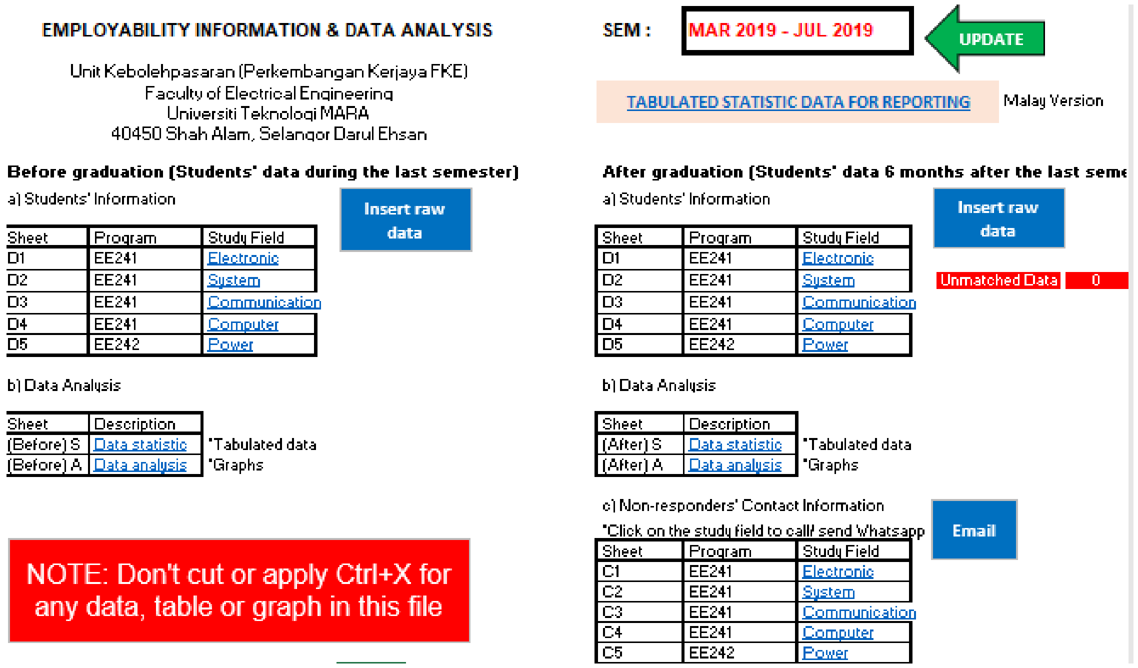
PROGRAM	NO OF STUDENT	No. of students applied for full/part-time jobs						
		Less than 5	Between 5 to 10	Between 11 to 15	Between 16 to 20	More than 20	TOTAL	%
EE241(ELECTRONIC)	41	12	11	0	0	1	24	58.
EE241(SYSTEM)	28	9	3	1	0	1	14	50.
EE241(COMMUNICATION)	16	8	1	0	0	0	9	56.
EE241(COMPUTER)	4	0	0	0	0	0	0	0.0
EE242(POWER)	112	27	18	4	1	7	57	50.
TOTAL CURRENT STUDENTS	201	56	33	5	1	9	104	51.

(a)

PROGRAM	NO OF STUDENT	NO OF RESPONDER		WORKING		NOT WORKING		JOB CATEGORY		
		FIELD	%	TOTAL	%	TOTAL	%	Employed (full-time)/Already get a full-time job offer and will start working soon	Employed (part-time)/Already get a part-time job offer and will start working soon	S e (: r b s g i
EE241(ELECTRONIC)	46	45	97.83%	40	88.89%	5	11.11%	26	9	4
EE241(SYSTEM)	29	28	96.55%	26	92.86%	2	7.14%	15	3	3
EE241(COMMUNICATION)	17	17	100.00%	16	94.12%	1	5.88%	8	3	3
EE241(COMPUTER)	4	4	100.00%	4	100.00%	0	0.00%	0	3	0
EE242(POWER)	115	114	99.13%	108	94.74%	6	5.26%	60	17	1
TOTAL STUDENTS	211	208	98.58%	194	93.27%	14	6.73%	109	35	2

(b)

Figure 7. Statistical data from the (a) first and (b) second questionnaires.



EMPLOYABILITY INFORMATION & DATA ANALYSIS

Unit Kebolehpasaran (Perkembangan Kerjaya FKE)
Faculty of Electrical Engineering
Universiti Teknologi MARA
40450 Shah Alam, Selangor Darul Ehsan

SEM : MAR 2019 - JUL 2019

TABULATED STATISTIC DATA FOR REPORTING

Malay Version

Before graduation (Students' data during the last semester)

a) Students' Information

Sheet	Program	Study Field
D1	EE241	Electronic
D2	EE241	System
D3	EE241	Communication
D4	EE241	Computer
D5	EE242	Power

b) Data Analysis

Sheet	Description	
(Before) S	Data statistic	*Tabulated data
(Before) A	Data analysis	*Graphs

NOTE: Don't cut or apply Ctrl+X for any data, table or graph in this file

After graduation (Students' data 6 months after the last seme

a) Students' Information

Sheet	Program	Study Field
D1	EE241	Electronic
D2	EE241	System
D3	EE241	Communication
D4	EE241	Computer
D5	EE242	Power

Unmatched Data 0

b) Data Analysis

Sheet	Description	
(After) S	Data statistic	*Tabulated data
(After) A	Data analysis	*Graphs

c) Non-responders' Contact Information

*Click on the study field to call/ send Whatsapp

Sheet	Program	Study Field
C1	EE241	Electronic
C2	EE241	System
C3	EE241	Communication
C4	EE241	Computer
C5	EE242	Power

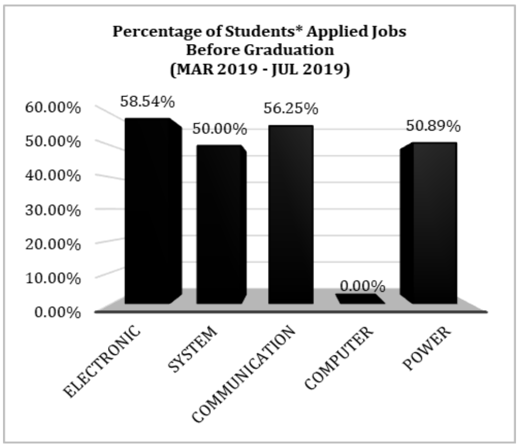
Figure 8. AOE desktop layout.

The Scholarship of Application: Scholarly Experience Sharing Papers

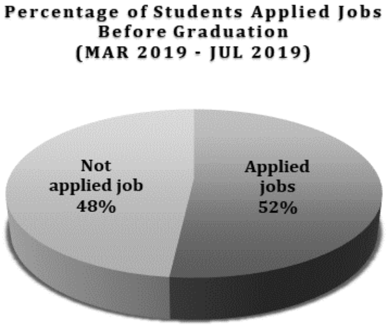
Figure 9 to 11 represent graphical analysis from D1 data. Additionally, Figure 12 to 14 depict graphs and pie charts from D2 data. Information from D1 is essential to analyse the effects on the students' action during the final semester related to job employment. Meanwhile, data form D2 can be used to measure the market demand for the Faculty of Engineering graduates.

Except for the computer majoring, Figure 9(a) shows that at least 50% of students from each study field had applied for jobs during the final semester. However, since students' denominator ratio in each study field is significantly different, this analysis focuses on the percentage of overall students, as shown in Figure 9(b). The approximate ratio between electronic, system, communication, computer and power majoring are 10:7:4:1:28. To increase the employment percentage, the faculty needs a plan to enhance the employability skills and job applications among the final year students. According to Figure 9(b), the percentage of job applications is 52% from 201 students. However, from 104 students who applied for jobs, there are 29.81% got an interview call before they completed their study. The statistic is shown in Figure 10(a).

These findings show that there is a chance for the students to obtain an interview call when they start to apply for it during the final semester. Nevertheless, based on Figure 10(b), only 23% of them managed to secure a job offer. This result is also affected by the students who successfully received a job offer without going through an interview session. Nevertheless, these results are sufficient to show market demand for the Faculty of Engineering graduate. Other than that, Figure 11 shows 6% of the overall students already involved in entrepreneurship during their final semester.

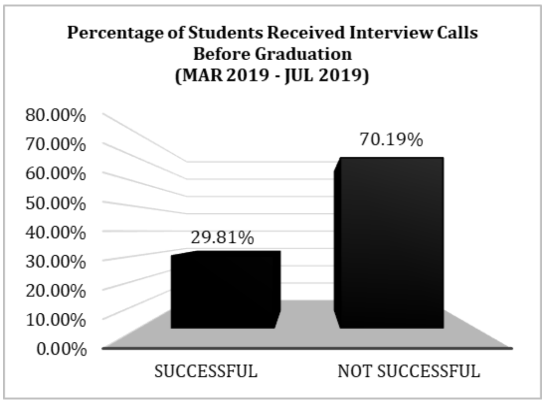


(a)

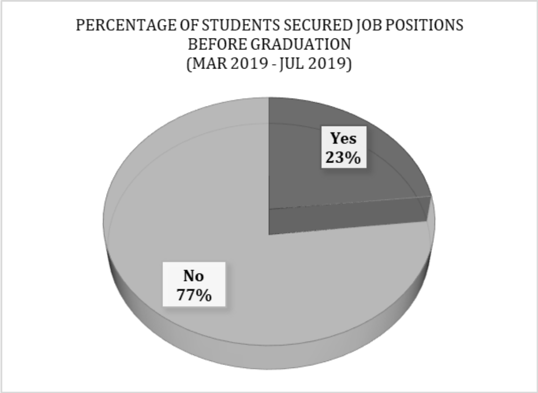


(b)

Figure 9 Percentage of students applied for jobs during the final semester. Data is based on (a) study filed and (b) overall students.



(a)



(b)

Figure 10. Percentage of students (a) received job interviews and (b) secured job positions during the final semester.

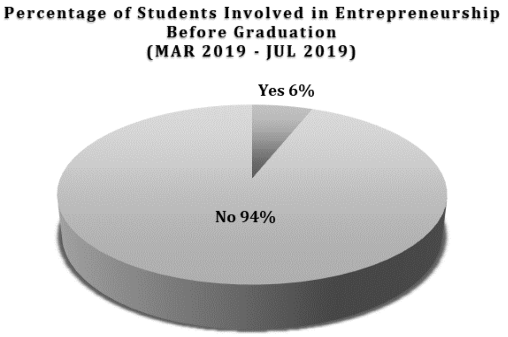
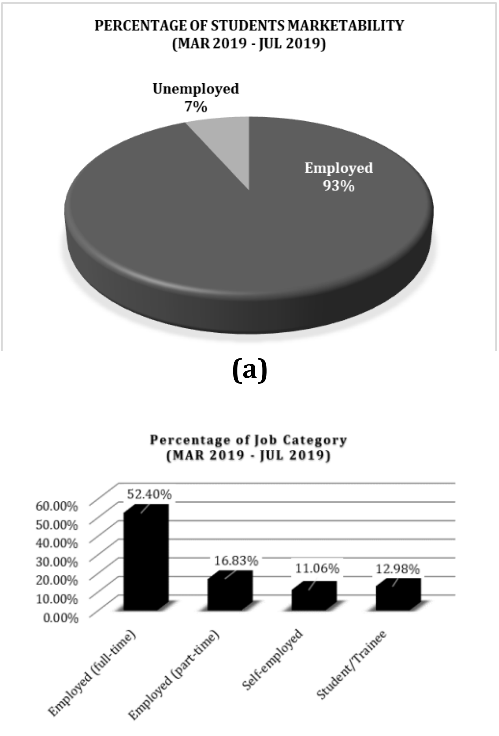


Figure 11. Percentage of students involved in entrepreneurship during the final semester.

Figure 12(a) displays 93% of 208 graduates who responded to the D2 questionnaire was employed within six months after the end of the final semester. This percentage considered full-time employment, part-time employment, self-employed and those who continue their study or training. The percentage calculation did not consider 3 graduates who did not respond to the questionnaire. Nonetheless, according to Figure 12(b), only 52.4% of 194 working graduates managed to get a full-time job placement.



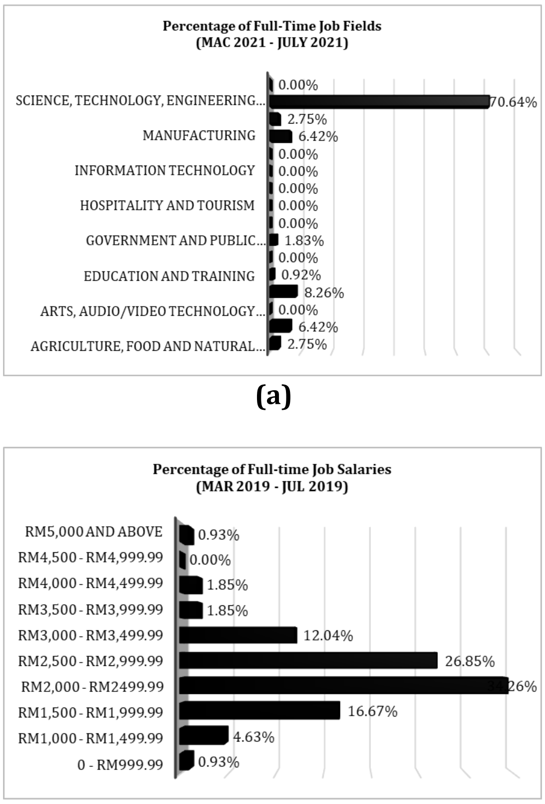
(a)

(b)

Figure 12. Percentage of graduates' (a) employment status and (b) job status

Based on Figure 13(a), most of them work in the science, technology and engineering sectors. Thus, we can say that most of the Faculty of Engineering graduates worked according to their study field. Hence, it shows there is a high demand from the industrial for these graduates. However, according to Figure 13(b), the highest salary range was between RM2,000 and RM2,499.99. The second highest salary range was RM2,500 to RM2,999.99. These salary ranges considered low based on the current living standard in Malaysia. This factor can be motivation for graduates to pursue a career in engineering fields. This low salary range is one reason why many engineering graduates pursue a job internationally or a job in various fields. Furthermore, due to high competition to seek jobs as an engineer or an alternative opportunity, some graduates changed their careers.

This finding in line with the finding from Inge et al. (2020); the authors use motivation as the premise for career mobility and identified motivation. The government should do an immediate rectification action to avoid any migration of these engineering graduates. Otherwise, problems related to the low number of graduate engineers in Malaysia will never resolve.



(a)

(b)

Figure 13. Percentage of graduates' (a) employment sector and (b) raw monthly salary

Finally, Figure 14 presents the percentage of entrepreneurship involvement among students before and after graduation. From the figures, we can see no change in the percentages of students engaged in the business. Other than those already involved in entrepreneurship, the data tells us there are no graduates who choose business as their full-time job. Hence, these findings help the faculty plan to increase students' interest to join the entrepreneurship field.

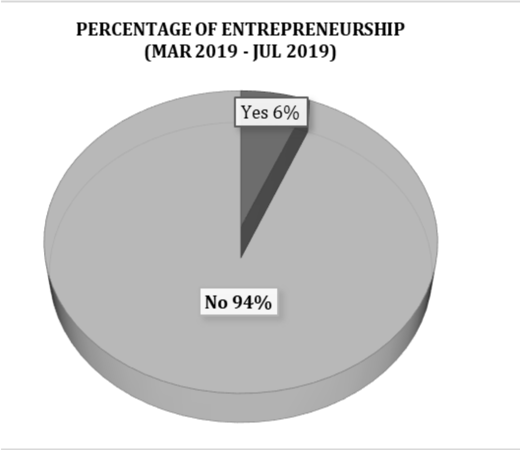


Figure 14. Percentage of graduates involved in entrepreneurship.

Conclusion

This section is used to acknowledge people who have aided authors in accomplishing the work presented as well as sources of funding The AOE instrument was successfully executed and verified for its effectiveness. The instrument can reduce the time consumption in analysing plentiful data and increase data analysis accuracy. By sorting and matching all data, the instrument can generate many informative graphs based on employability attributes. Thus, the AOE instrument is significant to be used as a data collection and analysis instrument. Based on the statistical data, the faculty can take proper actions to increase the graduates' employability percentage for the next batch. Furthermore, the tracking functions such as WhatsApp links and emails help the coordinator to gather information quickly and efficiently. This instrument could help institution to evaluate the correlation between the curriculum design, student activities and employability prospects to secure jobs. In the future, we can conduct various employability analyses based on gender, community, salary and challenges. Moreover, the AOE instrument should have additional features to broaden employability criteria that can be collected and analysed.

References

Mohamad, R., Rose, A.R., Azlin, M., & Puvanasvaran, A.P. (2012). Employability skills assessment tool development. International Education Studies, 5, 4356. https://doi.org/10.5539/ies.v5n5p43

Belen, M.T., Gemma, G.A., & Thelma, D.P. (2018) Evaluating information technology graduates employability using decision tree algorithm. Proceedings of 9th International Conference on E-Education, E-Business, E-Management and E-Learning, USA, 8893. https://doi.org/10.1145/3183586.3183603

Lee, H. (2001). Defining and measuring employability. Quality in Higher Education, 7(2), 97109. https://doi.org/10.1080/13538320120059990

Michavila, F., Martín-González, M., Martínez, J., García-Peñalvo, F., & Cruz-Benito, J. (2015). Analysing the employability and employment factors of graduate students in Spain: the OEEU information system. Proceeding of 3rd International Conference on Technological Ecosystems for Enhancing Multiculturality, USA, 277283. https://doi.org/10.1145/2808580.2808622

Dershem, L. (2016) Skills to succeed employability assessment tool: development of English version and adaptation process for the Philippine country office. Technical Report. http://dx.doi.org/10.13140/RG.2.1.1601.4960

Pažur Aničić, K., & Divjak, B. (2020). Maturity Model for Supporting Graduates' Early Careers Within Higher Education Institutions. SAGE Open. https://doi.org/10.1177%2F2158244019898733

Hashim, N., Chang, P.K., & Abdul Rahman, M.P. (2016) Stops: mengungkai isu kebolehpasaran graduan di Malaysia. Malaysian Journal of Communication, 32(2), 139164. https://doi.org/10.17576/JKMJC-2016-3202-08

Tahir, L., Samah, N., Omar, W., Mohammad, S., Abdul Latif, A., Mohd Yusof, S., Amin, N., Hamid, M., Arsat, M., & Musta'amal, A. (2018). Re-examine Malaysian HEIs graduates' employability: comparing perspectives from graduates and employees. The Turkish Online Journal of Design, Art and Communication, Special Edition, 16661685.

Shahrifudin, M.H. (2018). A study of perceived employability among undergraduate in Universiti Teknologi MARA (UiTM) Cawangan Melaka Kampus Bandaraya. [Final Year Degree Report, Universiti Teknologi MARA].

Misni, F., Mahmood, N., & Jamil, R. (2020). The effect of curriculum design on the employability competency of Malaysian graduates. Management Science Letters, 10(4), 909914. http://dx.doi.org/10.5267/j.msl.2019.10.005

Shariff, S., & Abdul Aziz, A.A. (2019). Modelling employability based on the ICT certification training program. e–Academia Special Issue GraCe, 9298.

Rothwell A., & Rothwell F. (2017). Graduate employability: A critical oversight. In M. Tomlinson & L. Holmes (Eds.) Graduate employability in context. Palgrave Macmillan, London. https://doi.org/10.1057/978-1-137-57168-7_2

Sicherman, N., & Galor, O. (1990). A Theory of Career Mobility. Journal of Political Economy, 98(1), 169-192. Retrieved May 6, 2021, from http://www.jstor.org/stable/2937647

Lindberg, M.E. (2009). Student and early career mobility patterns among highly educated people in Germany, Finland, Italy, and the United Kingdom. Higher Education, 58, 339–358. https://doi.org/10.1007/s10734-009-9198-9

Tolkach, D., & Tung, V.W.S. (2019). Tracing hospitality and tourism graduates' career mobility. International Journal of Contemporary Hospitality Management, 31(10), 41704187. https://doi.org/10.1108/IJCHM-10-2018-0857

Jacob, M., & Klein, M. (2019). Social origin, field of study and graduates' career progression: does social inequality vary across fields?. British Journal Sociology, 70, 18501873. https://doi.org/10.1111/1468-4446.12696

Kenneth, S.S., & Gary A.A. (2018). Aging and work in the 21st century. In C.F. Daniel & S.S. Kenneth (Eds.) Career Embeddedness and Career Crafting Among Older Workers. Routledge, New York. https://doi.org/10.4324/9781315167602

Inge, R., Rémi, S., & Simon, B. (2020). Unraveling the concept of employability, bringing together research on employability in higher education and the workplace. Studies in Higher Education, 45(12), 25882603. https://doi.org/10.1080/03075079.2019.1623770

Education Policy Planning and Research Division (2018). Laporan Kajian Penyelidikan Graduan 2018. Ministry of Education Malaysia. https://www.moe.gov.my/en/muat-turun/laporan-dan-statistik/pendidikan-tinggi/laporan-kajian-pengesanan-graduan/2018-11/3157-laporan-kajian-pengesanan-graduan-2018/file

Science Po Graduate Employability (2019). Graduate Survey 2019 Class of 2017. Science Pro, Great Britain. https://en.calameo.com/sciencespo/read/00416045497446300997f

Gauckler, B., & Körner, T. (2016). Measuring the employment status in the labour force survey and the German census 2011. Insights from Recent Research at Destatis. methods, data, analyses, 5(2), 25. https://doi.org/10.12758/mda.2011.010

John, W. (2014). Encyclopedia of Business Analytics and Optimization. In Owen P.H.J. (Eds.), Teaching and using analytics in management education, IGI Global. http://doi.org/10.4018/978-1-4666-5202-6.ch221

Defillippi, R., & Arthur, M. (1994). The boundaryless career: A competency-based perspective. Journal of Organizational Behavior, 15(4), 307⍰324. Retrieved May 7, 2021, from http://www.jstor.org/stable/2488429.