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Editorial Brief

Thankfully, the world is progressively working its way to new normality. We are seeing sign of positive recovery and improvement from the horrifying pandemic. Despite of any condition, either good or worse, ASEAN Journal of Engineering Education (AJEE) strives to serve the engineering education community with relevant updates on latest research development. For the sixth volume (Issue 2), AJEE has successfully published 8 engineering education manuscripts.

Three manuscripts involved electrical engineering education, where the first paper critically looked into the perception on the application of gamification and simulation in electrical engineering courses. The other manuscripts discussed on the mathematical competencies of electrical engineering students; while the final one evaluates the academic service learning (ASL) context of electrical engineering students on photovoltaic technology.

Another mathematics related investigation involving engineering mathematics delivery via MOOC is showcased in this issue. It is more inclined on the student's and lecturer's perception on the use of PutraMOOC platform developed by one of the top universities in Malaysia. Under mechanical engineering discipline, a contextual knowledge element that utilizes a 3D CAD model manipulation were established from the perspective of four experienced practicing engineers.

For those who have issues in gathering data using semi-structured interview, a beneficial helpful article is offered where tips and guides were shared on how to achieve complete interview. These challenges evolve around factors that affecting quality of data gathering. Other manuscripts include one that involved assessment of student's emotion within the online learning horizon. Final manuscript revolved around exploring leaners' experience in video conference platform that was induced through the emergence of pandemic. For this investigation, the Technology Acceptance Model (TAM) was adopted.

It is our aim that the manuscripts published in this volume can ignite some light on the present and relevant issues in engineering education; and lead to further development and studies for quality engineering teaching and learning.

Editorial Boards

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Non-Major Students' Perception on the Application of Gamification and Simulation in Electrical and Electronics Engineering Courses at Universities in Malaysia

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Abstract
In the field of electrical and electronics (E&E) technology that is evolving rapidly, the Ministry of Higher Education Malaysia emphasizes universities to ensure that the expected non-major E&E engineering graduates are fully equipped with the skills to fulfil market needs. However, it is challenging for non-major students to understand the topics taught to them through the methods as they are conventionally being delivered. Therefore, gamification and simulation such as Kahoot, Quizizz, Multisim and CircuitMod have been applied in the university to facilitate formative assessment in order to enhance interest and understanding, and also accomplish learning more effectively among non-major students. Hence, this research aims to examine the non-major students' perception of the implementation of gamification and simulation in class for face-to-face and online settings. To achieve this, a set of questionnaires was adapted with some modifications for the purpose of data collection. It was distributed to the students from random public universities in Malaysia who are currently enrolled in E&E engineering courses at their respective universities which majority of them are from a mechanical engineering background. Research questions concentrate on the advantages and students' perceptions of gamification and simulation in E&E engineering courses. The collected data has been analyzed using descriptive statistical analysis. Based on the perceptions of the participating non-major E&E engineering students, the majority of the respondents agreed that gamification and simulation provide a better learning experience with the highest score mean of 4.22. Moreover, gamification and simulation boost students' ability to learn, motivate them, increase their understanding, promote their well-being, and increase their achievement academically. Students hold a positive perception with 4.20 mean score, stating that it is suitable for application in the learning process as it is easy to use, fun, motivating, and more efficient. The results provided would encourage educators in Malaysian universities to better meet the needs of teaching non-major students with their lessons.

Keywords: Gamification, Simulation, Engineering Education, Teaching Method, Electrical and Electronics Engineering

Introduction

According to the Eleventh Malaysia Plan, Malaysia recorded an unemployment rate of 3.3% in 2019 (Semouk, 2019). Therefore, the Malaysian government has given special attention in the Twelfth Malaysia Plan towards enhancing the capability of individual employment and providing a large pool of highly skilled workers across various demanding industries, especially electronics technology in the field of electrical engineering (Lelchumanan, Ismail, & Sulaiman, 2019; Yong, 2019). Hence, this aspiration has created a new enthusiasm for universities as a part of the technical and vocational education and training to ensure that career needs can be accommodated by their expected engineering graduates such that their talents are not wasted.

Most of the electrical schools at the universities in Malaysia offer one or two introductory service courses in electrical and electronics (E&E) engineering to non-major students. For instance, Fundamental of Electrical Engineering and Electronics courses served as the introduction in the E&E engineering course at Universiti Teknologi Malaysia (UTM), Principle of Electric and Electronics, and Electric courses at Universiti Tun Hussein Onn Malaysia (UTHM) and Electronics Technology at Universiti Teknikal Malaysia Melaka (UTeM). The Electronic course offered by the School of Electrical Engineering, UTM for instance, is mainly intended to introduce non-major students to semiconductor devices and basic concepts in analogue electronics. The mapped course content includes the basic structure of electronic devices, their characteristics, circuit analysis and applications. The goal is to develop an excellent understanding of the operation of the device among non-major students to be applied in analogue and digital circuit design that may be required of the workforce according to the industrial trend. Other than that, the students will make relation with all relevant information, which was obtained during class conducted for Constructivism Learning Technique. Apart from that, they prefer to apply that information as their experiences to be applied in a reality. Based on this, the Constructivism Learning Technique has been embedded successfully which they can use all those information obtained during the class conducted. Then, they will be preferred to apply that information as their experiences to be applied in a reality (Matsumoto, Amagai, & Yuminaka, 2020).

However, a growing concern has been raised regarding non-major students' difficulties in coping with the topics taught in E&E engineering courses during the teaching and learning process. It was based on the fact that the mapped course contents were impractical and irrelevant to their field which has led to a learning barrier (Hajjar & Sobahi, 2012). This situation was further exacerbated by the severe impact of the Covid'19 pandemic which limited the students' ability to adapt and pay attention to the lesson. Consequently, there are methodological and effective strategies that are being implemented by the majority of the educators in lieu of traditional teaching methods (online lessons or in-presence), to get non-major students interested with their lessons to achieve the learning objectives effectively (Buckley & Doyle, 2016; Leung & Pluskwik, 2018; Majuri, Koivisto, & Hamari, 2018; Moccozet, Tardy, Opprecht, & Léonard, 2013; Nieto-Escamez & Roldán-Tapia, 2021; Wiggins, 2016) for example cooperative learning, competitive and innovative learning (gamification) (Matsumoto, Amagai, & Yuminaka, 2020), Project-Based Learning (PBL) and simulation learning.

Accordingly, the present paper aims to scrutinize the non-major students' perception of the gamification and simulation approaches at universities in Malaysia as a part of their learning journey in E&E engineering courses. This paper is divided into five sections. Section II gives a brief overview of related works on gamification and simulation approaches to teaching non-major students the E&E engineering courses, advantages of such teaching methods in class and tools of gamification and simulation as a part of teaching strategies whether it is face-to-face or online setting. The methodology of this research is briefly described in Section III, while the discussion on the results is presented in Section IV. The conclusions of this research are drawn in the final section.

Literature Review

According to Kapp, "gamification" is defined as games or activities that include fun elements to promote learning (Kapp, 2012). Kapp have identified nine elements of games and standard features which are shown in Figure 1. Brief explanation on each element can be found in (Kapp, 2012). Numerous studies have attempted to explain the advantages and usefulness of gamification in comparison to the traditional methods due to its potential in learning results (Buckley & Doyle, 2016; Furdu, Tomozei, & Kose, 2017; Kapp, 2012; Kapp, 2013; Leung & Pluskwik, 2018; Majuri et al., 2018; Moccozet et al., 2013; Nieto-Escamez & Roldán-Tapia, 2021; Wiggins, 2016). The implementation of gamification with a proper learning structure encourages and motivates the learners through an interesting way with enjoyment and satisfaction (Kapp, 2013). In other words, it assists the students to acquire skills and knowledge in a better environment through the reward.

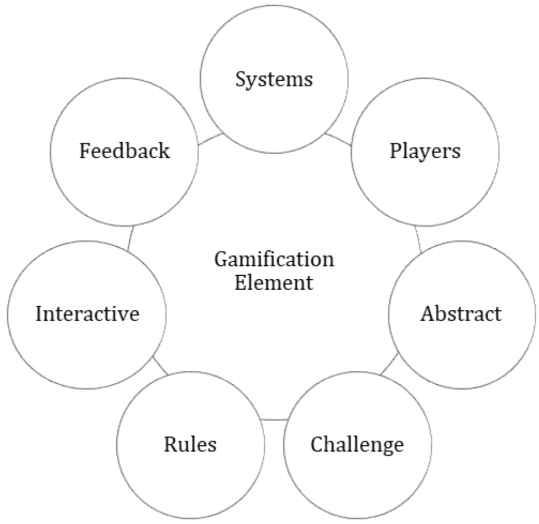

Figure 1: The element of gamification (Kapp, 2012).

In the same vein, Mullin in their recent research noted that the elements in gamification teaching strategy can develop both emotional and cognitive skills (Mullins & Sabherwal, 2020). Accordingly, gamification has become one of the popular teaching methods in higher education for competitive and innovative learning incorporated with project-based learning. The gamification strategy has been shown to be effective by the researchers through several studies in which the gamification strategy has been integrated in curricular for teaching higher education levels across the world. These include "computer science" (Ahmad et al., 2020), "microcontroller and microprocessor" (Ristov, Ackovska, & Kirandziska, 2015), "computer architecture" (Tlili, Essalmi, & Jemni, 2015) subjects.

Apart from gamification, simulation is also one of the teaching and learning approaches that is commonly used with distance learning concepts (Jamshidi & Milanovic, 2022; Kang & Temkin, 2022). It is similar to a virtual laboratory which is a holistic experiential learning process with more realistic user experience, multiple access, and high flexibility. Accordingly, it allows the students to reflect with critical analysis and foster the students' engagement creatively so the students can take initiative and learn from mistakes. With simulation, the concept of a complex system can be demonstrated, which allows engagement and interaction between the simulated equipment and the user for better practical understanding (Almasri, 2022; DeCoito & Estaiteyeh, 2022). In fact, several studies have found that the deployment of the simulation benefits the learning process (Campos, Nogal, Caliz, & Juan, 2020; Juan, Loch, Daradoumis, & Ventura, 2017).

Game-based education that is commonly used for teaching and learning application tools at universities in Malaysia are Kahoot and Quizizz. Both are technological online games that allow the educators to design interactive and incredible content and formative assessment with the aim to improve the impact of effective teaching and digital learning experiences. On the other hand, Multisim and CircuitMod are among the circuit simulators that are being applied for teaching and learning process, especially if it is related to the fundamental and analysis of the electrical circuit. Considerably, introducing gamification and simulation as part of the teaching method in a higher education curricular is anticipated to have the potential to replace the traditional method in enhancing students' understanding (Vlachopoulos & Makri, 2017).

Methodology

In this study, the questionnaires are adapted from Sunarti et al. (2022) with some modifications and disseminated through online google form for quantitative research due to its low cost, easy administration, and ability to represent a large population. The sample size was determined by selecting a random sample among non-major Electrical and Electronics (E&E) engineering students from public universities in Malaysia such as Universiti Teknologi Malaysia (UTM), Universiti Tun Hussein Onn (UTHM), Universiti Teknikal Melaka (UTeM) dan Universiti Teknologi Mara (UiTM) who are currently enrolled to the E&E engineering courses that served as a service course. A total of 380 students participated in this survey with a 100% response rate using convenient sampling method. Out of the total, 350 (92.1%) respondents are from Mechanical Engineering background and 30 (7.89%) respondents are from Naval Arch and Offshore Engineering background.

The advantages aspect of the gamification and simulation in E&E engineering courses were measured with seven (7) items including knowledge understanding, motivation towards lesson, learning experience and environment, instant feedback, flexibility to learn and academic performance. Meanwhile, another aspect in this study is the student's perception towards the application of gamification and simulation by which it is measured with five (5) items including importance of gamification and simulation during learning process, ease of use, interactive learning experience, effective learning process, interest, and motivation during the learning process. The 5-point scale question was used for each item in the questionnaire, which ranged from 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree) to 5 (strongly agree). Besides that, one multiple question is included in the survey to compare the students' preference application between gamification and simulation in E&E engineering courses learning. On top of that, this item of the questionnaire required the respondents to give an explanation on their preference application.

Result and Discussion

There were seven (7) advantages of the application of gamification and simulation in electrical and electronics (E&E) engineering courses that have been listed out in this research. From the results, it is found that the majority of those who responded to these items felt that the implementation of gamification and simulation in E&E engineering course benefits their study. The detailed mean for every items that measured the advantages of gamification and simulation that give benefits to the non-major students is shown in Table 1.

Table 1: Advantages of Gamification and Simulation in Learning E&E Engineering Course

Advantages	Mean
Gamification and simulation increased understanding in comparison to the traditional teaching method	4.19
Gamification and simulation are motivating	4.09
Gamification and simulation provided a better learning experience	4.22
Gamification and simulation in provided a better learning environment	4.16
Gamification and simulation provided instant feedback	4.11
Gamification and simulation allowed the students freedom to fail so that they can learn from failure	4.17
Gamification and simulation provided an advantage in academic performance	4.00

From the results, it can be seen that the aspect of "Gamification and simulation provided a better learning experience" recorded the highest mean with a 4.22 score followed by the aspects of "Gamification and simulation increased understanding in comparison to the traditional teaching method" and "Gamification and simulation allowed the students freedom to fail so that they can learn from failure" with 4.19 and 4.17 mean scores, respectively. This is in line with the research undertaken by Furdu, Tomozei and Kose in 2017 which stated that the combination of fun and learning in the class will make learning more enjoyable and attractive compared to the traditional method and hence, increase students' understanding of their studies. In fact, the students' engagement through the gamification and simulation may improve retention and memory (Furdu et al., 2017). Besides that, the implementation of gamification and simulation allowed the students to accept their mistakes thus leading towards the students' desire to learn (Doppelt & Schunn, 2008).

Meanwhile the fourth aspect the respondents agreed upon the most is the "Gamification and simulation is believed to provide better learning environment" with 4.16 mean score. According to Doppelt et al., a positive learning environment is one of the vital aspects that influences the learning outcome (Doppelt & Schunn, 2008). "Gamification and simulation provided instant feedback", "Gamification and simulation are motivating" and "Gamification and simulation provided an advantage in academic performance" are the three lowest means as selected by the respondents with 4.11, 4.09 and 4.00 mean scores, respectively.

According to students' perceptions, the students agreed that the implementation of gamification and simulation in E&E engineering course will be fun for learning process and can improve the process of learning effectively. The students also suggested that the application of gamification and simulation should be implemented in class so that it can enhance the students' motivation. Table 2 the shows the outcomes of the analysis which indicate the mean scores under students' perception.

Table 2: Students' Perception Towards Gamification and Simulation

Students' Perception	Mean
Gamification and simulation are vital to be implemented in the learning process	4.17
Gamification and simulation are easy to use	4.07
Gamification and simulation in class will be fun for the learning process	4.20
Gamification and simulation can improve the learning process effectively	4.17
Gamification and simulation can give motivation to students	4.14

On the other hand, the students' preference application to be used in E&E engineering courses is shown in Figure 2. From the results, it indicated that majority of the respondents (56.6%) opt to apply simulation over gamification in E&E Engineering courses. Some of the comments are "I would prefer to use simulation like Multisim in this course as it represents the real-world application", "For me, simulation could indicate the problem if the simulation went wrong", "Simulation gives a clear picture of how the processes take place for better understanding", "it is suitable to learn theory through simulation" and "it is easy to use with clear instructions". On top of that, a minority of participants (43.4%) indicated that they prefer gamification in E&E Engineering courses based on the fact that gamification could stimulate the brain and is exciting. Some of the comments are "Gamification in this course enhance my motivation to learn the subject effectively", "Gamification like Kahoot platform is always used by my lecturer and I found it was fun" and "I feel more excited to learn while using gamification approach". Therefore, this finding highlights the usefulness of gamification and simulation as teaching tools for non-major E&E engineering students. This is in good agreement with previous research (Buckley & Doyle, 2016; Leung & Pluskwik, 2018; Majuri et al., 2018; Moccozet et al., 2013; Nieto-Escamez & Roldán-Tapia, 2021; Wiggins, 2016).

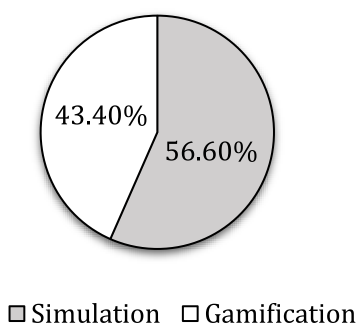

Figure 2: Non-major Students' Preferences of Teaching Tools

Conclusion

This paper has investigated the non-major students' perception on the application of gamification and simulation in electrical and electronics (E&E) engineering courses at universities in Malaysia. The research's outcomes might signal that the implementation of gamification and simulation may assist non-major students to enhance their understanding on the syllabus taught for E&E engineering service courses.

This study indicated both applications can be perceived as good alternatives compared to the traditional method. These applications motivate the students in achieving the learning objectives by providing better learning experience and environment, instant feedback, and a freedom to fail that gives advantages in academic performance.

Particularly, gamification is a more fun method that can induce a sense of accomplishment, healthy competition and happy emotions which will have a greater impact in memorization. Simulation on the other hand, is more formal, which can be applied to all range of students since gamification rewards the fastest and the skilled, instant visualization and results are key to create a better understanding of a component/system, and safe and better learning environment. Further data collection would be needed to determine exactly how effective the gamification and simulation influence the students' competency and comprehension in E&E engineering course.

Overall, this research provides the insight to the educators on the needs of teaching and learning process of E&E engineering course especially to non-major students to achieve the learning outcomes.

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Assessments of Student's Emotions and Their Relevance in Online Learning

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Abstract
Emotions are closely related to the feelings that exist in humans as a result of events or factors that occur around them, where they manifest in specific situations. Students' emotions are easily visible in traditional or face-to-face classrooms, and teachers can recognise emotional presence. Emotions can have a positive or negative impact on a student's learning capacity and motivation. Emotions have an indirect impact on student's cognitive ability to learn. Because of the physical absence of teachers in online learning environments, it is difficult for teachers to see and assess emotions. This concept paper examines the role of emotional presence in the learning process based on a Community of Inquiry framework. This paper also discusses several assessment methods used by previous researchers to assess emotional presence in the online learning environment. The effects of emotional presence on online student learning will also be discussed.

Keywords: Emotional Presence, Online Learning, Learning Management System, Community of Inquiry.

Introduction

Technology has taken over many roles in industries over the years and is rapidly expanding in our lives. In some ways, technology was intended to solve immediate problems and carry out activities faster and better than traditional methods, as well as to improve and increase efficiency (Emoavwodua, 2018). This is especially true in the education sector, where technology has greatly increased access to the educational field. The majority of formal teaching and learning opportunities are now available online. The number of students taking online courses has risen dramatically in recent years, particularly since the COVID-19 pandemic began in 2019. From early education to tertiary education, all parties in the educational sector are being forced to transition to fully online learning. However, the implementation of online learning and its efficacy remains a mystery. There are numerous factors to consider for students to have a meaningful online learning experience and excel academically. One aspect to consider is the student's emotions as they emerge during online learning.

Extensive research on human emotions has been conducted over the last decade. Human emotion research can be found in a variety of fields of study, ranging from developmental cognitive neuroscience to applied and social sciences. Unfortunately, in the development of education and instructional settings, emotion and learning have received little attention. As a result, considering students' emotions in the context of online learning may appear absurd. Humans, whether in the traditional classrooms or online learning environments, crave meaningful interaction. In addition, there is a growing body of literature that acknowledges the importance of emotions in the teaching and learning process. The last decade has also seen a growing recognition of the role of emotions, and recent studies have produced new insights demonstrating that emotions profoundly affect students' engagement, achievement, and identity, implying that they are critical for educational institutions' and society's agency (Boekaerts & Pekrun, 2015).

Students' emotional states during the learning process can influence their engagement and motivation, as well as their cognitive level, which leads to an improvement in academic achievement. It is critical to consider how students are feeling during the teaching and learning process, whether in traditional classroom or online learning settings, because there is evidence from a variety of sources that indicates emotions play a powerful role in learner engagement and achievement, and that the role of emotions in online learning requires special consideration (Artino, 2012; Rienties & Rivers, 2014). As a result of the increased accessibility of technologies in teaching and learning, the concept of considering human emotion is spreading from the physical classroom to online learning communities. This concept paper will discuss the roles of emotional presence in online learning and assess them using a few methods used in previous studies. Furthermore, the implications of emotional presence in online learning will be discussed in greater detail in the following subsection.

Emotions in Online Learning

There are numerous ways to define emotions in various terms. Emotions are typically defined as "multifaceted phenomena involving sets of coordinated psychological processes, including affective, cognitive, physiological, motivational, and expressive components," according to Shuman and Scherer (2014). For example, nervous, uneasy thoughts or feelings (affective), fears of failure (cognitive), increased heart rate (physiological), urges to flee the situation (motivation), and an agitated facial expression all contribute to a student's anxiety before an examination (expression). Emotions have long been thought to be an important and necessary component of the learning process; however, it is difficult to define precisely the emotional experience in text-based evidence when it comes to online learning settings (Cleveland-innes & Campbell, 2012).

Drew (2019) stated that learner feelings and emotions can have an impact on learning in four ways: motivational impact, psychological impact, social impact, and cognitive impact. Because of technological advancements, learning is expanding beyond classroom settings, reducing the visibility of emotional presence among students. This is based on nonverbal cues such as facial expression and accentuation, which are not visible in an online environment (Stenbom, Hrastinski, & Cleveland-Innes, 2016). Because of a decrease in nonverbal cues assumed to convey emotional information, online communication exchanges lacked emotional tone or content (Hancock, Landrigan, & Silver, 2007).

Although most teachers or online instructors want their students to have a positive, happy, and engaging learning experience, measuring such emotions is a difficult task because emotions are very subjective, especially when they are instinctive and physical, such as triggering physical responses to threats (fear) or rewards (reward) (happy). Measuring objectively bodily reactions based on pupil dilation (eye-tracking), heart rate, skin conductance, facial expressions, and brain activity is possible, just as it is in traditional classrooms (Farnsworth, 2020). Students' emotions can be easily seen in a face-to-face classroom, but not in an online learning setting. For example, in a face-to-face setting, cues such as smiling, making eye contact, and knowing students' names have a significant impact on developing trust and connection with the students. These emotional cues may entice them to participate more actively in line classes, but other influencing factors, such as learning environment, learning process, and learning outcomes, must also be considered (Stephan, Markus, & Gläser-Zikuda, 2019). As a result, in an online course setting, there must be a concerted effort to include cues that support emotional presence. For example, analysing written text in discussion forums or online chats by looking for keywords such as "frustrated," "overwhelmed," and "exciting" may provide insight into learners' emotions. Aside from keywords, learners may express their emotions using emoticons such as ":-)", ";-)", or ":-(".

Assessing Student's Emotions in Online Learning Environment

Assessing and measuring students' emotions in online learning may not provide a 100% accurate representation of how the students feel and experience the emotions. Nonetheless, there have been numerous attempts to assess the student's emotions using various methods from previous research. However, many previous studies relied on standard self-reporting tools. Even though measuring emotion may appear difficult, Farnsworth (2020) believed that emotions can be measured objectively through some observations such as pupil dilation or eye-tracking, skin conductance, brain activity, heart rate, and facial expressions, but only in traditional face-to-face settings. Because feelings are subjective in online learning environments, they can be measured using self-reporting instruments such as interviews, surveys, and questionnaires, which include rating scales and self-assessment methods.

Additionally, Rienties and Rivers (2014) found and summarized that there are 7 data gathering approaches to measure and understand emotions based on the previous studies on emotions in learning, where 3 of the methods were using the existing data from common virtual learning environments e.g., Learning Management System (LMS);

- Content analysis – could be done manually by annotating the indicators of opinions and emotions in written text, or by using a coding scheme based on the existing contents. For example, a study by Stenbom, Hrastinski, and Cleveland-Innes (2016) performed content analysis of conversations in forum discussions by identifying the categories based on the emotional presence coding instrument.
- Natural Language Processing (NLP) – a method by using automated systems to identify emotions in written text based on phrases that have been set such as the phrase containing the word "I feel.." across millions of blogs which has been set by Dodds and Danforth (2010) in their blog analyser that they developed.
- Identification of behavioural indicators – assessed through learner's behaviour in any records of communication like a transcript of discussion forums or transcript of recorded synchronous discussions e.g., video conference and chat. In a study by Derks, Bos, and Grumbkow (2007) they requested learner to join in online chats using text, emoticons or both and identified the indicator which used the most or less in a positive or negative discussions. Other than that, there are some researchers who utilized other behavioural analytic tool as Social Network Analysis (SNA) to investigate the pattern of interactions among learners through the use of networks. For example, Makos (2014) was thrilled how 'Like'

buttons could enhance social unity by bring up positive feelings and inspiring deeper learning.

At the same time, Rienties and Rivers (2014) also argues that with the learning attitudes as in emotions and motivations shown by learner while the behaviour assessment is ongoing, teachers can assist the at-risk learners at the early stage of their learning journey. While the other 4 methods to measure emotions in learning were using newly generated data approaches:

- Quantitative instruments – the self-reporting tools that are designed and validated for measuring emotions. They have been widely used for understanding learner's emotions in blended and online learning. For example, Sarsar and Kisla (2016) developed a 21-item survey comprise of 2 subfactors which are "Giving Emotions" and "Receiving Emotions" to understand the emotional exchanges in online learning.
- Offline interviews and purposeful online conversations – are often related to qualitative researches. However, this approach may not be ideal in large groups of learners. This approach also might be used as a part of mixed-method research in quantitative studies. Risquez and Sanchez-Garcia (2012) for example, used online peer mentoring conversations as a textual data to analyse emotional experiences.
- Wellbeing word cloud – a dynamic visualizations of learners' self-reported feelings based on the words like "overwhelmed", "tired", or "stress" as part of an early alert. Alternatively, simple emoticons of student's experience could be collected as well. For example, Nelson and Creagh (2013) reported that University of New England (UNE) in the Early Alert Program developed an Automated Wellness Engine (AWE) in 2010 to collect data and detect students who may be at potential of disengagement and demoralisation.
- Intelligent tutoring systems, agent engines and avatars, have been used to monitor students' cognitive and recognize emotional states and adjusts its replies based on these human characteristics. The on-screen agent or avatars responds to words, tone, facial expressions, and gestures of the learner. For example, Ahmed, Tang, Ahmad, and Ahmad (2013) installed an agent-based emotion engine for analysing student emotions while appraising lecturers.

Emotional Presence and Community of Inquiry

The researchers have made extensive use of the Community of Inquiry theoretical framework as a tool for creating a meaningful educational experience in online learning. Garrison, Anderson, and Archer (2000) pioneered the Community of Inquiry (CoI) framework. Tolu (2013) argued that this framework has been shown to be an important framework for online teaching and conducting online education studies because it emphasises the importance of creating an effective learning environment in which students feel a bond with other learners and the teacher and participate in well-designed collaborative learning activities because it is based on a collaborative and socio-constructivist approach. This CoI framework mainly consists of three elements which are cognitive presence, social presence, and teaching presence. At first, the emotional expressions category is part of the social presence categories. However, previous studies have shown that there is a need for the addition of an element of emotional presence within the original CoI framework (Cleveland-innes & Campbell, 2012; Stenbom et al., 2016; Sarsar & Kisla, 2016; Parker, 2021).

Cleveland-Innes and Campbell (2012) were the first who introduced and suggested a fourth distinct presence in the current Community of Inquiry framework, and defined emotional presence as "the outward expression of emotion, affect, and feeling by individuals and among individuals in a community of inquiry, as they relate to and interact with the learning technology, course content, students, and the instructor". They strongly believed and found that emotions existed in the cognitive presence, social presence, and teaching presence. Given by the points as in Rienties and Rivers (2014) article, they emphasized that emotions can emerge at any point during the learning process, in any of the four presence areas where the emotional presence has a diverse effect on cognitive presence, social presence, and teaching presence, and might result in entirely different, even conflicting emotions for different students.

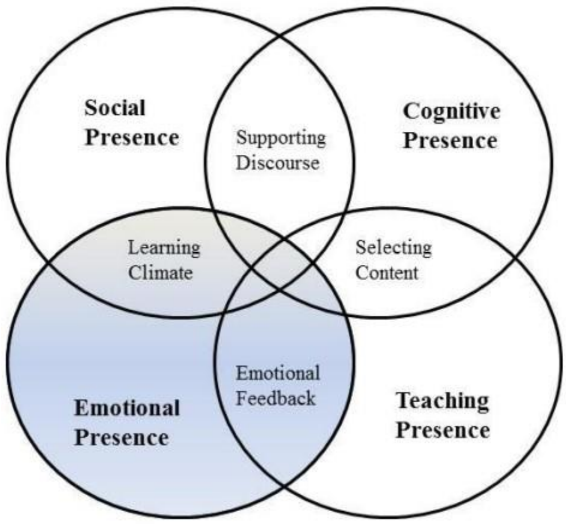

Figure 1. Emotional presence is added to the original Community of Inquiry (adapted from Stenbom, Cleveland-Innes, & Hrastinski, 2014)

Study on particular emotional presence was then continued by Stenbom et al. (2016) and proposed 3 categories or components in emotional presence element as presented in Table 1.

Table 1. Emotional presence elements

Components	Description
Activity emotion	the continuing conversation's process and content
Outcome emotion	the teaching session's expectation or outcome value
Directed affectiveness	the acknowledgement and exchange of emotions between two people in a relationship

In the study, they defined the activity emotion as “ongoing process and content of the conversation”, outcome emotion as “the expectancy or outcome value of the coaching session”, and directed affectiveness as “the recognition and sharing of emotions or moods between the two individuals in the relationship”. They also discovered that emotional presence can be measured in addition to social presence. More and more research on emotional presence supports the need to supplement the CoI framework with an emotional presence component. For example, Sarsar and Kisla (2016) created a survey in their study that included a “Giving Emotions” and “Receiving Emotions” category to help instructors better understand their students' emotional statements. They are adamant that by understanding students' feelings, a strong communication between students and instructors can be established, and students will feel closer, safer, and more at ease with their instructors.

Majeski, Stover, and Valais (2018), on the other hand, conceptualised emotional presence in terms of emotional intelligence because it encourages a much larger role for emotional presence in learning and welcomes emotions in the learning process to a greater extent. They argued that the role of emotional presence in learning extends beyond the original CoI framework's focus on emotional expressions and includes motivating and affective experiential factors such as openness and self-efficacy. A study conducted by Jiang and Koo (2020) discovered that emotional presence, despite being rated lower than cognitive, social, and teaching presence, was a good predictor of students' online learning contentment on its own. The ability of the instructor to connect and express emotional presence influences learner emotion, enthusiasm, behaviour, and ability to learn. In online learning environments, an online educator can use emotional presence to reduce learner isolation as well as the perceived distance and proximity between students and instructors (Parker, 2021).

Discussion and Implication of Emotional Presence in Online Learning Environment

Cleveland-Innes and Campbell (2012) asserted that knowledge about the role of emotion in online learning is still limited. Positive and negative emotions can coexist in online learning. When attempting to increase positive emotions and decrease negativity, instructors must be aware of different students' emotional responses and pay attention to their emotional needs (Jiang & Koo, 2020). If students feel neglected during the learning process because their emotional needs are not met by teachers or learning environments, the consequences can be negative, as they may become unmotivated and lose interest in their studies.

Because emotion has a profound effect on human cognitive functions such as perception, attention, learning, memory, reasoning, and problem-solving (Tyng, Amin, Saad, & Malik, 2017), teachers and educators cannot afford to ignore students' open displays of emotion during the teaching and learning process. However, Trezise (2017) asserted that when it comes to improving students' learning and emotional conditions, education research frequently avoids or neutralises emotions. Trezise and Reeve (2014) discovered that the relationship between cognition and emotion can shift in a short period of time, and cognition and emotion levels predict change and stability, indicating that emotion has a significant impact on cognitive states. Meanwhile, in order to implement more effective emotional elements, the characteristics of learners and their academic needs should be carefully examined (Jiang & Koo, 2020).

A study that assessed recall and recognition for emotionally positive, negative, and neutral words to investigate the effects of emotional content on explicit verbal memory found that emotion significantly influences memory performance and that both positive and negative words were remembered more effectively than neutral words (Khairudin et al., 2012). Furthermore, in a recognition versus recall test, emotional words were remembered better. As a result, instructor roles are critical in online learning to ensure that emotional exchanges in text-based communications are positive.

Assessments of student’s emotion may be varied, but a survey instrument and content analysis are common recently. However, the aim is almost similar. Mainly the purpose of emotional presence researches in online learning is to cater the needs to reassess the effectiveness of online learning in student’s learning journey context, as emotional presence can derive other successful factors such as a positive and active engagement, that contribute to the success of a student.

Conclusion

In conclusion, emotional presence connects people through technology. As it manifests genuine and caring human characteristics, emotional presence has been empirically demonstrated to play a critical role in online learning by humanising the online learning experience (Parker, 2021). From the review of the literature, it is obvious that emotional presence is exists in online learning environments which is beyond and outside social presence context, and the importance of the emotional presence in teaching and learning online is very impactful in order to provide a better learning experience among the students. Other than teaching presence, online teachers or instructors should be able to recognize and identify the emotions triggered by the students during online learning sessions to maximize the students' level of learning for better cognitive stages, motivation states, and even the performance of academic achievement.

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Students' and Lecturers' Perception on the Use of Introductory Engineering Mathematics PutraMOOC

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Abstract
This paper presents the perceptions of lecturers and students on the use of the Introductory Engineering Mathematics PutraMOOC as a medium of learning and teaching for first year engineering students. The objectives of the study include respondents' perceptions of the characteristics of the PutraMOOC and its impact on the implementation of OBE. To measure the findings based on the respondents' experience on using the PutraMOOC, questionnaires which was also linked to students' scores, as well as interviews with lecturers were conducted. The results of this study show a positive impact and perception of the use of the PutraMOOC. However, based on the findings, there are also some improvements that need to be made in helping the effectiveness of the PutraMOOC in the future use.

Keywords: Assessment for Learning (AfL), Massive Open Online Course (MOOC), Outcome Based Education (OBE), e-learning, Introductory Engineering Mathematics.

Introduction

Research Background

With the advancement of online learning, MOOCs (Massive Open Online Courses) which have been introduced in 2008 embarks the world class teaching and educational resources beyond geographical and social boundaries. Despite of many models of MOOCs, the blended MOOC (bMOOC) model converges the cMOOC (i.e. focus on knowledge creation and generation) and xMOOC (i.e. focus on knowledge duplication) and hybrids both MOOC and face-to-face learning. It has been much more popular as it promotes more personalized and scaffold learning. Among the criteria that would fulfill the effectiveness of MOOC listed by Yousef et al. (2015) are blended learning, flexibility, high quality Content Instructional Design and Learning methodologies, life-long learning, network learning, openness, and student-centred learning. Meanwhile, Marks et al. (2005) have suggested that there are three main aspects of online learning need to be taken into consideration which are instructor-student interaction, student-student interaction, and student-content interaction.

The Introductory Engineering Mathematics PutraMOOC has been offered in the Faculty of Engineering, Universiti Putra Malaysia in 2017 and has undergone two cohorts of students, comprising around 600 students to year 2019. This course is very crucial as it is a basic course to mastering engineering fields, and it has been developed on the Massive Open Online Course (MOOC) environment in blended mode - bMOOC with the purpose that the course could be considered in the credit transfer system in future once it is fully a MOOC. The course was designed to suit with the Outcome Based Education model when it is run on the PutraMOOC. Using appropriate and effective assessment is one of the important aspects to be considered in this course so that the learning objectives can be achieved on bMOOC environment. Traditionally, assessment methods focus much on summative assessments where students' performance is assessed solely through tests and examinations. It was found that by applying the assessment based on summative assessment alone, it was quite challenging for instructors to recognize the shortcomings of the students at early stage and accordingly, very little remedial activity could be done. Since the summative assessments only could not help shaping the progress of a student, formative assessment or known as 'assessment for learning (AfL)' was also highlighted in this work.

Assessment for learning (AfL) is a type of assessment that is observed during the students' learning process. During the process, lecturers identify the weaknesses and learning needs of students and take appropriate actions so that the students have better preparation for summative assessment afterwards. Numerous cases reported the effectiveness of AfL (William, 2007). Behind its implementation, students need to know and understand the following before learning can take place: what is the aim of the learning? why do they need to learn it? where are they in terms of achieving the aim? and how can they achieve the aim? This indicates how critical it is to the students' attention to their learning progress, and to show the need for teachers to inspire such attention as much as possible. Kesianye (2015) also agreed that assessments which are focused during the process of learning and progress made by students could help the AfL becomes more effective. Effective teaching is usually assisted by five teaching strategies which are clarifying and sharing goals for learning and criteria for success with learners; conducting effective classroom discussions, questions, activities, and tasks that show evidence of students' learning; providing feedback that moves learning forward; activating students as owners of their own learning; and activating student as learning resources for one another (William, 2007).

Influenced by constructivism learning theory which emphasizes on the role of students in achieving higher level of thinking, authentic assessment for learning becomes an interest of this study. There are ten characteristics of assessment activities that have been identified by Reeves et. al. (2002) in which the authentic activities are seamlessly integrated with assessment. The authentic assessment provides a platform for students to solve real-world, ill-defined, and complex problem while collaborating with other parties, applying multi-, cross- or even trans-disciplinary knowledge or skills, and prepare the students to become creative and innovative. An extended study of authentic assessment by Herrington et al. (2004) argues that as the development of technology grows very fast, the value of authentic activity is not constrained to learning in classroom or face-to-face manner, but the benefits of authentic activity can also be realized through careful design of e-learning environments.

Although there have been many studies that have outlined ways of effective online course or even MOOC (Zulkifli, Hamzah & Bashah, (2020), the perceptions among respondents would be different based on the ways the course was offered. Therefore, more investigations on examining challenges or perceptions need to be done on upgrading the course efficiency for the Introductory Engineering Mathematics PutraMOOC. Among the aspects to be considered are based on i) the features of PutraMOOC, ii) the use of PutraMOOC for Outcome Base Education model, ii) the impact of the use of PutraMOOC towards students' achievement and iv) the potential of PutraMOOC as a credit transfer course. Therefore, this work is intended to see any possibilities of resolving the issues by formulating the following research objectives; to what extent do students and lecturers perceive the use of the Introductory Engineering Mathematics PutraMOOC? and to what extent do PutraMOOC tells the differences in students' tests performance?

Research Framework

The overall research framework of this study is shown in Figure 1. It focuses on blended MOOC (bMOOC) and refers to the perceptions and performance of engineering students who take the Introductory Engineering Mathematics PutraMOOC course. The study also involves lecturers in obtaining their perceptions on the use of the platform and its potential towards a credit transfer course. The form of assessments carried out are inspired by the learning of constructivism which assigns students to produce an explanatory video on mathematical applications in engineering, as well as behaviourism learning theory via quizzes. The findings are expected to contribute for the upgrading of the Introductory Engineering Mathematics PutraMOOC for future use.

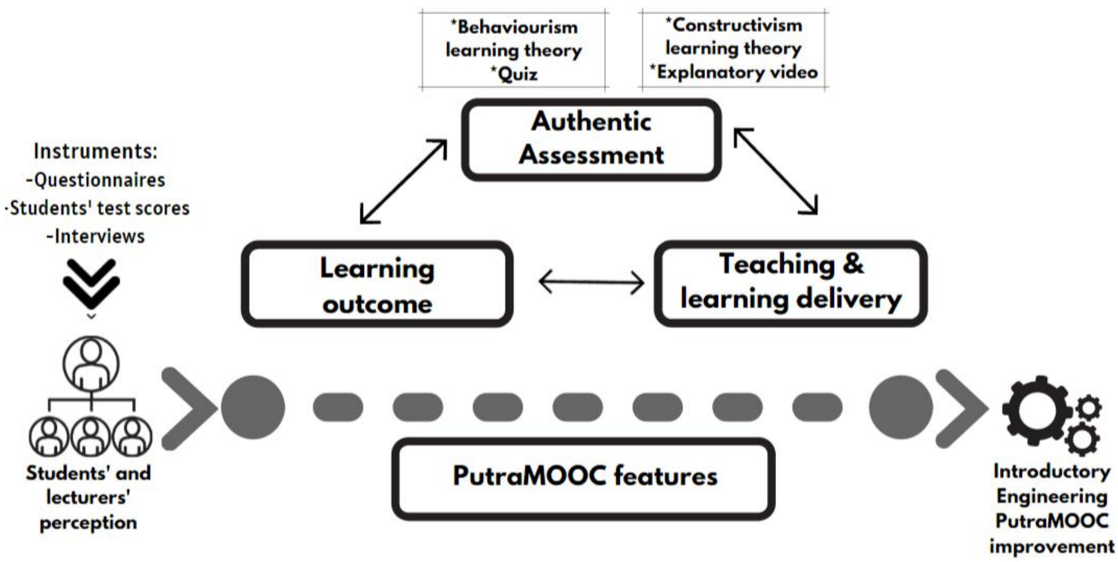

Figure 1. Research framework

Methodology

Development of assessment instruments

The types of assessment are multiple choice questions (optional for students for self-assessment) and video assignment (compulsory). The assessments were developed by considering the course content and outcomes that requires students to apply and explain the use of mathematics in solving engineering problems. In a group of three students, students were given a task create a short video (3-5 minutes) and explain a big idea of 'function' in real life. The explanatory video could be in any form (such as animation, talking head, documentary, and dramatic reconstruction) and using dynamic visual medium (such as diagrams, simulations, physical demonstrations etc.) rather than explaining in front of a whiteboard. The videos are assessed according to the teamwork, content, and creativity criteria. Since there are 8 groups of students from different programs in this PutraMOOC, each lecturer who conduct his/her group would assign any relevant topics or issues to students. One of the triggers given is depicted in Figure 2.

Development of questionnaires

The main objectives of the questionnaires are to examine the perception of students on the use of The Introductory Engineering Mathematic PutraMOOC. The Likert scale was used as the perception indication with the range of 1 to 5 (1: Strongly disagree, 2: Disagree, 3: Neither agree nor disagree, Agree and 5: Strongly agree). A few open-ended questions were also included as parts of qualitative data. The first questionnaires were distributed to a small number of students in looking for the views on any parts that they like or dislike about the Introductory Engineering Mathematics PutraMOOC features and specific opinion about the course. Their perception was also mapped to individual's test score in finding relationship between students' perception and their test scores. The second questionnaires were given to bigger number of students in finding their detailed perception on the implementation of AfL in the PutraMOOC.

Interviews with lecturers

Individual interviews were held after the semester ended once lecturers have completely done the course activity and grading. The questions were asked based on their teaching and learning implementation using the Introductory Engineering Mathematics PutraMOOC and their perceptions regarding the usage of PutraMOOC with relation to authentic assessment, recommendation to the course improvement, and opinions on the challenges using this MOOC as a credit transfer course.

Data collection and analysis

There were 3 lecturers involved in the interviews: one male and two female lecturers. Meanwhile, 16 students involved for the first questionnaires and 263 students took part for second survey, consisting of engineering students from various engineering programs such as computer and communication systems engineering, electric and electronics engineering, civil engineering, and chemical engineering. The data were collected and analysed based on recording from the interviews, statistical parameters of mean and variance from the questionnaires, as well as views from the respondents.

Results and Discussion

Students' perception on the Introductory Engineering Mathematics PutraMOOC features and its impact towards the summative assessment

A questionnaire to identify whether students favour the use of PutraMOOC in assessing their understanding was done after they took the test in the middle of the semester. There were 16 students involved in this study. They were given the option of expressing their preference as well as the reason for supporting their respective standings. The pie chart (in Figure 3) shows the characteristics that have been categorized according to the student's response.

Figure 2. An example of trigger for video assignment

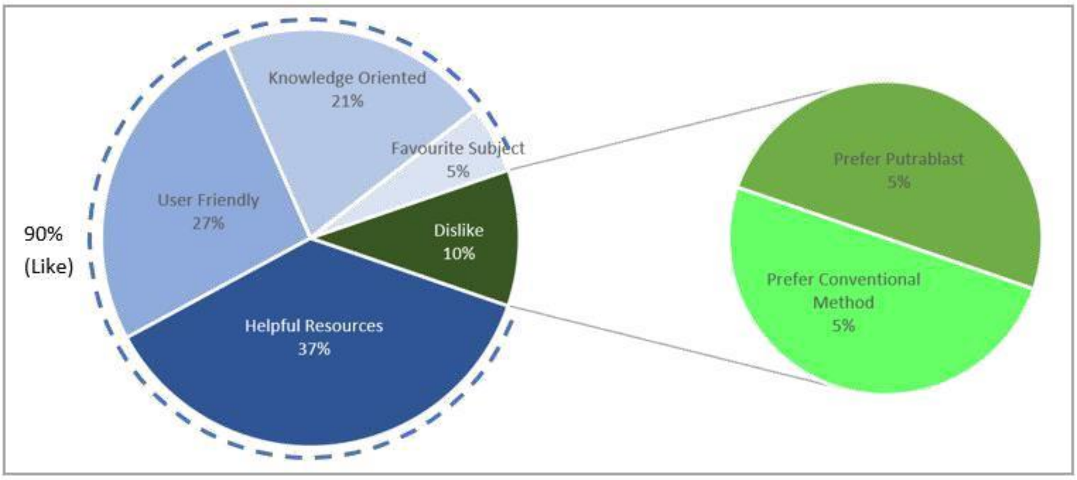

Figure 3. Perception of students about the Introductory Engineering Mathematics PutraMOOC

The findings show that 90% are likely to prefer the PutraMOOC use. Among the 90% of students who prefer PutraMOOC; 37% of students feel that PutrMOOC provides helpful resources, 27% stated that PutraMOOC is a user-friendly platform, 21% found that PutraMOOC is knowledge oriented while 5% like this course as a favorite subject. Meanwhile, among the 10% who do not prefer PutraMOOC, 5% prefer the use of PutraBlast which is the common learning management system at the University and 5% prefer the conventional lecture. The main challenge identified from the questionnaire is related to a server connection where some students recommend that server connection must be improved.

The questionnaire was also aimed to find out whether there is a link between the preference of the student to PutraMOOC and their achievement in the test. In order to look at these relationships, the 'like' perception was evaluated to scale 5 while the 'dislike' was assessed to scale 1.

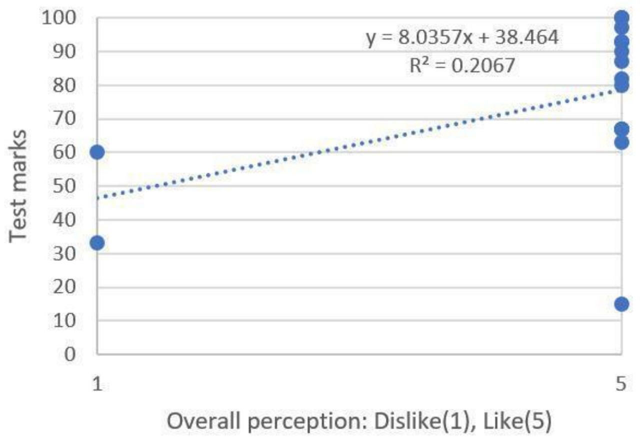

Figure 4. Overall perception with relation to test marks

Scores of students according to their preference are shown in Figure 4. It can be noted that there is a positive correlation where most students who love PutraMOOC perform better than those who do not like. This observation indicates a positive response towards the use of PutraMOOC as a platform for attaining learning outcomes among students.

Students' perception on the usage of the Introductory Engineering Mathematics PutraMOOC in Outcome Based Education implementation

At the end of the semester, a total of 263 students participated in a detailed questionnaire of students' perceptions on three main categories of Outcome Based Education via PutraMOOC. The overall results are shown in Table 1.

In general, this finding clearly shows that there is a good acceptance among students in using PutraMOOC as platform for them to attain learning outcomes based on assessments and teaching and learning delivery, and have good interaction with both lecturers and peers. Majority of students showed a uniform response with a small variance value (<1.00) for each question item. Nevertheless, the aspects that need to be addressed are the ways lecturers give feedback to students on their assessment, and the extensive contents of the teaching and learning materials.

Lecturers' perception on the usage of the Introductory Engineering Mathematics PutraMOOC

Based on the interviews with three lecturers, it is found that they used PutraMOOC in supporting their teaching and learning activities.

Assessment for Learning (AfL) strategies

One of interesting assessment methods that they used was video assignment. It is observed the ways lecturers ran the assignment fulfils effective learning strategies as summarized in Table 2. This had opened opportunities for both lecturer and students to involve in active learning approach.

Table 1. Students' perceptions on three main categories of Outcome Based Education via the Introductory Mathematics PutraMOOC.

No	Question	Category	Mean	Variance
1	The online content are well structured and easy to follow	Course structure	3.93	0.84
2	The materials from the video assignment which are shared online from my peers help me to increase my understanding of the topics	Assessment-Learning Outcomes	3.91	0.78
3	The video assignment given in this course stimulates my thinking	Assessment-Learning Outcomes	4.03	0.68
4	Additional online questions (such as multiple questions) given in this course stimulate my thinking	Assessment-Learning Outcomes	3.99	0.68
5	Additional online questions (such as multiple questions) given to me is appropriate with the learning outcomes	Assessment-Learning Outcomes	4.05	0.63
6	The feedback from the lecturer help to increase my understanding	Assessment-Teaching and Learning Delivery	4.19	0.72
7	**The lecturer gives online feedback for my assignment**	**Assessment-Teaching and Learning Delivery**	**3.92**	**0.90**
8	The video assignment given to me is appropriate with the learning outcomes	Assessment-Learning Outcomes	4.04	0.68
9	Most of the contents delivered help me to understand the topic effectively	Teaching and Learning Delivery-Learning Outcomes	4.01	0.82
10	Most of the contents delivered attract my interest in mathematics	Teaching and Learning Delivery (Contents)	3.92	0.92
11	**There are sufficient examples explained in the contents**	**Teaching and Learning Delivery (Contents)**	**3.80**	**1.00**
12	I am satisfied with the online interaction I had with my lecturer	Teaching and Learning Delivery (Interaction with Lecturer)	3.96	0.86
13	I am satisfied with the online interaction I had with students in this course	Teaching and Learning Delivery (Interaction with Peers)	3.97	0.86
14	Learning outcome are stated clearly at the beginning of each topic	Learning Outcomes	4.21	0.65
15	Summary of the lesson is given at the end of each topic	Learning Outcomes	4.04	0.88

Table 2. Video assignment strategies

Clarifying learning objectives	Conducting classroom discussion	Providing feedback	Activating students as owners of their own learning	Activating student as learning resources for as one another
Lecturers mentioned the learning objectives in class and PutraMOOC	Lecturers motivated students to discuss via chat room/ forum	Lecturers gave feedback in class and PutraMOOC	Students gave comments in PutraMOOC and contributed their works with open access to other lecturers and students	Students learnt among themselves by sharing their works in PutraMOOC

Benefits and Recommendation for the Introductory Mathematics PutraMOOC

There is positive feedback from lecturers in their views on the benefits of this course when it is run in bMOOC environment. The aspects that they appreciate are more on the cross-department visibility, additional supports on the teaching and learning materials, involvement of big number of students and it offers flexibility for lecturers to do asynchronous lecture mode. The summary of their views is shown in Table 3.

Meanwhile, in terms of their thoughts on making improvement to the PutraMOOC, they prefer to improve the contents, system interface and their skill in using the platform. More trainings are needed so that they can fully utilize the features offered by the PutraMOOC platform. Detailed recommendation can be found in Table 4.

Considerations of the Introductory Mathematics PutraMOOC as a credit transfer course

Another important aspect is in seeking views from lecturers about the consideration of the Introductory Engineering PutraMOOC as a credits transfer course. Their concerns are mainly based on the contents and the effective assessments strategies that can be monitored by lecturers, as mentioned in Table 5.

Table 3. Opinions by lecturers on the benefits of the Introductory Mathematics PutraMOOC

Lecturer	Benefits
#1	- Lecturers can provide additional notes and teaching video to students - Unlimited participants.
#2	- Students can join between classes of different department. - Lecturers can upload teaching video and set time for student to do the assignment outside class when lecturer not available to attend lecture. - Student can choose to learn Maths freely.
#3	- Lecturers can upload teaching video to students for self-learning. - Unlimited number of students is possible.

Table 4. Recommendations by lecturers on the improvement of the Introductory Mathematics PutraMOOC

Lecturer	Recommendation
#1	- Modules need to be improved - Need a lot of self-assessment problem for student in PutraMOOC, a lot more functions and better user-friendly quiz interface - Need more training for system features full utilization. Some features are not fully learnt yet.
#2	- Need more training for system features full utilization.
#3	- Provide training for lecturers - Avoid materials uploaded by students to be private - Create an apps integrated with messaging feature.

Table 5. Feedback by lecturers regarding the consideration of the Introductory Engineering PutraMOOC as a credits transfer course

Lecturer	Feedback
#1	Can be considered if there are proper modules that fulfil criteria according to standard requirements for Maths related subject.
#2	Course module must be complete first (e.g. notes, assessment, syllabus, course content). The main issue would be based on monitoring the student progress because the student can access the system everywhere without others to monitor. There is a probability that student's work is not genuine.
#3	There is a possibility to be implemented if the course module is complete and have standard passing mark for credit transfer. However, the challenge is due to difficulty to monitor students who has poor attitude and lack of practice.

Conclusion

Overall, this work observed perception from both students and lecturers about the use of Introductory Engineering Mathematics PutraMOOC in its initial implementation. Majority of students liked the use of PutraMOOC although there were constraints in terms of internet access. It can be noted that there is a positive correlation between the preference of using PutraMOOC with students' performance in their test. The results show that there is a good acceptance among students in using PutraMOOC as their learning platform. More attentions need to be addressed on the lecturers' feedback and the course contents. Meanwhile, the recommendations made by lecturers are useful for upgrading the PutraMOOC in terms of its contents and features. More studies on effective assessment monitoring need to be done on realizing this course for credit transfer in future.

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Solutions to the Engineering Education Research Activity Challenges in Sudan

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Abstract
Currently, the researcher has been engaging in engineering education research in Sudan. Needless to say, the researcher has encountered many challenges while gathering data using semi-structured interview. This paper discusses these challenges, and how the researcher was able to successfully overcome most of them, and to achieve complete interview. These challenges evolve around factors that affecting the quality of gathered data: experienced participants, well-developed interview protocol, interview environment and logistics, interviewer's experience and training, language of the interview, and transcription of recorded audio interviews to text. Researcher's network and his professional connections enabled the researcher to assemble and approach a group of experienced participants who were willing to share their expertise related to the research topics. Also, researcher knowledge of both Arabic and English languages was instrumental in conducting quality Arabic interviews, transcription of audio interviews, and accurate translation between the two languages. At the same time researcher's expertise and his upfront preparation helped in avoiding interview distraction and letting the participant to talk freely, while keep the participant focused on the research topics.

Keywords: Narrative Inquiry, Semi-Structured Interview, Interview Process Challenges, Interview Challenge Solutions.

1. Introduction

Sudan is located in North East Africa, and is considered one of the developing Sub Saharan African (SSA) countries. Since its independent in 1956, the country has been facing many political, social, and economic challenges. These challenges have crippled the country from investing its vast natural resources. Sudan is one of the low-income countries; its natural resources include: water, land, agriculture, forestry, livestock, crude oil, and minerals. With its above average Natural Capital (NC) score of 49.3%, Sudan ranked 78 out of 180 countries in NC. The NC indicator measures the country's ability to sustain the population and the economy, now and into the future (Minalla et al., 2021; Sudan GSCI, 2020).

The direct relationship between a country's economic development and its engineering capacity, which include enough well-trained engineers, is well known and documented (Zakaria, 2021; RAE, 2012; UNESCO, 2010, 2018 and 2019; World Bank, 2018). For instance, UNESCO (2010, p28) stated, 'The engineering profession plays a major role not only in the growth and development of a country's economy but also in improving the quality of life for its citizens. The engineering profession is also playing an ever-increasing role in enabling a country to participate in the global economy and in the protection of the environment'.

However, the engineering education systems in SSA countries, including Sudan, are very poor and the situation is worsening rather than getting any better (UNESCO, 2010; UNESCO, 2019; Mohamedbhai, 2014). Other researchers were investigating challenges facing engineering education in Africa, such as insufficient funding, inappropriate facilities, lack of adequate human capacity, brain drain due to unattractive working environment in SSA, and missing of quality control and accreditation measures (Mohamedbhai, 2014; Falade, 2008). Moreover, The Royal Academy of Engineering (RAE) UK, has developed a single Engineering Index (EI), which consists of eight different engineering related indicators: i) Employment in engineering related industries, ii) human capital investment in engineering, iii) number of engineering businesses, iv) the quality of infrastructure, v) the gender balance of engineers, vi) the quality of digital infrastructure, vii) wages and salaries of engineers, and viii) exports of engineering-related goods. In 2016, about 99 countries were ranked based on the EI; none of SSA countries was included in this ranking either due to data availability or weak indicators' values (Ettridge, 2020).

Sudan has never been ranked based on the EI of RAE, and the country is very behind in the above-mentioned eight engineering indicators. Things are not getting any better due to poor situation of engineering education, and due to the accelerating rate of deterioration of engineering education in the country, compared to the most of SSA countries (Elhadary, 2010; Gasim, 2010; and El-Hassan, 1992). This fact is proved by the inability of engineering education system to accommodate the increasing number of desired students to study engineering, and to graduate competent engineers ready to meet the challenges of the 21st century (Osman, 2014).

The researcher has investigated issues related to engineering education in Sudan, and he summarized them as follow: Poor funding, outdated curricula, ineffective teaching and learning methods, inadequate human capacity, students' under preparedness for college, inadequate number and quality of facilities, issues of quality control and accreditation measures, absence of academic freedom, poor research and publishing conditions, inadequate educational technology and ICT environment, and weak university/industry relationship (Minalla et al., 2021).

These issues require the utmost attention of policymakers, academic administration, industry, and engineering educators, and resolving them would give Sudan the opportunity to achieve its full potential and become a prosperous country.

In addition, poor research and publishing condition in the country has resulted in a big gap in research activities, including engineering education research. Sudanese scholars are required to do more in this area to fill the research gap. The researcher himself believes that he has been doing his part, by engaging in engineering research in Sudan, since 2019. See section 4.

Moreover, the purpose of this paper is to discuss the seven challenges, see section 5, that have faced the researcher while conducting semi-structured interview, in Sudan, and how the researcher has been able to overcome those challenges. Hopefully, this effort helps other researchers while collecting data using similar instruments.

2. Literature Review

Semi-structured interview is considered as a method of choice in qualitative research. According to DeJonckheere (2019), a successful semi-structured interview depends on certain elements such as: (i) determining the purpose and scope of the study; (ii) identifying participants; (iii) considering ethical issues; (iv) planning logistical aspects; (v) developing the interview guide; (vi) establishing trust and rapport; (vii) conducting the interview; (viii) memoing and reflection; (ix) analyzing the data; (x) demonstrating the trustworthiness of the research; and (xi) presenting findings in a paper or report. In line with DeJonckheere, George (2022) identified 5 steps for successful semi-structured interview, namely, 'i) set your goals and objectives, ii) design your questions, iii) assemble your participants, iv) decide on your medium, and v) conduct your interviews.

The researcher encountered challenges, related to some of the above-mentioned elements, while performing semi-structured interview in Sudan: Engagement with experienced participants, semi-structured interview protocol, language barrier, transcription of Arabic interviews, interview cancellation, avoiding interview distraction, and completeness of the interview. This section summarizes reviewed articles on these challenges.

2.1 Engagement with Experienced Participants

Many researchers connect the quality of data collection, to great extent, to the relationship between the researcher and experienced participants who are willing to share their lived experience on the research topic (Kakilla, 2021; Denzin, 2017; Nguyen, 2015; Santoso et al., 2011; and Guba and Lincoln, 1994). For instance: Finding enough participants may not be an easy task; Santoso et. al. (2011) reported that only 4 participants, out of 45 potential ones, agreed to participate in the interview. They added, 'Involving more participants in terms of quantity and variety would provide more conclusive results. Four students are not enough to capture a clear portrait of student's self-reports.' As well, in some cases, participants are unwilling to fully share their own experiences due to various reasons; of them are: the language barrier (Kakilla, 2021), limited understanding of the topic (Denzin, 2017; Nguyen, 2015), and/or distinct cultural values (Nguyen, 2015).

2.2 Semi-structured Interview Protocol

Preparing a semi-structured interview questions may be very challenging because semi-structured interviews require a balance between preparing fixed questions and conducting the interview (DeJonckheere et al., 2019; Kallio, 2016). The semi-structured interview allows the researcher to write fixed questions without following a certain number or order of questions; as well, the researcher has the flexibility to ask follow questions, when the need arises, to clarify, elaborate, and/or confirm participants' answers. However, it is not easy to develop a good set of questions for conducting a proper interview. George (2022) states, 'Semi-structured interviews can be difficult to conduct correctly due to their delicate balance of prior planning and spontaneous asides. Every participant is different in their willingness to share. It can be difficult to be both encouraging and unbiased.'

2.3 Language Barrier

Kakilla (2021) wrote a critical essay on the pros and cons of applying semi-structured interview in a qualitative research method. According to Kakilla, one of the weaknesses of the semi-structured interview is data loss due to language barrier. Kakilla suggests that employing translators might resolve the issue; however, the interviewer may lose the direct meaning through translation (Kakilla, 2021).

2.4 Transcription of Arabic Interviews

The first step in preparation of the interviews for analysis is transcription from verbal to written MS Word documents. Then written texts were edited and necessary corrections were made. This is a crucial step to prevent misinterpretation of any findings due to unnoticed /uncorrected errors. Santoso et al., 2011 states, 'Transcription of the interview proved to be very tasking because the interviews proved to be wordy and not specific to the questions asked.' They recommend that to pre-interview all participants and choose from them who demonstrate good communication skills. The researcher believes that this recommendation is not practical, and it is cumbersome to both interviewees and interviewers. Others utilize software, such as QSR NVIVO 10, for transcription of audio recording interviews.

2.5 Planning Logistics of Semi-structured Interview

Conducting a good semi-structured interview, requires a thoughtful planning which includes: identifying respondents, deciding on the number of interviews and preparing the interviews. DeJonckheere et al. (2019) wrote, 'Careful planning particularly around the technical aspects of interviews can be the difference between a great interview and a not so great interview.' In other words, good planning of a semi-structured interview would result in completion of the interview, without interview distraction and/or cancellation. Planning includes: contact potential interviewees, obtain informed consent, arrange interview times and locations convenient for both participant and researcher, and test recording equipment (Tomaszewski et al., 2020; DeJonckheere et al., 2019; and Creswell et al., 2018).

3. Method

Using the narrative inquiry, within the qualitative approach, this study will answer the research questions of challenges and solutions to conduct semi-structured interview in Sudan: What are the challenges that have faced the researcher while conducting semi-structured interview? And how the researcher was able to overcome them (solutions)?

Connelly and Clandinin (1990) define the narrative inquire as, 'the study of lived experience "in the field," within formal settings (e.g., schools, organizations, clubs)' (Clandinin and Connelly, 2000). As they introduced it, narrative inquire has many features; of them are: data is gathered through various qualitative data instruments, such as: interviews, observations, documents, pictures, etc; there are 4 types of narrative analysis: thematic, structural, dialogic/performance, and visual analysis; and narratives occur within context, specific places or situations.' (Riessman, 2008, as cited in Creswell, 2013 p. 71).

Narrative inquiry has been employed in many fields such as medical field, cognitive science, knowledge theory, organizational studies, linguistics, sociology, education, just to name a few (Riessman, 2005; Victor, 2009). Zakaria (2021) employed the narrative inquiry method, as introduced by Connelly and Clandinin (1990), because he believes that this method is suitable in the field of educational research; Zakaria (2021) states, 'In the context of educational research, this concept is developed into the perspective that education and educational researches are the construction and reconstruction of stories from one individual and a group of people socially. Learners, teachers, and researchers are storytellers and characters in their own stories or tell other people's stories'.

The researcher is using the narrative inquire, within a qualitative approach, to tell his own experience while performing engineering education research in Sudan; narrative data was collected through semi-structured interviews, researcher's observations, and recorded field notes. To answer the above-mentioned research questions, the researcher is using the Riessman's thematic analysis to analyze his own experience, as a semi-structured interview inquirer, and his own observations while gathering data, , about Sudanese engineering education system, using semi-structured interview method.

4. The Interest in Engineering Education Research

For many years, the researcher, who is a chemical engineering educator, has expanded his research interests to include engineering education research, in addition to his research in the areas of biotechnology, microfluidic technology, and nanotechnology.

4.1 Engineering Education Research- Sudan

Since 2019, the researcher's focus has shifted to cover engineering education research in SSA countries, focusing in Sudan. His research efforts have been covering various topics, such as: i) Overview of the situation of engineering education in Sudan. ii) Issues related to engineering education in Sudan (Minalla, 2021). iii) Engineering curriculum; for instance, the researcher has proposed flexible engineering curriculum for promoting engineering students' success (Minalla et al., 2022). iv) Teaching and learning methods required for graduating competent engineers.

While performing engineering education research in Sudan, the researcher has been using various instruments for data collection. As Figure 1 shows, his data collection process has been evolving through four distinctive stages.

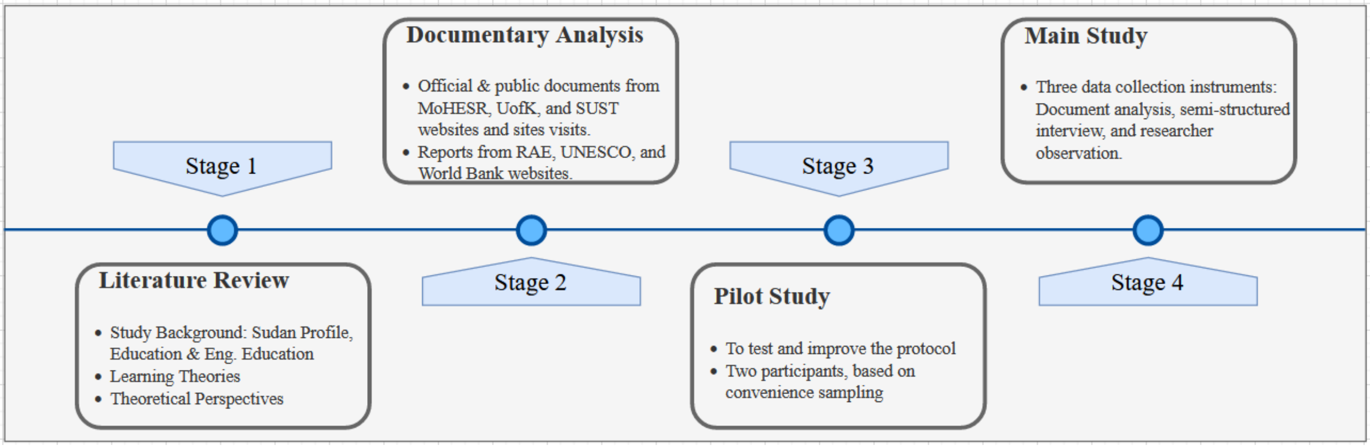

Figure 1. Four distinctive stages of data collection

Stage 1: The researcher performed literature review around three themes: the first theme was concerned with Sudan background, which included the country's profile, an overview of the general education sector, and engineering education as part of tertiary education; the second theme covered historical background of the learning theories; while the third theme dealt with theoretical perspectives and frameworks (Minalla et al. 2021).

Stage 2: Documentary analysis represented a source of secondary data; documents included: Official and public documents from Ministry of Higher Education and Scientific Research (MoHESR), University of Khartoum (UofK), Sudan University of Science and Technology (SUST), in addition to reports from RAE, UNESCO, and World Bank websites (Minalla etal. 2021).

These two stages have inspired me to advance my research into a new horizon. This led me to acquire primary data by interviewing engineering education stakeholders in the country, thereafter called the main study. While preparing for the main study I had to conduct a pilot study.

Stage 3: The pilot study allowed the researcher to test and improve the interview protocol and to prepare well prior to the commence of the main study. Based on convenience sampling, the researcher chose three participants, Int 1, Int 2, and Int 3, as shown in Table 1, for the pilot study. They were contacted and the interviews were completed in January of 2022.

Stage 4: The main data collection phase, which is in progress stage, consists of semi-structured interview, the main source of primary data, in addition to documentary analysis and the researcher's observations.

4.2 The Main Study- In Progress

Since July of 2022, the main study is ongoing data collection stage. As shown in Figure 1, this stage consists of semi-structured interview, the main source of primary data, in addition to documentary analysis and the researcher's observations. Data sources are Ministry of Higher Education and Scientific Research (MoHESR), University of Khartoum (UofK), Sudan University of Science and Technology (SUST), and relevant industries. Research activities have been split into field work, which included site visits, observations, documents collection, and interviews, and additional semi-structured interview through Zoom Conference Platform. The researcher has prepared a list of potential participants, semi-structured interview protocol, and other logistics for the interviews.

Table 1 shows the list of interviewees who participated on the study. They include: Academicians, education and engineering education administrators, policymakers, engineering professionals, and industry practitioners. Participants were contacted by email, phone calls, and/or direct personal contact. Upon their acceptance of participation on the interviews, participants were formally informed about the purpose of the study, and their consents were obtained prior to the data collection. So far, a total of 9 participants (part.) were selected and interviewed.

5. Challenges and Solutions

5.1 Engagement with Experienced Participants

A good quality interview requires experienced participants in the area of engineering education who are willing to share their own experience in their fields. As well, participants' availability to engage in the interview is very crucial for the study. It can be very challenging to prepare and approach a list of experienced participants. For instance: Finding enough participants may not be an easy task; Santoso et. al. (2011) reported that only 4 participants, out of 45 potential ones, agreed to participate in the interview. As well, in some cases, participants are unwilling to fully share their own experiences due to various reasons; of them are: the language barrier (Kakilla, 2021), limited understanding of the topic (Denzin, 2017; Nguyen, 2015), and/or distinct cultural values (Nguyen, 2015).

Solution: Being a Sudanese who have connections with many Sudanese academicians and professionals, in addition to the Sudanese culture that allows at ease connections and networking, enabled me to assemble a list of purposeful participants, and easily approach them and access their institutions. Table 1 shows the list of participants who have already got involved in the interviews.

It is worth noting that, the researcher, who born and raised in Sudan, has studied, worked and travelled extensively in Europe, USA, Africa, Middle East, and Asia. The researcher earned his first chemical engineering degree from Romania, and a master degree in chemical engineering from USA. Since 2015 the researcher has moved to United Arab Emirates (UAE), and he has been working as a chemical engineering lecturer at Higher Colleges of Technology, UAE. Throughout his career as a professional engineer, and as engineering educators, the researcher has been able to establish his professional network that includes Sudanese scholars inside the country and diaspora.

According to Guba and Lincoln (1994), the qualitative interpretative research requires strong link between the researcher and the participants while creating meanings, which means certain researcher's biases may influence the study. Nevertheless, the researcher believes that his bias, values, beliefs, and background have positive addition to this study rather than negative impact.

Table 1. Semi-structured Interview Participants (Part.)

Part.	Gender	Affiliation	Experience	Note
Int 1	Male	UofK	Academia 25+ yrs	Pilot Study
Int 2	Female	MoHESR	Administration & Academia 10+ yrs	
Int 3	Male	MoHESR	Administration & Academia 10+ yrs	
Int 4	Female	UofK	Academia 5+ yrs	Main Study
Int 5	Male	Industry	Industry & Academia 30+ yrs	
Int 6	Male	Industry	Industry 30+ yrs	
Int 7	Female	UofK/ MoHESR	Administration & Academia 10+ yrs	
Int 8	Female	MoHESR	Administration & Academia 10+ yrs	
Int 9	Male	UofK	Academia 25+ yrs	

5.2 Semi-structured Interview Protocol

A well-developed semi-structured interview protocol is crucial for generating a quality data in terms of objectivity and trustworthiness, which means plausible results.

Like structured interview, the semi-structured interview allows the researcher to write fixed questions without following a certain number or order of questions; as well, the researcher has the flexibility to ask follow questions, when the need arises, to clarify, elaborate, and/or confirm participants' answers. However, it is not easy to develop a good set of questions for conducting a proper interview (DeJonckheere, 2019; Kallio, 2016). George (2022) states, 'Semi-structured interviews can be difficult to conduct correctly due to their delicate balance of prior planning and spontaneous asides. Every participant is different in their willingness to share. It can be difficult to be both encouraging and unbiased.'

Solution: Starting with research objectives and research questions, the researcher developed a bilingual (English/Arabic) semi-structured interview protocol draft, see next section about the language barrier. This draft has been tested, revised, and finalized during the pilot study. Then, this predetermined semi-structured interview protocol has been used to collect the data for the main study.

After completion of the first few semi-structured interviews, the researcher was able to determine that their quality was unsatisfactory, in terms of the amount of gathered information, missing information about certain topics, and unreliable information. Unsatisfactory data might be caused by biased and leading questions. Therefore, another semi-structured interview protocol revision had been completed, and a well-developed, bilingual semi-structured interview protocol was produced. Then, the main data collection has been resumed.

5.3 Language Barrier

Although English is the official teaching language in most of the Sudanese universities, the researcher decided to prepare a bilingual (Arabic/ English) semi-structured interview protocol because Arabic is the country's official language, and it is the mother tongue of most of Sudanese. As well, to ensure that participants thought and opinions precisely captured, the researcher decided that interviews to be performed in Arabic, unless participants choose otherwise; then, the following step is translation of transcribed interviews to English.

The challenge was to accurately translate back and forth between Arabic and English languages.

Solution: At the beginning, the semi-structured interview protocol was prepared in English, then translated into Arabic language through two-step translation process: The first step was translation using google translator. Although google translator has done a reasonable job producing the Arabic version of the protocol, still a second step was performed to revise and correct any mistranslation. A proper bilingual protocol was obtained.

On top of that a rigour understanding and translating of Arabic interviews is crucial to capture, without distortion, all gathered information. Google translator, followed by rigours editing step resulted in a neat translation of transcribed interviews. This is a very time-consuming task, but it is critical, though. The researcher's knowledge of both Arabic and English languages guaranteed the translation accuracy.

5.4 Transcription of Arabic Interviews

As above-mentioned, the researcher decided to conduct all interviews in Arabic language, which resulted in the burden of transcribing Arabic audio to text. This has become one of the main challenges because of one or more of the following reasons: Zoom Conference Platform does not support transcription of audio in Arabic language; free transcription software could not support lengthy audio interviews; Commercial transcription software is too expensive, at a rate between $90-$180 per one-hour audio. The researcher was very reluctant to utilize expensive commercial Arabic transcription software, with no guarantee that these types of software would complete the transcription accurately; bear in mind, interviewees, most of the time, were talking using Sudanese dialect rather than standard Arabic language.

Solution: Manual intelligent verbatim transcription was the option, knowing that it is very time-consuming task; however, the researcher took the opportunity to complete simultaneously multiple tasks, namely: transcription, translation, and coding; in addition, verbatim transcription allowed the researcher, who knows both Arabic and English languages, to identify and address any inconsistency within the interview or questions that come up as he listens to the recorded interviews.

5.5 Interview Cancellation

Some of scheduled interviews have been cancelled due to one or more of the following reasons: i) unplanned work-related commitments of participants; ii) unexpected social events happened to them; and/or iii) a wave of political unrest during the period of data collection. In addition, some of Face-to-Face interviews were cut very short for the same reasons.

Solution: Interview cancellation forced the researcher either to reschedule missing interviews (Int 3 and Int 7), or in few cases to omit the interview completely and replace it with another participant. Incomplete Face-to-Face interviews were continued using Zoom Conference Platform (Int 5, Int 6 and Int 9). At the same time, the researcher has to capitalize on few opportunities and to conduct informal meetings/discussions. These meetings, in some instances, turned out to be very fruitful, where participants willingly provided meaningful insights about the research topic. One example was the meeting with the chair of the chemical engineering program (Int 4), which has become a complete interview.

5.6 Avoiding Interview Distraction

Avoiding distraction, during the interview, is key for gathering high quality Information. Distraction may occur due to various reasons, for instance: lack of interviewing experience, inaccurate preparation for the interview, interview surroundings, etc.

Focusing on a research topic during the interview has represented another challenge since conducting a successful semi-structured interview requires that the interviewer remains an active listener and non-judgmental who is able to let the participant to guide the interview, while keep him focus on the research topics (Adams, 2010).

Solution: However, to overcome these challenges: the researcher prepared well for the interview (participants and logistics), used a well-developed, bilingual semi-structured interview protocol; during the interview, he avoided leading questions and closed-ended questions, and he had become a good listener rather than a participant in the discussion (Santoso et al., 2011).

5.7 Completeness of the Interview

Incomplete interviews and/or loss of data represents a real challenge. Potential loss of data might be caused by: language barrier, limited understanding of the research topic, uncooperative participant who fails to share his own experience, and incomplete interview (Kakilla, 2021).

Solution: Performing data analysis immediately after the data was collected helped me to improve and correct any errors. For instance, I found out that the first few interviews were very poorly conducted due to the semi-structured interview protocol. Accordingly, the interview protocol was reviewed and improved, see section 5.2. Then, I continued interviewing, a total of 9 participants. To ensure the integrity and completion of the interview, the researcher allowed himself sometime, at the end of each interview, to review it, write his own remarks, record the gap, and evaluate the quality of the information. Although the quality of the interviews was much better than the first few, I noticed reasonable gaps within collected data. I have been filling the gaps using Zoom Conference Platform with the same participants. Zoom meetings have been working very well, and I am planning to do more interviews through Zoom Conference Platform.

6. Ethical Considerations

Sochacka et al. (2018) claim that the research quality is connected to its ethics in two ways; they report, 'First, we found that the quality of our work improved when we critically explored the intersections between our motivations and intentions for investigating particular research topics and broader cultural agendas and assumptions. Second, we found that when we actively sought to do justice to the participants, co-investigators, and readers of our research, we were afforded with opportunities to increase the quality of our work, in sometimes quite unexpected ways.' On the other hand, qualitative researchers have to consider the ethical issues of their work.

Therefore, all participants were informed about the research, and its academic nature, and their consents were obtained. As well, participants were informed that their participation is voluntary with no obligation to complete the research. On the other hand, the researcher has an obligation towards all participants and their wellbeing; the researcher should ensure participants' anonymities and the confidentiality of the information.

Conclusion

In conclusion, the researcher has encountered many challenges while performing semi-structured interview in the context of Sudan. These challenges were: Engagement with experienced participants, semi-structured interview protocol, language barrier, transcription of Arabic interviews, interview cancellation, avoiding interview distraction, and completeness of the interview.

Moreover, the paper discussed how the researcher has been able to overcome most of these challenges, to conduct complete interviews, and to gather high quality data.

The significance of this study is to illustrate explicitly both challenges, faced the researcher while conducting semi-structured interview, and proposed solutions, by the researcher, to overcome these challenges.

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The Implementation of Photovoltaic Academic Service Learning at School and Its Impact on Student Schools and Student Facilitators

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Abstract
This paper presents the implementation of academic service learning (ASL) and its impact on secondary school students as the community and the university undergraduate students who act as facilitators. The facilitators are the final year students from the Faculty of Electrical Engineering undertaking a photovoltaic technology course at Universiti Teknologi Malaysia. The ASL aims to transfer the knowledge of photovoltaic technology to the school student from the university's students and increase their interest in pursuing tertiary study in the science, technology, and mathematics (STEM) stream. At the same time, it will benefit the facilitators by enriching their communication skills, personality, and academics. The objective achievement of the activity is measured qualitatively through a set of questionnaires after the activity. It was found that ASL has positively impacted the school student's knowledge of photovoltaic technology. To measure the impact on the facilitator, questionnaires were given to them after a year of graduation. The majority of them agreed that ASL improved their communication skills and personality. However, most facilitators agreed that ASL has minimum impact on enhancing their knowledge of photovoltaics.

Keywords: academic service-learning; photovoltaic; secondary school students; university.

Introduction

There are three educational learning theories: behaviorism, cognitivism, and constructivism. Behaviorism is a theory based on routines that "drill" information into a student's memory bank and positive feedback from teachers and an educational institution (Rodríguez-Izquierdo, 2020). The theorem is only concerned with observable stimulus-response behaviors. On the contrary, cognitivism moves away from behaviorism and focuses on the mind's role in learning instead. Learning relies on external factors (like information or data) and the internal thought process. The constructivism theorem is more on the active engagement of the learners towards its surrounding, i.e., community. The learner builds upon their previous experience and understanding to construct a new understanding.

Academic service learning (ASL) is an educational approach categorized under the constructivism theorem (Buntat et al., 2013). It combines classroom instruction with real-world experience. Students learn academic concepts and theories while gaining practical skills and knowledge through service projects. Service learning can take many forms, but all programs share a common goal - to provide students with opportunities to apply what they are learning in the classroom to real-world situations.

This hands-on approach helps students develop a deeper understanding of course material and how it can be used in the real world. Service-learning projects can be designed to meet any community's needs and be structured to fit the available time and resources. Programs can range from a one-time project to an ongoing commitment involving individuals or groups of students. No matter what form it takes, ASL provides students with valuable experience that can help them in their future studies and careers (Friman, 2017).

In line with that, the National Education Development Plan 2015-2025 (for High Education) highlighted the necessity of deploying a service-learning approach that combines experience-based education and entrepreneurship into the university's curriculum. For that, Service Learning Malaysia (SULAM) initiative is launched (Ministry of Education Malaysia, 2019). The objectives of SULAM are:

a. To increase student learning by combining both theory and community services.
b. To enhance the personality and civic of the student.
c. To fulfill the community needs using the theory learned by the students.
d. To build a conducive teaching and learning environment between lecturer, student, and community.
e. To give opportunities for NGOs to run and provide corporate social responsibility (CSR)

Under SULAM, various programs involving universities-community projects have been conducted. At Universiti Malaysia Sarawak (UNIMAS), a project named Waste Separation Workshop with Kota Samarahan City Council (MPKS), Worming Up, and Farley Supermarket was held. In Universiti Teknologi Malaysia, a landscape project with Flat Taman Plentong Utama residents was carried out in 2015. This project involved the re-design of an unattended flat courtyard with an edible garden concept (Ministry of Education Malaysia, 2019).

This paper will present the implementation of Photovoltaic Academic Service Learning for secondary schools. Firstly, the outline of the Photovoltaic Technology course will be briefly described. The assessment method of ASL will be presented and discussed. Lastly, the outcome of the survey questionnaire on the ASL effectiveness in promoting Science, Technology, and Mathematics (STEM) among secondary schools is discussed. In addition, results from the survey to qualitatively analyze the ASL activity towards the civic, academics, and communication of the facilitators after they graduated will be presented.

Literature Review

It has been reported that the number of students studying science, technology, engineering, and mathematics (STEM) is falling by 6,000 annually (Malik, 2019). According to Akademi Sains, Malaysia's Science and Technology Human Capital Report and Science Outlook 2015, the country needs at least 270,000 science students annually to take the Sijil Pelajaran Malaysia exam. However, only around 90,000 are left (Nasa and Anwar, 2016). The number is quite worrying, and educators have urged the government to step up efforts to promote STEM interest among students to achieve the 60:40 ratio between STEM and non-STEM students (Zainudin et al., 2015).

In line with the effort, the Faculty of Electrical Engineering, Universiti Teknologi Malaysia, in 2017, introduced an academic service-learning (ASL) element in several school courses. The introduction of ASL is concurrent with the vision of UTM to strengthen public-university ties (Omar, 2018). In this course, the students must conduct knowledge transfer activities with the public. Apart from that, service learning will benefit the students, namely personality growth, civic learning, and academic enhancement. The relationship between the content of service learning and the goal is illustrated in Figure 1.

Photovoltaic Technology is an elective course in the Bachelor of Electrical Engineering at Universiti Teknologi Malaysia. In this course, the students are exposed to the technology of photovoltaic systems. The content covers solar panel materials technology, wind turbine, conversion system, energy storage system, and the direction of recent research in both energy technologies.

There is no specific guideline on the ASL implementation, credit hours, academic load, or assessment method for ASL courses (Ministry of Education Malaysia, 2019). Based on the literature, the assessment tools for ASL can be in the form of interview conduct, documentary, training module, portfolio, peer observation, exhibition, reflection journal, product design, and pitching session. It must be highlighted that the implementation of ASL and its assessment must be suitable with the course materials.

Based on that, the course will have an assessment: 50% from the final exam, 20% from the test, and 30% from the academic service-learning (ASL) activity. Out of the ASL assessment mark, 25% will come from the ASL activity, 15% from the ASL report, and 5% from the peer review assessment.

Methodology

In the academic session 2018/2019 semester 1, 57 students took this course and were grouped into five groups containing around 10 to 11 members. Firstly, each group is requested to identify potential secondary schools and communicate with the principal or counsellor. For this cycle, five secondary schools were approached, and they are:

a. SMK Taman Impian Emas
b. SMK Bandar Baru Uda
c. SMK Bandar Selesa Jaya
d. SMK Taman Pulai Perdana
e. SMK Taman Universiti 2

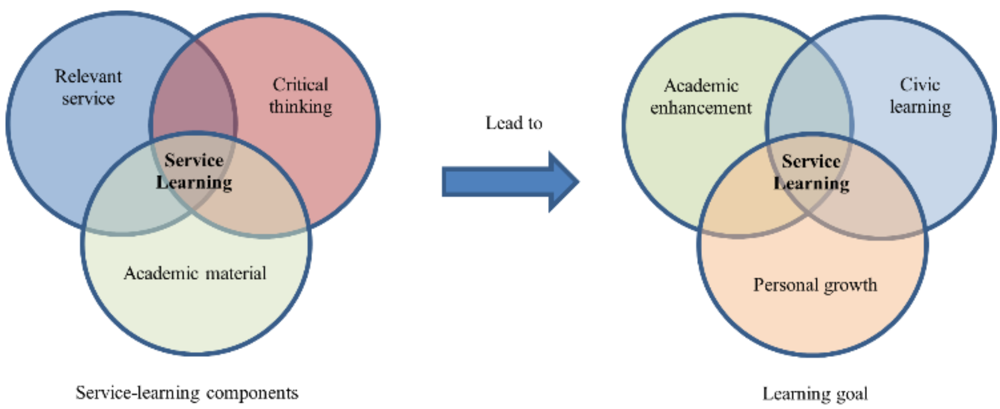
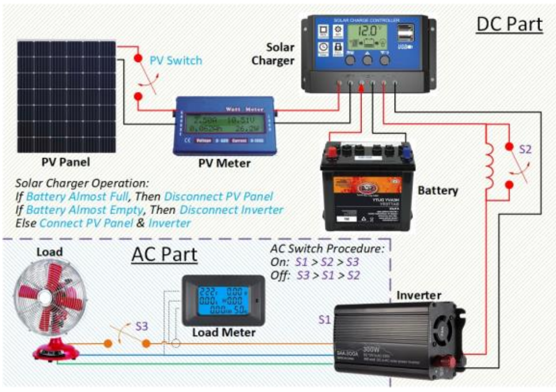


Figure 1. The component of service-learning and its learning goal

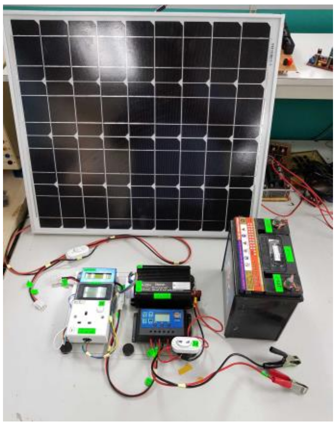
The groups came out with their proposal, which was discussed with the lecturer. The groups need to have two compulsory components in their activity. The first should be the 1-hour academic talk about photovoltaics and the second component is the 2-hour interactive activities. For the activities, students are compulsory to conduct a demonstration of the PV system. For this, a set of PV education kits was built for the demonstration, as shown in Figure 2. The PV education kit comprises of:

a. Solar panel Monocrystalline 20 Watt
b. PV meter and Load meter
c. Solar charge controller (PWM based)
d. 50-Watt Inverter
e. 240Vrms socket plug to connect an ac load
f. Lead-acid battery

The proposal will be assessed based on the talk's content and activities. All the activities development tool cost is limited to only RM200.00 per group. At the end of the ASL, each group will write a report on the activities that have been conducted. The mark of ASL activity will be 30% of their final mark. The breakdown of the marks is planning (5%), execution (20%), and Peer Review (5%). Figure 3 shows the interactive activities of the student. For the report preparation, all groups must design the report using a magazine template presentation style. Figure 4 shows the submitted report.



(a)



(b)

Figure 2. (a) The schematic diagram of the PV education kit, (b) The actual PV education kit

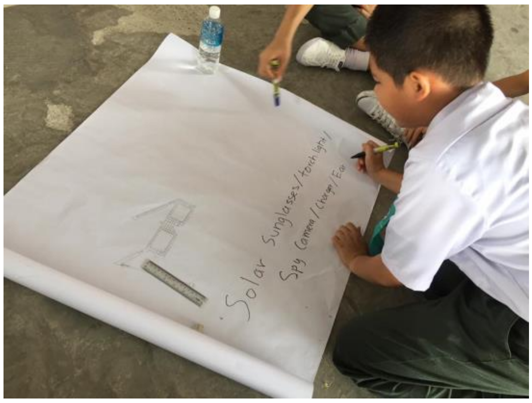


Figure 3. One of the interactive activities conducted in the ASL activity

Figure 4. Snapshot of reports on the ASL activities prepared by each group

Findings and Discussion

More than 200 feedback responses from school students were taken to evaluate the effectiveness of the activities in promoting STEM interest among the school students. Figure 5 is the chart that shows the percentage of students who have been exposed to photovoltaic technology. About 72% (blue coloured) of them have been exposed to this technology, while almost 28% did not have any exposure to PV technology at all. It is a worrying figure when considering the science textbook syllabus and internet infrastructure, where the information of photovoltaic can be easily accessed.

Figure 5. Chart showing the percentage of the student with PV knowledge exposure

Figure 6 shows a pie chart on the distribution of students who have high (blue coloured), medium (orange coloured), low (red coloured), zero level of knowledge (green coloured) on the photovoltaic technology. Comparing both Figures 5 and 6, out of 28% (Figure 5) who have no exposure on photovoltaic technology, only half of them have zero knowledge (Figure 6) on photovoltaic technology.

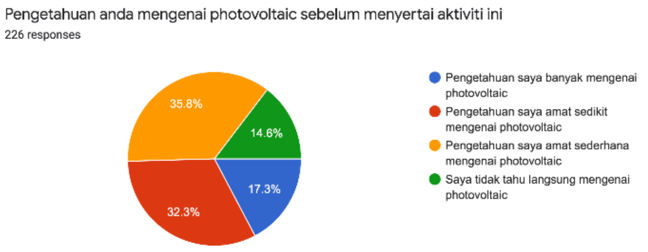


Figure 6. Chart showing the percentage of the knowledge level of the student with PV knowledge

Figure 7 shows the percentage of students who have gained knowledge of PV technology after the activity. Most of them agreed that the ASL activities had boosted their knowledge of PV technology. Only 1.8% (purple coloured - 4 respondents) said they had not benefited from the activity.

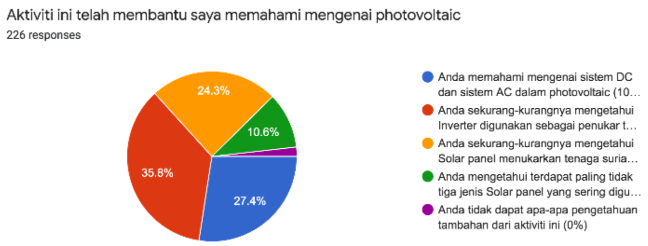


Figure 7. Chart showing the percentage of the knowledge level of the student with PV knowledge

As previously stated, the activity also aims to promote the school student's interest in STEM fields for the tertiary education. Figure 8 shows the result of the outcome. From the result, it is clearly shown that more than 87.6% of the students have an interest increment in pursuing STEM. However, there is 12.4% not interested to proceed with STEM fields. Several of the comments stated that they enjoy science and engineering but are worried about their ability. There were also feedback comments that their family barred them from pursue in STEM stream due to several unknown reasons.

Figure 8. Chart showing the percentage of students who will pursue in STEM stream

The outcome of ASL on civic, academic, and communication enhancement towards the facilitators is shown in Figure 9. Please note that the survey was conducted one year after they graduated from the program. Out of 57 candidates, however, only 50 respondents replied. None of the survey respondents continue their studies at the Masters or Ph.D. level. From the survey, most of them are already employed by governments and private sectors.

From the survey, it was shown that 100% respondents agreed that ASL has high impact in their communication skills. This is evident since they are responsible for approaching the school administration, which involves many discussions and occasional meetings to conduct the activity in the school. They learn how to communicate effectively with different level of school administrators. About 76% of the respondent agreed that ASL moderately enhances their personality. Some comments stated that they are more confident in managing a group task, working as a team, and responding effectively under pressure. Lastly, the academic enhancement is quite moderate. The distribution is quite equal. Some comments stated that the PV education kit that the lecturers develop is too technical for them to comprehend. Most respondents stated that it might be more beneficial if they were tasked to develop the PV education kit. By doing this, the learning process will be more effective.

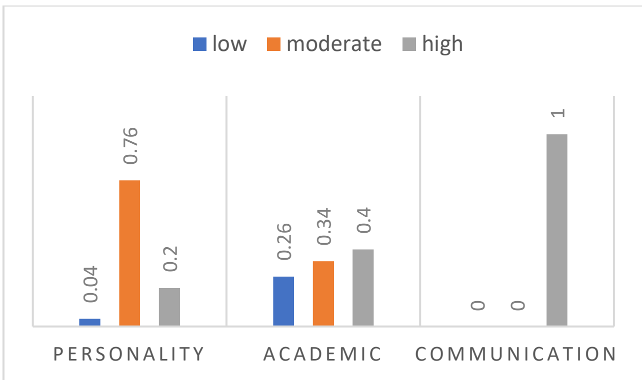


Figure 9. Summary of survey outcome based on personality, academic, and communication enhancement

Conclusion

This paper presents the implementation of photovoltaic academic service learning (ASL) and its impact on secondary school students and the facilitators. About five secondary schools with 200 pupils have benefited from the activity. The activity involves a 1-hour talk on PV technology by the students. Then it continued with a demonstration of PV technology using a self-developed PV education kit and interactive activities. From the feedback, it was found that the activity has increased their knowledge of photovoltaic technology and increased their interest in pursuing STEM education in the future.

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Exploring Learners' Experiences in Video-conference Classrooms through the Extended Technology Acceptance Model

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Abstract

The forced switch to fully online learning during the pandemic lockdown resulted in the conversion of video-conference platforms into digital classrooms. The emergency situation at the time left no room for necessary research, training and adequate deployment process, thus forcing both learners and instructors to adopt these learning environments as the only solution to learning during those times. After the lockdown seasons were over, several educational institutions have been considering hybrid instructional modes, thereby making these platforms to persist within education. This necessitates the assessment of learners' perception on learning in these new classrooms. This study aims to inform and inspire the design of inclusive, and sensitive future learning environments and schools where the needs of all types of learners are factored into instructional design and delivery. An analysis model based on the Technology Acceptance Model (TAM) was deployed in this study which reports on findings from an online survey of 86 respondents consisting of 48 males and 38 females all educated at post-secondary levels. Respondents ages were between 17 and 60 years with a mean age of 30.49 years. Findings show positive learners' perceptions of video-conference in terms of most constructs, with more neutral and almost negative feedback regarding support for collaboration and instructor presence. No negative perceptions were reported regarding frustration with the technology, and no difference in perception was expressed regarding continuation of virtual learning on video-conference, or return to physical classroom. Platforms were rated by respondents based on factors considered by respondents as important for learning; the highest ratings were assigned based on features including screen sharing, host meeting control capabilities and guest control.

Keywords: Video-conference classroom, Zoom, Post-COVID education, technology acceptance model, TAM, communication technology.

Introduction

Communication technologies have significantly improved classroom communication, especially in higher education (Youssef & Dahmani, 2008). The pandemic outbreak of 2020 was unexpected, and came at a time when many institutions across the world were still grappling with adjustment to new media and encouraging teachers to adopt eLearning more. The pandemic took the entire world by surprise, leaving nations with no choice than to fully relocate education to online classrooms as the whole world shut down to hide from the deadly corona virus. With return to post-COVID 'normalcy', many institutions have either remained partly or fully online, and many are considering standardizing to hybrid modes.

Feedback on the benefits of online learning had been mixed. Decreased achievement in both math and language arts were reported for students who attended charter schools (Fitzpatrick et al., 2020), while other studies (Darkwa et al., 2021) reported greater effectiveness based on support for better retention and a lesser amount of time required for learning. Although these learning models are increasing the options open to learners and teachers, they are employing novel 'classroom learning environments' (CLEs).

Research Objectives

The shift to online learning during the pandemic was sudden and without planning. The situation left no room to effectively design systems necessary for transition to virtual delivery. As excellently as the video-conference platforms have supported learning during the pandemic lockdown, several challenges were also recorded. Connectivity issues, infrastructure cost, Zoom fatigue (Agarwal et al., 2021; Fauville et al., 2021a; Usta Kara & Ersoy, 2022) as well as reports of poor student performance and dropout were all noted.

By the time the lockdown was over, some parents and students were not very enthusiastic about return to the physical classroom. However, many want things to return as fast as possible to where they were in pre-COVID times. Many universities and colleges were also considering gradual, partial or full return to physical classrooms. Others were trying to settle for hybrid learning approaches. With all these options open to learners, instructors and academic institutions, assessment of learners' perceptions on these video-conference classrooms become a priority. Such evaluation should inform post-lockdown teaching practices and learning.

Many studies have examined students' perceptions of learning on video-conference platforms. For example, Berges (2021) described several classroom engagement strategies and how the strategies can be incorporated into video conference classrooms to promote learner engagement at all grade levels. Other studies (Agarwal et al., 2021; D. Bailey, 2022; Islam et al., 2020; Lech & Johnson, 2021; Minhas et al., 2021) examined other related issues. However, the specific significance of issues that specifically inherent in learning on video-conference has not been the subject of extensive studies. Examples include the challenges of classroom control for teachers, user frustration and stress (e.g. 'zoom fatigue') or constraints on interactivity in relation to social learning or presence, among others. Evaluation of these factors have important implications for learning and instructional design and delivery. An understanding of factors that may hinder effective teaching and learning in these video-conference classrooms will enable instructors to be well-prepared through adequate instructional design planning. This study therefore focuses on evaluating the perceptions of learners regarding learning in video-conference classrooms with respect to the limitations and challenges of these platforms as CLEs.

The Technology Acceptance Model or TAM (Davis, 1989) represents one of the most commonly employed framework for accessing technology adoption and use. The deployment of video-conference platforms as replacement for traditional classrooms, however comes with unique challenges that need to be addressed. Some of these issues, captured as elements of a modified TAM are examined in this study. One of these issues is user frustrations reported as zoom fatigue (Fauville et al., 2021b; Montag et al., 2022; Nadler, 2020). The limitations of these platforms regarding support for engagement, collaboration, and learner choice or student-directed learning (CSDL) (Berges, 2021; Hilal et al., 2022; Li et al., 2022; Minhas et al., 2021) is another issue. So are perceptions of the benefits of fully-remote learning, user's platform preferences, as well as the preference factors (expectations) in relation to perceptions of use (PU) and perceptions of ease of use (PEU) of video-conference for learning.

This paper focuses on answering the broad research question: "What are student perceptions of video-conference technology as classroom learning environments (CLEs)?". This broad question is addressed through the following three (3) sub-questions:

i. How do learners perceive video-conference platforms as classroom learning environments in terms of perception of use (PU) for learning?
ii. How do learners perceive video-conference platforms as classroom learning environments in terms of perceptions of ease of use (PEU) for learning?
iii. What are learners' preferred video-conference platform for learning and what are the preference factors?

The TAM has been used in many studies including education studies. This study's main contribution and innovation include the proposal of a technology model that is more appropriate for a post-pandemic scenario, and to present part of the initial results of the study that used the model. The study also contributes to the understanding of the changing education landscape and emerging CLEs as a result of current digital transformation, how this is impacting current instructional approaches, and learners, and what their potential impacts might mean for the future classroom.

Literature Review

This section presents a review of related studies and addresses emerging educational technologies and classrooms of the future, video-conference platforms as CLEs, teaching and learning in video-conference classrooms, the TAM, external variables and their impact on the TAM, and online learning and integrated learning models.

Emerging Educational Technologies and Classrooms of the Future

Learning environments play critical roles in student satisfaction and performance (Barrett et al., 2015; Yang et al., 2013), and overall effective instruction, including motivation, interest, and attendance (Park & Choi, 2014) have been discussed extensively. Technology-enabled learning or TEL was redefined as new classrooms on video-conference platforms emerged, and Zoom, Google Meet, Microsoft Teams, Webex, etc. became the new schools.

With this change came the emerging challenge of effective, fully online instruction. New teacher skills, learner skills, parental monitoring, and other issues that were hitherto mostly optional became key concerns. While mainstream education is faced with these challenges in developed nations, developing economies were faced with additional issues including internet access, gadget affordability, power, and more. This paper presents findings on a study conducted to assess learners' experiences in these novel learning spaces as a means of informing instructional design for, and in post-COVID education.

The emergence of video-conference platforms

Video-conference platforms have been in existence for quite some time. Launched as a person-to-person communication option after dissatisfaction with voice telephony, two-way video communication emerged as far back as the 1930s (Andy Patrizio, 2021). The journey from two-person communication 'with black and white still images to multi-party transmissions with 4k resolution in real-time' is a long one that involved many players. The oldest among the most popular platforms of today is WebEx which was founded in 1995 (Wikipedia.org, 2022). Skype was first introduced in 2003 (Augustyn, 2022); GoToWebinar followed in 2006 (Livestorm, 2021), while Zoom was launched in 2011 (Zoom Video Communications, 2022). Worldwide launch of Microsoft Teams was on March 14, 2017 (Microsoft Teams, 2022) around the same time as the initial launch of Google Meet as 'an enterprise-friendly version of Hangout' in February (Perez, 2027). However, Meet only became available to the general public in 2020 during the pandemic, making it the last in line of top currently popular platforms in the public space.

With the emergence of COVID-19 at the end of 2019 and subsequent closure of schools at all levels while the world hid from the coronavirus, there was a global demand for all nations to move learning into online spaces. Hence, in the last 3 years, the world has seen the emergence of several new video-conference platforms providing solutions for in-person meetings for few as well as several hundred participants. These video-conference became global life-savers during the pandemic lockdown, and have remained persistent features in teaching and learning even after the pandemic lockdown was over. As the education community continues to debate and consider hybrid learning modes, video-conference software will continue to feature in education. With these changes, and their implication for schools and universities, especially in terms of data privacy, it might become a necessity for institutions to begin developing their own platforms.

Teaching and learning in video-conference classrooms

Apart from its support for anywhere, anytime access to learning, remote learning on video-conference platforms offers additional advantages. The recording feature supports flexible and student-cantered learning whereby learners can access learning materials and content in their own time and pace. In addition, huge amounts of travel costs were saved by teachers and students due to travel restrictions. Though there are limitations with mobile access, most of the platforms are accessible on any smart device as long as there is internet connection. These changes have also exposed educators to global audiences and an unprecedented number of lessons and learning materials are continuing to be uploaded online.

The cost of setting up an online classroom being much lower than that of a brick-and-mortar classroom, many teachers have been exploring these learning spaces, making more and more useful materials available to students worldwide. Assessing and comparing the performance of remote and in-person learners as well as the effect of proctoring on student performance is still under investigation (Cherry et al., 2021; Wuthisatian, 2020). There is also hope that in the future, more advanced technologies like deep learning (Kaddoura & Gumaei, 2022) and blockchain (Sattar et al., 2023) might provide more effective, efficient and secure frameworks for assessment in online classrooms. On the other side of things, classroom control in remote classrooms, especially with very large groups is still challenging. Moreover, students, teachers as well as school administrators still have much to learn to operate comfortably in fully online learning.

Video-conference platforms are rated by users based on several factors, including their features that support various aspects of teaching. These features determine how effective learning on these platforms. Some of the most important features include cost (free vs paid), number of participants supported by the free subscription, recording feature (including the duration permitted as well as access to cloud saving), meeting controls, security and encryption, screen sharing, chat, meeting duration, and the ability of unregistered users to join a meeting.

A theoretical framework for learning on video-conference platforms integrates several learning theories. By its very nature, it draws from the Technology Acceptance Model (Davis 1989, Bagozzi, Davis & Warshaw 1992), connectivism (Corbett & Spinello, 2020; Dunaway, 2011), heutagogy (Marie Blaschke, 2012) and social learning (Bandura, 1977) theories. These theories are briefly discussed in the following sections.

Technology Acceptance Model (TAM)

The TAM is an extension of the Theory of Reasoned Action (Ajzen & Fishbein 1980). It predicts individual adoption and use of new technologies. Several studies within education and other sectors have employed either the original TAM or its variants. Previous studies on eLearning (Anderson & Ainley, 2010; Arbaugh, 2010; Sarosa, 2022) as well as more recent ones on emerging technologies like autonomous vehicles (Dimitrakopoulos et al., 2021), and robots in healthcare (Mois & Beer, 2020) have also employed the TAM.

The original TAM (Davis 1989, Bagozzi, Davis & Warshaw 1992), consists of five variables, including perceived ease of use (PEU), perceived usefulness (PU), attitude toward use, behavioral intention to use, and actual use. The two most significant factors in the model are captured as perceived usefulness, and perceived ease of use. They determine whether a computer system or technological tool or application will be accepted by its potential users. While PU describes the degree to which a person believes that a technology can increase their performance, efficiency or effectiveness, PEU refers to the required level of mental or physical effort a person has to make to use the technology. Figure 1 shows the original TAM.

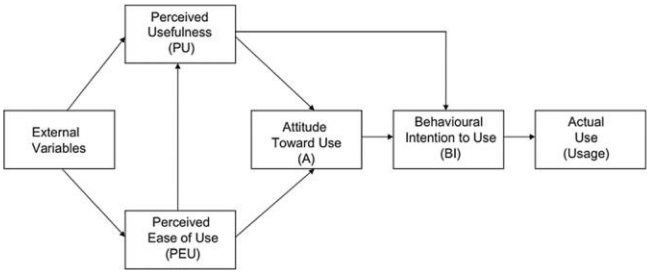

Figure 1. Original TAM (Davis, 1989)

The TAM was originally developed for the adoption of IT in the workplace, and thus neglects important factors relevant to the main constructs. The original TAM has also been criticized for its lack of subjective norms or social impact and the failure of the central constructs (PU and PEU) to provide information about how to make technology more useful and easier to use (Acceptance Lab, 2022). It has thus been extended/modified to include not just computer systems but various types of hardware and software leading to two extended versions, TAM 2 and TAM 3 (Davis, 1996; Venkatesh & Davis, 2000, Venkatesh & Bala, 2008). Figure 2 shows TAM 1, 2 and 3, their elements, and relationships.

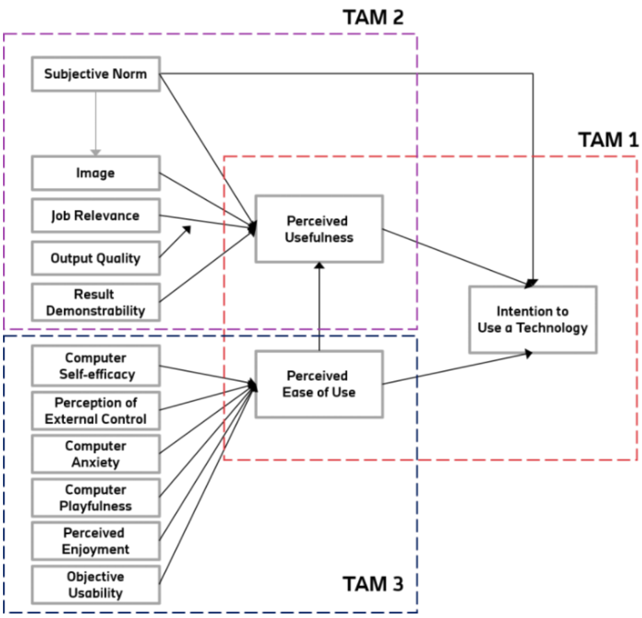

Figure 2. TAM 1, 2 and 3 (Venkatesh & Davis, 2000, Venkatesh & Bala, 2008)

External Variables and their Impact on the TAM

The interaction of external user factors with TAM had been studied extensively (e.g. Alfadda and Mahdi (2021); González-Gómez et al. 2012; Terzis and Economides 2011). Previous results on the impact of gender were contradictory (H. Al Shammari, 2021); Padilla-MeléNdez et al. 2013; Terzis and Economides, 2011). Studies on the impact of experience confirmed the moderating effect of experience over time as users gained more experience with the technology or tool (Castañeda et al., 2007); Hsu and Lu, 2004).

The peculiar nature of learning on video-conference opened up several issues with potential to impact acceptance and use by learners. While a number of important constructs like availability and acceptance has been captured in previous TAM, there are others that are specifically relevant to learning on these platforms. They include convenience and presence, frustration/fatigue, and the ability of the platforms to support collaboration, and learner choice/student-directed learning (CSDL) among others. Learners' perceptions of the benefits of remote learning, and the preference factors directly related to individual platforms or features are also important factors. They are described in the analysis model and mapped to the relevant subsets of PU and PEU.

Online learning and emerging learning models

The digital nature of the learning relates directly to connectivism which focuses on understanding learning in a digital world. Connectivism emphasizes how internet technologies (e.g. online discussion forums, and social networks) contribute to new ways of learning. With extensive changes in how, when, and where we now learn, Siemens (2017) had identified several principles of connectivism. They include i) learning and knowledge as residing within diversity of opinions, and ii) learning as the connecting of specialized nodes or information sources, which can also reside in non-human appliances. Others are that iii) the capacity to know more is more critical than what is currently known, and iv) nurturing and maintaining connections is a requirement for facilitating continual learning. Other principles include v) the ability to see connections between fields, ideas, and concepts being a core skill, while vi) accurate, up-to-date knowledge (referred to as 'currency'), becomes the intent of all connectivist learning activities. Decision-making as the last of the principles refers to vi) a learning process whereby the choice of what to learn and 'the meaning of incoming information is seen through the lens of a shifting reality'.

Siemens (2017) thus maintains that there is no constancy in right or wrong answers as today's right might be tomorrow's wrong as a result of continuous changes in the information climate influencing current decisions. Figure 3 shows the theory of connectivism.

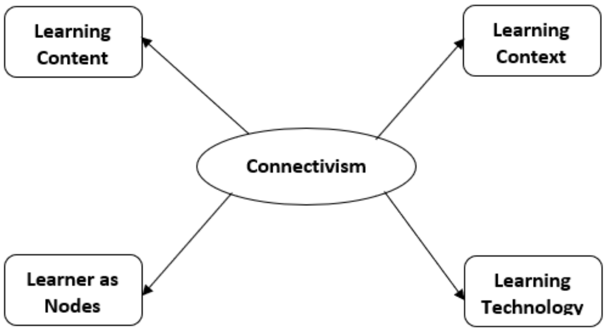

Figure 3. Connectivism

Heutagogy is a theory of self-determined learning. It is a learner-centered instructional approach that emphasizes the development of autonomy, capacity, and capability. It is one of the major frameworks upon which lifelong learning is based. Its practices and principles are rooted in andragogy. Advancement in technological development and emerging educational technologies has renewed interest in heutagogy (Marie Blaschke, 2012). It is of special interest to distance education, its attributes include 'learner autonomy and self-directedness'. In self-determined learning, learners exhibit self-efficacy, and continuously reflect on the learning process; they show communication and teamwork, creativity, and innovation as well as adaptability and flexibility in approach as well as positive values. Learning in video-conference classrooms demands self-directedness on the part of the learner and captures the many attributes of heutagogy. Figure 4 shows the features and elements of the heutagogy learning theory.

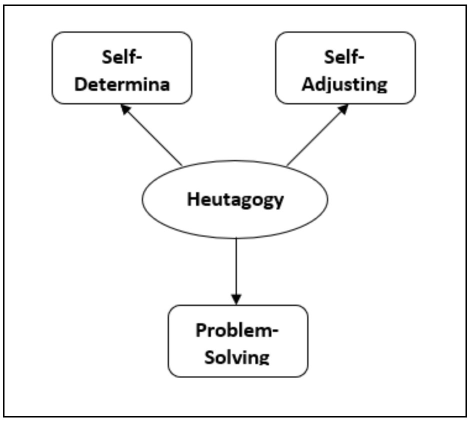

Figure 4. Heutagogy

The last of the common theories inherent in remote learning is the social learning. It proposes that new behaviors can be acquired by observing and imitating others. Bandura (Bandura, 1977) proposed that learning is more than behavior changes through conditioning (behavioral theories) or psychological influences like attention and memory (cognitive theories). He believes that people observe behavior either directly through social interactions with others or indirectly through media. However, similar to behaviorism, actions that are rewarded are more likely to be imitated, while those that are punished are avoided. The social learning theory captures several concepts related to learning as personal, behavioural, and environmental factors (see Figure 5).

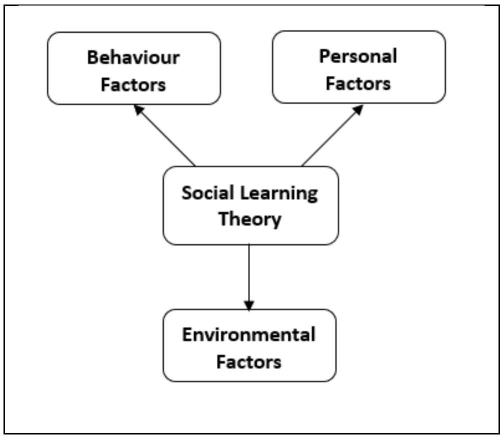

Figure 5. Social Learning Theory

Theoretical Framework

The theoretical framework of the study acknowledges the role of the TAM as a key framework for predicting individual adoption and use of new technologies. Later versions of the TAM highlight the significance of external factors. For example, Sternad and Bobek (2013) identified personal, organizational, and system/technological factors. In a similar manner, Abdullah and Ward (2016a) identified the most commonly used external factors of TAM in the context of e-learning adoption in the last ten years to include Self-Efficacy, Subjective Norm, Enjoyment, Computer Anxiety and Experience. A similar study covering publications in the last twelve years (Salloum et al., 2019) also indicated computer self-efficacy, subjective/social norm, perceived enjoyment, system quality, information quality, content quality, accessibility, and computer playfulness as the most common external factors of TAM. These factors which are directly related to the personal, behavioural and environmental factors of social learning.

The learners, learning content, context and technology aspects of connectivism links directly with the environmental factors of social learning, and the self-determination, self-adjusting and problem-solving elements of heutagogy. The behavioural requirements of heutagogy are also directly related to the behavioural factors of social learning. Hence, we highlight how the external factors of TAM align with several elements in the theories discussed as shown in Figure 6.

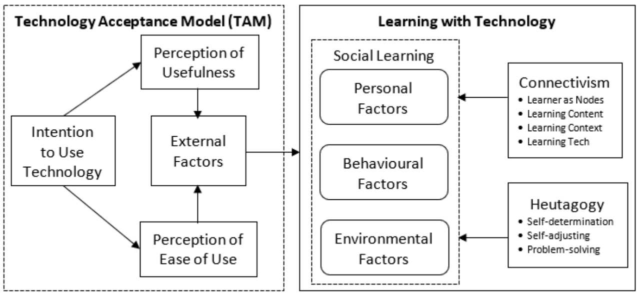

Figure 6. Theoretical Framework

Methodology

The study adopted a statistical approach involving the collection of quantitative data. This section presents the research methodology and describes the sample, analysis model, data collection procedure and data analysis. Online learning during the pandemic covered all levels of education and all subject areas including engineering and engineering education. The study participants are at post-secondary education levels and include engineering and engineering education students. Findings from the study also have application in the fields of engineering and engineering education.

Sample and Sampling

Learning on video-conference happened in all countries across the world and to learners at all stages of learning. In the first round of the study, 86 participants were surveyed. Respondents were completely randomly selected. Apart from the main themes in the study, descriptive data on age, gender, location, type of location, usage, affordability/access, level of IT knowledge, gadgets for accessing internet and video-conference classroom, as well as level of education were also collected to characterize the sample.

Analysis model: The Extended TAM Instrument

This analysis model assesses learners' experiences in emerging Classroom Learning Environment (CLEs) on video-conference platforms. It builds on the elements highlighted in the theoretical framework, and the most common external factors of TAM (Abdullah & Ward, 2016a; Salloum et al., 2019; Sternad & Bobek, 2013). The instrument consists of two sections. Section 1 captures demographic information including age, gender, location, location type and level of technological skills, as well as infrastructures for accessing remote classrooms.

The second section explores important concepts related to learning in video-conference classrooms. Apart from the issues captured in the TAM like access, especially in terms of cost and internet quality (Nunes & Ozog, 2021), a number of other issues have also received extensive focus. For example, convenience and (social) presence has been discussed in relation to social interaction as a key element of social learning (Ardiansyahmiraja et al., 2021; D. Bailey, 2022).

Frustration has also been discussed in terms of exhaustion and public/mental health (Agarwal et al., 2021; Mishra & Kumar, 2021) and fatigue (Usta Kara & Ersoy, 2022). Video-conference support for CSDL within the flipped classroom paradigm has also been explored (Guiter et al., 2021; Maphalala et al., 2021). The perceived benefits of remote learning (Cardullo et al., 2021; Lech & Johnson, 2021), and learner expectations as regards the features of video-conferencing that supports effective learning (Berges, 2021; Minhas et al., 2021) were also examined. In addition to these are an assessment of learner preference factors which influence the choice of video-conference platform (H. Al Shammari, 2021; Islam et al., 2020).

Based on the factors highlighted, the second part of the TAM instrument thus consists of 11 sub-sections containing 78 items/indicators. Table 1 shows the summary of the survey items.

Table 1. Summary of survey items & indicators

Indicators	Items	TAM Label
Availability of Technology	7	Perception of Ease of Use (PEU)
Convenience and Presence	13	
Confidence	11	
Frustration	6	
Acceptance of Technology	8	Perception of Use (PU)
Use of Technology	6	
Collaboration	5	
Choice & Student-directed Learning (CSDL)	5	
Benefits of remote learning	6	
Preference Factors	4	
User Expectation (Features)	7	
Total	78	TAM

Results

This paper reports initial quantitative results based on data collected internationally from 86 participants from 8 countries across Asia, Europe, Africa, and Australia.

Demographic Statistics

The following describes the demographic information about the study participants. A total of 86 responses were received. More than half (N=48; 55.8%) are males and 38 (44.2%) are females.

Respondents' ages range from 17 to 60 with a mean of 30.49 years (SD 11.976), a modal age of 21 years and median age of 25 years. The minimum level of education of respondents is post-high school with a higher percentage (N=70; 81.4%) having bachelor degree or higher. 67 respondents (77.9%) were based in cities while 19 (22.1%) live in towns. 59 respondents (68.6%) identified themselves as having low-to-medium level of computing knowledge and skills (i.e. able to "handle basic tasks like emails, social media, online purchases, and working with office tools like MS Word and PowerPoint, online banking, and general computing, etc."). The remaining one-third (N=27; 31.4%) indicate they have high-to-expert computing skills (i.e. between being "very conversant with technology" and knowing "at least a programming language"). About one-quarter of respondents (N=21; 24%) access remote learning only through smartphones, while 13 (15%) access the internet only through PCs. 42 respondents (61%) are able to access remote learning through multiple gadgets. 18 respondents (21%) have access to mobile internet, 26 of the respondents (30%) have access to Wi-Fi internet and almost half (N=42; 49%) have access to both mobile and Wi-Fi internet services for accessing remote learning.

Learners' perceptions of video-conference for learning based on modified TAM

All indicators were measured on a 7-point Likert scale with a minimum score of 1 (Strongly Disagree or SD) and maximum score of 7 (Strongly Agree or SA) per item. Table 2 presents the summary of descriptive statistics for all indicators. The following sub-sections discuss the various concepts related to learners' perception of learning on video-conference.

Learners' perception of learning on video-conference:

<u>Access</u>

Overall mean score for Access was 38.10 (SD = 10.98), indicating respondents have a positive perception of access and consider themselves as adequately provided for in regarding infrastructure for remote instruction. A mean value >5.00 (somewhat agree) for all items indicates respondents agreed that they have access to necessary hardware, software, internet speed and stability required for remote learning. They also believe these infrastructures are affordable for their family or institution.

<u>Use of Technology</u>

Overall mean score of 71.09 (SD = 14.80), indicating a positive perception of respondents' ability to work with video-conference technology. Mean values for each item is mostly >5.0 (somewhat agree). Mean score for 'search for information' (Mean = 6.16, SD = 1.43) is the highest followed by using 'mobile technologies to connect to the internet' (Mean = 6.10, SD = 1.28), 'social media' (Mean = 5.97, SD = 1.31), 'office software' (Mean = 5.91, SD = 1.67), and 'different kinds of digital apps' (Mean = 5.83, SD = 1.42). Negative response to the item 'I have never used video-conference software for learning before the pandemic' (Mean 3.43) indicates that respondents were already familiar with, and have been using video-conferencing software even before the pandemic. This is further confirmed by the positive response to the item 'I have been using video-conferencing software regularly before the pandemic'.

<u>Convenience and Presence</u>

Descriptive statistics indicates ease of use of technology. It focuses on assessing how respondents perceive the support of video-conference software for supporting interaction, social presence, and an enjoyable learning experience within the virtual space. Table 2 reveal an overall mean score of 46.80 (SD = 12.10), indicating a perception closer to neutral (44.00) than positive. Although the mean score values for individual items are all <5.0, with many being in the 'disagree' region, it is important to note that some items in this section are negatively worded to indicate a negative perception of convenience and presence, hence, disagreement or negative response indicates positive perception. The overall sum of response thus indicate neutrality that is tending towards positive perception.

Table 2: Descriptive statistics for all indicators

N= 86	Age	Availability	Tech use	Con& Presence	Acceptance	Frustration	Collaboration	CSDL	Benefits	Preference	Features
Mean	30.49	38.10	71.09	46.80	38.30	26.14	23.95	22.31	32.29	18.77	37.06
Med	25.00	42.00	74.00	48.00	40.50	25.50	25.00	22.00	33.00	20.00	39.00
Mode	21	49.00	73.00[a]	60.00	32.00	36.00	30.00	20.00[a]	42.00	22.00	49.00
SD	11.98	10.98	14.80	12.10	10.33	10.12	8.15	6.70	7.50	5.60	9.63
Min	17	7.00	13.00	11.00	10.00	6.00	8.00	6.00	13.00	6.00	13.00
Max	60	49.00	91.00	69.00	56.00	42.00	35.00	35.00	42.00	28.00	49.00

Frustration

Responses were mostly in the 'neutral' (4.0) region for most items including finding online learning stressful (Mean = 3.51, SD = 1.97), demanding (Mean = 4.15, SD = 2.032), learning in remote classrooms being the same as in physical classroom (Mean = 3.99, SD = 2.08) or that 'instructors make more demands on students in online learning' (Mean = 3.97, SD = 1.93). However, respondents indicate preference for putting their cameras off in a video-conference call (Mean = 4.88, SD = 1.97) and they indicate that 'seeing instructor on video conference feels different from being with them in a physical classroom' (Mean = 4.99, SD = 1.78), implying a negative perception of instructor's social presence.

Self-confidence

Respondents' confidence regarding the use of various digital tools for remote learning reveal an overall mean score of 34.34 (SD = 7.96) indicating a positive perception of personal confidence in the handling of technological tools required for remote learning. Considering the fact that more of the respondents identify themselves as having low-to-medium level computing skills, this score imply that learners do not require high-level computing skills to access remote learning. Most respondents agree that they 'have the skills to operate a computer' (Mean = 6.06, SD = 1.45), are 'able to use office software for content delivery and demonstration' (Mean = 6.10, SD = 1.44) and to 'work on projects (Mean = 5.99, SD = 1.51). Respondents also agreed that 'remote learning is easy' (Mean = 5.42, SD = 1.745) and that they are 'very okay with remote learning' (Mean = 5.47, SD = 1.780).

Acceptance

Descriptive statistics for acceptance reveal an overall mean score of 38.30 (SD = 10.33) indicating an overall positive perception of acceptance. Individual mean scores for each of the item is however mostly close to the neutral region. Responses to items assessing perceptions of the ability of remote learning to promote greater effectiveness than the physical classroom, enable better learner-instructor communication or feel like the physical classroom, are all close to neutral rather than strong positive. In addition, respondents did not indicate strong desire to continue learning remotely after the pandemic. However, a similar response was provided to the item assessing the desire to return to the physical classroom. These feedbacks confirm that respondents hold generally near-neutral position regarding the choice of remote or physical classroom. There was a general indication of acceptance of remote learning as well as willingness to support remote learning in their institutions.

Collaboration

Descriptive statistics for collaboration also reveal a result similar to acceptance, with an overall mean score of 23.95 (SD = 8.15), indicating an average/neutral perception of the potential of remote learning to support collaboration for learning purposes. None of the individual items has an average value up to 5.0, indicating that the learners do not have strong positive perception of the potential or ability of remote learning to support collaboration.

Choice and Student-Directed Learning (CSDL)

Choice and student-directed learning assess how learners perceive video-conference as supportive of learner's voice and autonomy, or individual difference in learning. The descriptive statistics show an overall mean score of 22.31 (SD = 6.70), very similar to the perception of the technology for collaboration, and indicating an overall average or neutral perception. Also similar to collaboration, average values for individual are all <5.0, indicating that the learners do not have strong positive perception of the ability of remote learning to support collaboration for learning.

Perceived Benefits of Remote Learning

Respondents' perception of the benefits of remote learning through video-conference was assessed based on items including being able to 'watch lesson later' (Mean = 5.84; SD = 1.57), 'access learning materials after class' (Mean = 5.98; SD = 1.41), 'feel less anxious about performance' (Mean = 5.02; SD = 1.64), support 'flexible timing' (Mean = 5.62; SD = 1.57), every learner being able to get the instructor's attention (Mean = 4.74; SD = 1.82) and its potential to help learners comprehend learned content better (Mean = 5.09; SD = 1.57). The statistics reveal an overall positive perception with the lowest being the ability to promote individualized attention.

Preference

Preference was measured based on user's preferred platform. Respondents rated four of the most popular video-conference platforms employed during the pandemic, including Zoom, Google Meet, Microsoft Teams and GoToWebinar. Descriptive statistics for preference is shown in Table 3. The table shows greater preference for Zoom (Mean = 5.61; SD = 1.79) and least for GoToWebinar (Mean = 3.67; SD = 1.82), and implying learners prefer learning on Zoom to the other three platforms.

Table 3: Respondents Rating of Preferred Video-conference Platforms

N = 86	Mean	SD
Zoom	5.605	1.7907
Google Meet	4.953	1.7006
Microsoft Team	4.535	1.9745
GoToWebinar	3.674	1.8178

Features of video-conference platforms for learning

To further examine respondents' preferences, respondents were asked to indicate their perceptions of the important features of video-conference for learning for their preferred platform. This also provide an indication of users' expectations in terms of learning through video-conference. Table 4 presents feedback from respondents on the listed features. Participants rated all the features almost equally positively, indicating perceptions of these features as strong requirements for a video-conference platform for learning.

Table 4: Important features of video-conference for learning (Preference Factors)

	Min	Max	Mean	Std. Deviation
Screen Sharing	1.0	7.0	5.453	1.6063
Chat features	2.0	7.0	5.360	1.5256
Unlimited Recording	1.0	7.0	5.000	1.8912
User/Guest Control	2.0	7.0	5.279	1.5541
Meeting Rooms	1.0	7.0	5.244	1.6301
Host Control Capabilities	2.0	7.0	5.407	1.4823
User/Guest Control	1.0	7.0	5.314	1.5205

Screen-sharing (Mean = 5.45, SD = 1.60) and host meeting control capabilities (Mean = 5.407, SD = 1.48) are rated highest. Both can be linked directly to instructional presentation for facilitating learning, and instructor classroom control, both of which are important for management of learning in the physical classroom.

Unlimited recording was rated lowest (Mean = 5.00, SD = 1.89). This is not surprising, considering that it is not directly related to learning facilitation, instructional delivery or classroom control. Users or 'guests', as the attendees on a video-conference are popularly addressed, have little concern about recording. In many cases, they may not be aware of the demands of meeting recording as the task usually lies with the 'host'. While in many cases, learners expect access to the recording of the learning session, the surrounding technicalities (e.g. recording on gadget or cloud, or other storage and access issues) are the least of the concerns of participants or learners.

Discussion

The interaction of personal/external user factors with TAM had been the subject of many studies (e.g. Alfadda and Mahdi, 2021; González-Gómez et al. 2012; Terzis and Economides 2011). Previous studies related to learning on video-conference employing TAM (Alfadda & Mahdi, 2021; İBİLİ et al., 2022; Vu & Tran, 2022) confirm the perceived usefulness of remote tutoring systems and attitudes towards use as determinants of usage intentions. This is in line with the findings of this study. The result of this study also aligns with recent findings (Abdullah & Ward, 2016b; D. R. Bailey et al., 2022); it indicates that all variables share some relationships with one another – a common emergence within TAM literature according to Park (2009).

In their study in Korea involving a comparison of online learning using pre-recorded video lectures and live Zoom lectures, Islam, Kim and Kwon (2020) reported that students prefer pre-recorded video lectures to live Zoom lectures when each is used alone. However, a higher number of respondents (30.8%) prefer a combination of both to zoom lecture only (7.7%). Reasons given include the flexibility, convenience, and educational effectiveness of pre-recorded video lectures. They however acknowledge the importance of learners' motivation for self-learning. They noted that in the absence of clear deadlines, workload may accumulate, resulting in future challenges, especially in relation to examinations. Though the current study does not involve a comparison, the findings of Islam, Kim and Kwon (2020) throws more light on possible means of addressing effective student learning in hybrid classrooms. For example, recorded zoom lessons can become very useful learning resources after zoom lessons.

Al Shammari (2021) examined the reasons for learners' preferences for the two leading online learning platforms in Saudi Arabia – Blackboard and Zoom – during the pandemic. He found that learners preferred Zoom to Blackboard due mainly to the ease of use, and mobility (ability to access on smartphones or mobile app). Others were less technical problems and connection latency with respect to Zoom. This is also in line with the findings of the current study. However, Al-Shammari (2021) reported gender differences in preferences. Effective class management and simple interface of the Zoom application, in addition to screen sharing, and lecture recording features of zoom reported by Minhas et al. (2021) is in line with the findings of our study.

One of the key findings of the current study is the feedback indicating a neutral to negative perception of instructor's social presence. This might be one of the most important issues in video-conference CLEs. The significance of face-to-face interaction for social learning, classroom management, and instructor-student communication in traditional learning environment has been a long-standing advantage. Its absence poses a great challenge in remote classrooms on video-conference as teachers may find themselves speaking to blank screens. Respondents in this study indicated the desire to keep their cameras off; such situations make it challenging for teachers to know whether students are present or are engaged with learning. These are among issues requiring attention.

Respondents rated the ability of video-conference lessons to support collaborative learning and social presence low. In line with this finding, Berges (2021) had reported that many teachers have struggled with incorporating engagement strategies into video-conference lessons. He however suggested that traditional classroom engagement strategies can be modified to fit the online learning modality. He described several classroom engagement strategies, especially, utilizing features of video conferencing platforms, for example, breakout rooms, chat feature, emojis, and whiteboards.

Conclusion and Suggestions for Future Studies

The study's findings confirm learners' positive perceptions regarding both PU and PEU of video-conference for learning. The statistics show generally positive perceptions of most constructs and generally neutral perceptions of others. There are no strong negative perceptions indicated regarding any of the constructs. Future correlation studies are necessary to assess the interaction of the various constructs. Though internet connectivity continues to improve, some emerging technological systems require very high broadband for proper functioning and users do experience disconnections or video and/or audio lags during lessons.

Affordability of setup and operation costs for the required technologies may also be challenging for learners and schools in poor communities. Although this study captured respondents from towns and cities, future studies focused on survey of very poor communities may shed more light on possible relevant relationships. Privacy concerns, ethical issues, users' rights (Steve Melendez, 2017) are also important subjects for future studies. Issues of 'zoom fatigue' is already in learning discourses and education studies (Fauville et al., 2021a), and other emerging issues may become critical in the future. Emerging technologies have always played significant roles in changing classroom practices, and education make changes to accommodate such developments. However, current changes have been adjudged most drastic. More studies reporting impact on social, health and physical well-being of teachers and students will help in addressing future issues.

The significance of training for instructional facilitators cannot be over-emphasized. The emergency surrounding the switch to online classrooms left no room for supporting teachers with necessary training. Many instructors were forced to adopt a learn-as-you-go approach which left gaps in knowledge that many instructors are still struggling with. Helping teachers with focused training and incorporating these changes into teacher education can become very important for promoting strategies for increasing learner engagement for students at all grade levels. These strategies will also assist in promoting instructor self-efficacy as a means of promoting more effective instruction.

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Contextual Knowledge Elements Utilization in 3D CAD Model Manipulation from the Practicing Engineers Perspectives

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Abstract
Engineers' ability to contextualize their created 3D CAD model during the design stage is the most important aspect of product design. In this conducted research, researcher has found that there was a lack of contextual knowledge among Mechanical Engineering Undergraduates and fresh graduate engineers in utilizing Three-Dimensional Computer Aided Design (3D CAD) modeling software in developing a good product design. In addressing this issue, a study has been conducted to focus on the representation of contextual knowledge elements in 3D CAD modeling applications. This article focused on presenting essential elements of contextual knowledge utilized among practicing engineers in their daily design works, in the aspect of Model Manipulation. Transcendental phenomenology approach has been utilized as the main research methodology. Four practicing engineers from engineering department of one shipbuilding company in Peninsular Malaysia were purposively selected to be studied. From the analysis, there are three most frequent emerging themes in the application of contextual knowledge in manipulating model using 3D CAD modeling: Realization, Design Intention and Normalization. These three elements play an important role in helping engineers to contextualize their design work during the stage of manipulating created model for new product development process.

Keywords: Three-Dimensional Computer Aided Design Modeling; Contextual Knowledge; Engineering Education

Introduction

Recently, many studies have been conducted on improving the engineering undergraduates' contextual competencies level (Beena and Suresh, 2022; Bell et al., 2019; Kyoung Ro et al., 2017). Having a good level of contextual competence helps to improve individual understanding and establishing their place in the profession in engineering design work (Engineering Accreditation Commission, 2018). The importance to promote contextualization ability among engineering undergraduates in engineering practice also has been stressed in the ABET program accreditation under the criteria of 3.c, 3.f, 3.h and 3.j (Engineering Accreditation Commission, 2018). According to Grasso and Burkins (2010) in their book "Holistic Engineering Education," the advancement of contextual knowledge in 3D CAD modeling can also improve engineers' ability to develop creative and innovative product designs.

However, based on conducted structure interviews in the preliminary study, results have shown that there was lack of contextual knowledge in the applications of 3D CAD modeling among Mechanical Engineering undergraduates and fresh graduate engineers. Due to this lack of knowledge, product designers are unable to contextualize their produced models in order to build a successful product design for users and manufacturing applications. According to Ma and Zhang (2010), product designers frequently commit a number of mistakes. During the design stage, the focus is typically on the function of the product rather than the manufacturability of the parts, which has resulted in the inability to manufacture some components. By considering the manufacturing constraints throughout the product design phase, numerous issues can be avoided (Nguyen and Martin, 2015).

Therefore, this study was conducted to enhance engineering students' contextual knowledge in the application of 3D CAD modelling software in engineering design tasks and to advance the engineering education reformation movement. The main aim of this study is to construct a framework of contextual knowledge that can be utilized to improve the fundamental knowledge of Mechanical Engineering undergraduates in the application of 3D CAD modeling software. The questions of what are the essential elements of contextual knowledge in the application of 3D CAD modeling in creating a product design from the practicing engineers' experiences and how the practicing engineers employ the essential elements in the application of 3D CAD modeling within the four contexts of digital product modeling (Model Creation, Model Manipulation, Model Visualization and Model Transfer) are answered in this study. In this article, the finding of the essential

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contextual knowledge elements in Model Manipulation process that have been utilized among practicing engineers in their daily design work are presented. This article is conceptually structured to present the significance of contextual knowledge in learning 3D CAD modelling and, as a subsequent step, to inform the engineering education community about the presence of contextual knowledge in the process of 3D CAD modeling.

Contextual Knowledge in 3D CAD Modeling

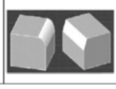
The individual's level of success in completing the engineering design task is dependent on the amount of information that is stored in their cognitive mind (Adnan, 2021). In order to provide a solid theoretical foundation for the research that was conducted, the cognitive constructivism theory was selected as the appropriate theoretical framework. The cognitive constructivism theory emphasizes the importance on the mental processes people utilize in order sense of their surroundings (Kaufman, 2018; Amineh and Asl, 2015). Declarative knowledge, procedural knowledge, and contextual knowledge are the three categories of knowledge existed in the field of education (Ubbes and Njoku, 2022; Ubbes, 2008; Tennyson and Breuer, 2002.

In this study, contextual knowledge was investigated based on the difficulty described in the preceding section. According to Tennyson and Breuer (2002), contextual knowledge is an individual's understanding of how to apply specific concepts, rules, and principles in the context of knowing why, when, and where the knowledge should be applied to fulfil a specific task. Aspers (2006) stated that there are two main elements to represent contextual knowledge: lifeworld and province of meaning. The lifeworld is referring to the lived and experienced world and thus, it is something more than the world itself rather than the subject itself (Aspers, 2006). The province of meaning refers to the understanding the meaning of a picture or seeing it in the same way that someone else does is a result of shared experiences, schooling and other similarities (Aspers, 2006). These two elements are crucial for solving the real-world problems and the role of contextual knowledge is to help an agent behave quickly, automatically and appropriately for its current problem-solving situation (Brézillon, 1999).

Contextual knowledge in 3D CAD modeling has been identified as an individual's understanding of why, where and where to use the essential lifeworld and province of meaning elements in 3D CAD modeling activities within four digital product modeling contexts: model creation, model manipulation, model visualization and model transfer. As mentioned before, lifeworld and province of meaning are the two main elements of contextual knowledge. These two elements have been adapted for this study in exploring contextual knowledge among practicing engineers. Therefore, these elements are redefined into the contexts of this study. The lifeworld element in this study is known as the practicing engineer's knowledge on the real problems, situations and applications face by them when applying 3D CAD modeling activities within four digital product modeling contexts in their product design (Adnan, 2021). For the element of province of meaning, it has been defined as the practicing engineer's knowledge in having same understanding on the application of 3D CAD modeling activities within digital product modeling context with other engineers in the same manufacturing firm. In addition, they know what their customers want (Adnan, 2021).

In the manufacturing industry's real design world, these two elements actually play an essential role when the engineer wants to design a product by using any 3D CAD modeling software. Table 1 shows the applications of contextual knowledge elements in the 3D CAD modeling process. For example, when the engineer wants to design a product that embed safety element. The engineer needs to think before he or she designs the product by using 3D CAD modeling software in order to make sure the final product can be workable and safe to use by the users. Usually, in 3D CAD modeling, the activity like fillet or chamfer will be involved in every sharp edges area in the product in order to develop a safety product to the users.

Table 1. Contextual Knowledge in 3D CAD Modeling Process

Modeling within the Contexts	Modeling Activities	Lifeworld	Province of meaning
Safety	▪ Fillet ▪ Chamfer 	?	?

Based on the findings of the preliminary interview with a practicing engineer in one of the manufacturing industries, that engineer admitted that he had made a lots of mistake when he was tasked to design a ferry toilet. As a consequence of his design errors, his company had to bear substantial loss. This mistake happened because his design does not think about the ferry users' application. He does not put himself as the user of the toilet and this has caused him not to be able to think about what would happen to the users when they use the toilet while the ferry is moving or in other situational context. These problems actually relate to what has been reported by Ma and Zhang (2010) in their study. They have reported the most frequent mistakes that are commonly made by product designers in manufacturing industries. There were mistakes that caused some designed parts not to be ably machined during the manufacturing stage.

These mistakes occurred mainly because the designers considered more on the product function rather than the aspects of product manufacturability.

Therefore, the essential elements of lifeworld and province meaning when the practicing engineers want to design by using 3D CAD modeling need to be explored in this study.

Model Manipulation in 3D CAD Modeling

This research focused on the representation of contextual knowledge in CAD modeling, which can be used to assist engineers in contextualizing their 3D models during the product design process. Yan et al. (2006) digital product modeling framework that is directed toward manufacturing operations is investigated in order to fully understand the common tasks or activities associated with the use of the modeling method in the creation of a product model. The framework of digital product modeling used in this study has been adapted from conceptual knowledge in the 3D CAD modeling framework by Daud (2012). According to Daud's framework, the constructs of Model Creation, Manipulation, Exploratory Visualization, Model Transfer and Collaboration have been explored to understand the conceptual knowledge applications in 3D CAD modeling.

In this study, four constructs of the framework have been adapted and redefined to make it applicable to the context of this study. There are the constructs of Model Creation, Model Manipulation, Model Visualization and Model Transfer. These four constructs actually represent the standard process involved in the application of 3D CAD modeling software. Figure 1 shows the cycle of these four constructs utilization in the process of product design development in 3D CAD modeling. According to McEwan and Butterfield (2011), the integration of all design aspects provides a complete digital product modeling platform. These integration aspects have allowed the downstream life cycle phases like testing and certification, maintenance and operation and the disposal integration aspect need in the conceptual design process.

Since manipulation is one of the most critical activities during the model creation process, it is viewed separately from the model creation context to emphasize the relative importance of the contextual knowledge involved. In this model manipulation context, the study is focused on the system understanding and utilizing in performing the manipulation tasks in producing the alternatives and preferred solution. The activity of manipulating the modeled object needs to be involved in this model development process. Silva and Chang (2002) and Khan et al. (2018) state that the process of modeling the product design commonly involves frequent design changes. In addition, Silva and Chang (2002) added that the design changes complexity increases due to the design process need to involve various engineering disciplines.

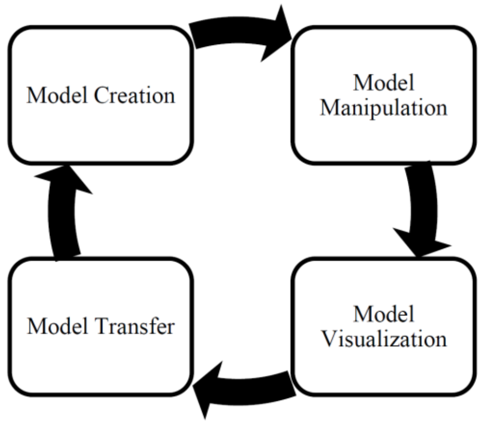


Figure 1. Process Involve in Product Design Development in CAD

Vajna et al. (2020) and Hovarth et al. (2004) stated that the advancement in the customer-oriented product design process necessitates repeated modeled object modification. In further, Hovarth et al. (2004) have explained that engineers gain built-in knowledge from the existing models during the product development and modification stages. This knowledge helps to prevent the quality of model from being deteriorating for future applications and modifications. Since design is an iterative process, Lee et al. (2008) have mentioned the need for product designers to explore and experiment with the alternative design when they are in the early stages of developing a new product design. In addition, Lee et al. (2008) highlighted that applying this approach actually can help the product designers to identify the best design options by using the best-known solutions.

Product modification and diversification have made manipulation activities an important task in 3D CAD modeling due to recent advancements in the product development process (Daud, 2012). Chu et al. (2009) emphasized the importance of such activity in their study. They demonstrate how to use manipulation tasks in a 3D CAD modeling system in modifying product design. By modifying the parts combination, the assembly form selection and the assembly sequence rearrangement, these approaches allow for the automatic generation of 3D product variations structures. According to Yoshimura (2010), the use of rapid prototyping technologies in conjunction with 3D CAD systems has equipped product designers with advanced support for manipulating realistic manufactured models.

In this model manipulation context, the proper utilization of 3D CAD modeling features would boost innovation and aid in problem-solving of practicing engineers during the process of product design development. Having a good competency in the process of modifying design ideas extremely helps the designers to reduce the amount of time spent and also allowed for a quicker design manufacturing process (Mehta, 2020; Wang et al., 2009; Visser, 2006). In creating the desired product design, CAD features technology has been proved as an effective tool in manipulating the shapes of the created model. Wang et al. (2009) provide an example of this type of facility by stating that any modifications made to any part or assembly are automatically generated in all associated parts and drawing sheets, resulting in all relevant files being modified simultaneously when the main part is manipulated. According to Daud et al. (2012), the final shape of the created model can be manipulated by modifying the geometry or features of the part. In order to achieve a rich diversity of design variations, this context has been explored in this study in order to contextualize the manipulation activity within the context of 3D CAD modeling process among practicing engineers in the manufacturing industry.

Research Methodology

This research was carried out using a transcendental phenomenology research design to explore the story of practicing engineers experienced in utilizing the elements of contextual knowledge in 3D CAD modeling application in their daily design work. This approach enables the researcher to emphasis more on the description of the practicing engineers' experiences and less on the researcher's interpretations. Four practicing engineers from a Peninsular Malaysian shipbuilding company were selected using a homogenous sample approach (Creswell and Guetterman, 2019; Patton, 2015). This selection allows for an in-depth and representative exploration of the contextual knowledge of practicing engineers in developing 3D CAD models. This study's selection of practicing engineers as respondents is limited to samples with at least three years of daily work experience using 3D CAD modelling software. As suggested by the Engineering Accreditation Commission (2018), a professional engineer in their specialty must have three years of practical experience.

The concept of data saturation has been utilized in this conducted study. The saturation stage has occurred when there are no new themes emerged with the fourth practicing engineer and he has repeated the same information as the previous engineers. Even though there are only four respondents has been explored in this study, Lincoln and Guba (1985) and Corbin and Strauss (2014) stated that this sample is considered to be sufficient for a qualitative phenomenology study as long as it can provide an understanding of the exploration phenomenon from those respondents. According to Dukes (1984), he recommends to study three to ten persons in one phenomenological research. This recommendation has also been supported by Smith et al. (2009) and they suggested to the novice researcher to conduct at least three and above respondents for the phenomenology study.

Table 2 shows the demographic information of the four practicing engineers participated in this exploration study. Husserl's concepts of epoche (or bracketing) were used to capture a good description of the experiences of practicing engineers in this study: "put aside personal experiences as much as possible and take a fresh look at the phenomena under investigation in this study" (Creswell and Poth, 2018). A series of phenomenological interviews and document analysis were used to acquire the data for this study. During their free time, each session of the phenomenological interview lasted around one and a half hours. Started in March 2014 and continuing until March 2015, the interview session was done periodically in four series. During interview sessions, the Moustakas (1994) standards for phenomenological interviews were followed. According to Kennedy (2010), conducting a phenomenological interview requires the researcher to keep the questions open and devoid of preconceived concepts and leading phrases, allowing for a more interviewee-guided, rich narrative of a phenomena.

Table 2. Practicing Engineers Background

No. of Practicing Engineers	Gender	Position in company (Technical Executive = Project Engineer)	Years of experienced in using CAD software (years)	Types of CAD software has been used	Skill level in using of CAD software (Novice 1 → 5 Expert)	Educational Background
1	Female	Senior Technical Executive	8	AutoCAD, PDMS	4	Mechanical Engineering
2	Male	Senior Technical Executive	5	AutoCAD, SolidWorks, CATIA, AVEVA	4	Mechanical Engineering
3	Male	Technical Executive	10	AutoCAD, RDM6, MAXSURF, HYDROMAX	5	Naval Architecture and Shipbuilding
4	Male	Technical Executive	4	AutoCAD, AVEVA, Maxsurf	4	Mechanical Engineering

Then, interviews data were analyzed using the Stevick-Colaizzi-Keen modification phenomenological analysis method by Moustakas (1994). This phenomenological analysis was chosen based on the underpinning process of this analysis that has helped the researcher to answer the research questions of this study and allowed the researcher to capture rich descriptions of the participants' experiences. The analysis began after all the interviews data has been transcribed. All the interviews' transcriptions then were continued with the horizonalization analysis process to find significant statement from each practicing engineers (Moustakas, 1994). From the analysis process, 28 significant statements that related to the utilization of contextual knowledge in 3D CAD model manipulation have emerged from the horizonalization process. Then, all listed significant statements were used to construct the textural descriptions to capture on what are the essential contextual knowledge elements from each practicing engineers in the application of 3D CAD model manipulation contexts. Subsequently, structural descriptions were formed to summarize details on how practicing engineers employed the essential contextual knowledge elements in the application of 3D CAD model manipulation contexts.

In forming the main theme of this study, the textural and structural descriptions were integrated to provide a synthesis of the meanings and essences of the practicing engineers' experience. Relevant documents such as printed engineering drawing, drawing standard and guidelines were also collected from the engineers as supported data to increase the reliability of the interview findings. A whole visual representation of this operational research framework is shown in Figure 2.

Research Findings and Discussion

This article presents the findings from the exploration of the practicing engineers' contextual knowledge application when using 3D CAD modeling software to create a product design. Answers for the question of what are the essential elements of contextual knowledge in the application of 3D CAD modeling during model manipulation stage from the practicing engineers' experiences and how the practicing engineers employ those essential elements in the application of 3D CAD modeling are discussed in this section. Three most frequent themes emerge in the application of contextual knowledge in manipulating a model using 3D CAD modeling are: Realization, Design Intention and Normalization. Figure 3 showed the sub-elements that emerged on each theme that needs to be contextualized by engineer when manipulating a 3D CAD model.

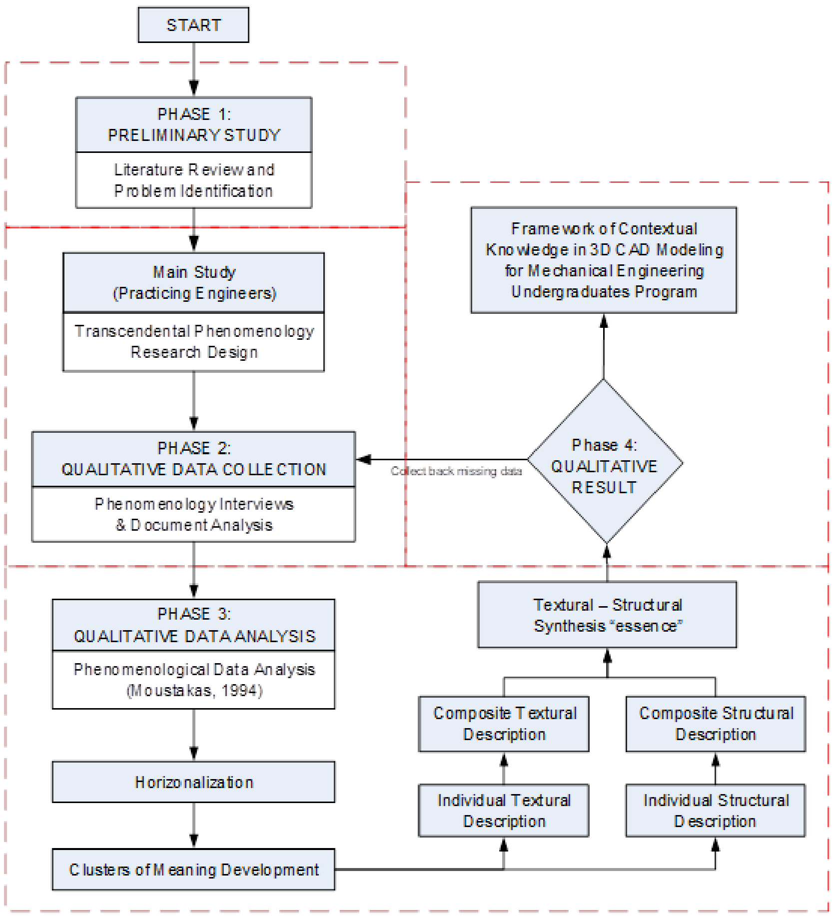


Figure 2. Visual Representation of Research Operational Framework

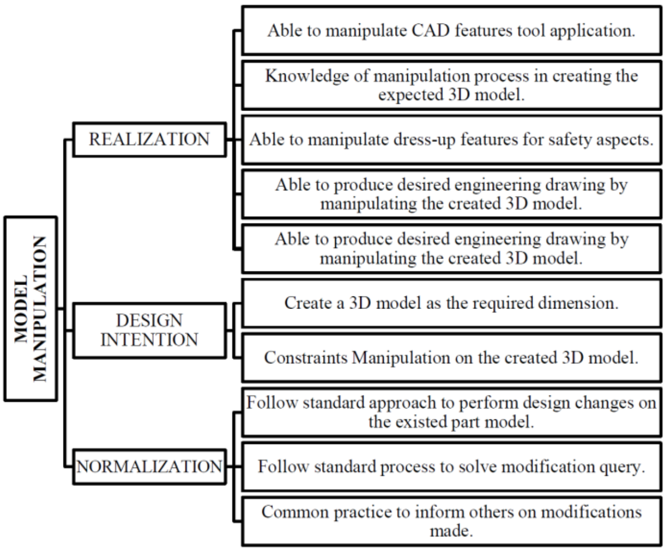


Figure 3. Contextual Knowledge Elements in Model Manipulation

Detailed definitions of these three contextual knowledge elements emerged from this study are explained in Table 3.

Table 3. Summarize of Contextual Knowledge Elements Definition in Model Manipulation Context

Contextual Knowledge Elements in Model Manipulation Context	Definition
Realization	Element that the engineer needs to utilize the action of the imagination to manipulate the created product design that was bringing something vividly to the users' or manufacturers' application.
Design Intention	Element that the engineer needs to plan on how to employ the manipulation process on the created part design during the product design development stage.
Normalization	Element that the engineer brings the creation model into conformity with standards and requirements after performing the manipulation process.

Realization in Model Manipulation

In this study, realization is defined as the element that the engineer needs to utilize the action of the imagination to manipulate the created product design that was bringing something vividly to the users' or manufacturers' application. By realizing the users' or manufacturers' applications can help the engineers to create a good model that is more friendly to users and manufacturers' sites. They need to be able to manipulate CAD features tool application, knowing the manipulation process in creating the expected 3D model, able to manipulate dress-up features for safety aspects, able to produce desired engineering drawing by manipulating the created 3D model and able to manipulate 3D CAD model for exploring created design.

Able to manipulate CAD features tool application. The engineer's ability to manipulate all the provided CAD modeling features has been highlighted during the researcher exploration on the practicing engineers experienced in the model manipulation stage. This element has been emphasized by them as a vital element to helps the engineer in the process of creating the desired product design. According to Ault and Phillips (2016) and Doutre et al. (2017), this element has played an important role in making the engineer achieved to model their desired design shapes.

As been said by Jost et al. (2020), generally, to form a complete 3D model, the engineer needs to utilize various CAD features. This statement actually was aligned with what has been said by most of the practicing engineers from this study. Since there was more than one CAD modeling software have been experienced among them, they have highlighted the importance of engineer to have an ability to transfer their previous knowledge in utilizing the CAD modeling features during the model manipulation stage. The work on CAD features knowledge transfer has been explored by Guidera (2004) in his research study.

Knowledge of manipulation process in creating the expected 3D model. This element has been emerged by the practicing engineers when they tried to relate the features tools application in creating the desired product design. Based on the findings, most of them have mentioned the impact of knowing the manipulation process during the model creation stage. The works by Hudson et al. (2012) have discussed the implication of engineers for having good knowledge in the manipulation process for creating the desired product design.

According to practicing engineers' experiences, by realizing the manipulation process will help the engineer to plan the desired features tools that need to be utilized in creating the expected product design. As mentioned by Cohen et al. (2019), the intensive manipulation process helps the engineer to transform the ideas generation into the desired 3D CAD model. Therefore, as engineers, they need to realize which manipulating process needs to be performed to speed up their ability to create the expected 3D model (Bordegoni and Rizzi, 2011).

Able to manipulate dress-up features for safety aspects. Based on the findings, this element has been emerged by practicing engineers in creating a good product design. They have emphasized the importance of engineers to have the ability to manipulate the dress-up features for making the created product design safer for the user applications. This element also has been highlighted by Kamdar (2015) in his study on designing and manufacturing of wheel for the magnetic climbing robot.

Referring to the practicing engineers experienced, the dress-up features like fillet or chamfer are the most common features been used on the critical part during the product design. These dress-up features also have been used as the standard features that commonly been used by other engineers during the 3D CAD model creation (Agarwal et al., 2018; Kamdar, 2015).

Able to produce desired engineering drawing by manipulating the created 3D model. The engineer's ability to produce the engineering drawing for product development is one of the essential elements emphasized by practicing engineers in this study. The findings show that most of the practicing engineers agreed that the CAD system had helped them a lot to produce a required engineering drawing for product development. According to Kasik et al. (2005), by fully utilizing the CAD system will help the engineer to produce a good engineering drawing for production site applications. Good engineering drawing actually can help the production site to positively interpret the shape, information and requirements of the created product design (Simmons and Maguire, 2012; Dobelis et al., 2012; Kasik et al., 2005).

Therefore, the engineer needs to fully manipulate the created 3D model to produce a good engineering drawing for product development applications. Based on the findings, practicing engineers have realized that the applications of features tool in the recent CAD modeling software to speed up the process of creating needed engineering drawings from the created 3D model. Gaddam (1995) has mentioned that a good utilization of CAD modeling software helps the designer transform the 3D model into a desired engineering drawing.

Able to manipulate 3D CAD model for exploring created design. The practicing engineers had highlighted this element when they shared their attractive experienced when using CAD modeling software. They have shared their experiences in utilizing the 3D model exploration features tools. In the recent CAD modeling software, the 3D model exploration features tools have been equipped to help the engineer explore their created model during the model creation stage. According to Rodriguez (2015), 3D model exploration is the process of manipulating the created 3D model by interacting with the 3D content to visualize the model from any angle and making the part model analysis.

Based on the findings, the practicing engineers have shown the ability to explore their created model by making the part model manipulation. They have made the part model analysis, applied the orbit rotation tools to view the part model from a different angle and making the 3D model simulation to make sure their created part is functional and workable design. Making a functional and workable product design is the most crucial aspect that engineers need to emphasize during the part model manipulation process (Park et al., 2019; Ope-Tairu, 2016).

Design Intention in Model Manipulation

In this Model Manipulation context, the design intention is defined as the element that the engineer needs to plan on how to employ the manipulation process on the created part design during the product design development stage. By contextualizing the intention of the created part design, it will help the engineer to speed up the process of product development. They need to create a 3D model as the required dimension and knowing the constraints manipulation on the created 3D model.

Create a 3D model as the required dimension. In the process of creating and manipulating the part model, this element has been highlighted as the crucial element by the practicing engineers in this study. They have stated that all the design part needs to follow as what the size requested by the clients or customers. According to Louie (2018), there is a must of an engineer to make sure the final dimension of the parts as the customer needs. He added the engineer need to put this aspect as the main requirement that needs to be followed and achieved during the part modeling stage. If the engineer cannot achieve this requirement, commonly, it will affect the expected function of the created product (Prats, 2007).

Based on the findings, practicing engineers have also highlighted the importance of engineers to ensure all the required dimensions are inserted or shown in the produced engineering drawing. They have emphasized that this aspect is vital in order to help the production site develop the created product design as required. Other researchers have also emphasized this aspect in their research works (Henderson, 2014; Henderson and Swaminathan, 2003).

Constraints manipulation on the created 3D model. In the stage of manipulating the created model, the practicing engineers in this study have emphasized this element as the essential elements that need to be alert by the engineer during the model development stage. The exploration of this constraints manipulation in 3D CAD modeling has been done by Hartman (2005) in his research study. Based on the findings, there were two types of constraints that have been mentioned during the exploration of constraints manipulation in part model development.

There are geometric constraints and dimensional constraints.

Cai et al. (2020) have defined geometric constraints as a geometric relationship between two shapes that affect the relative constrained shape transformation with the fixed shape. The applications of these geometric constraints in CAD modeling can be explored in Perzylo et al. (2015). For the dimensional constraints, Hanratty (1995) has defined these constraints as the constraints that have been used to control the geometry through large shape variations. As mentioned by practicing engineers in the findings, these two constraints need to be well manipulated in order to create the expected part model design. Therefore, the engineer's fundamental understanding on the application of these two constraints during the model development stage needs to be contextualized in order to speed up the process of designing the part model (Hartman, 2005).

Normalization in Model Manipulation

In this Model Manipulation stage, the normalization is defined as the element that the engineer brings the creation model into conformity with standards and requirements after performing the manipulation process. By contextualizing the common manipulating activities during the model manipulation stage, it will help the engineer to speed up the process of product development. Figure 2 shows the normalization elements that the engineer needs to emphasize when manipulating a 3D CAD model. They need to create a model that follows the standard approach to perform design changes on the existed part model, follow standard process to solve modification query and the common practice to inform others on modifications made.

Follow standard approach to perform design changes on the existed part model. In performing design changes or modifications on the created part model during the process of product development, the practicing engineers in this study have emerged this element as a vital element that needs to be followed in their company practiced. Based on the previous chapter's findings, all the engineers in this study have mentioned the existence of the Site Technical Query (STQ) form as the standard of practice in performing design changes during product development. The conceptual understanding in performing the CAD design changes among the practicing engineers has been explored by Daud (2012). In this study, the practicing engineers have also highlighted this element's existence by contextualizing the standard of practice on implementing this element in their daily design works.

According to the works by Kang et al. (2019), there were a lot of approaches have been practiced by manufacturing industries in performing the design changes during the process of product development. Kang et al. (2019) have summarized the list of the standard of practice regarding to this element. The implementation of this element actually helps the companies to standardize all their design changes work has been performed during the product development process and updating the recent changes has been made by the engineer.

Follow standard process to solve modification query. This element is related to the previous emerged element. It was more focused on solving the process of modification query made during the product development process. Based on these element findings, the practicing engineers of this study have highlighted the importance of the engineer in understanding the problem category before proceeds with the solving process for the problem. This was due to the standard of practiced needs to be followed to solve the modification query by the production site. According to the research study by Hack et al. (2010), they have found that there were many approaches and standards of practice have been utilized by the manufacturing industries in managing the modification query.

Based on the findings, the problem categories can be divided into three types of problems either the query of dimension modification or the shape design changes or the request for material changes. After clearly understand the problem and the category of the problem, the engineer needs to plan and take action to solve the modification query based on their company standard of practice. The approach to solving the CAD design modification query also has been discussed by Pratt and Anderson (2000) in their research study.

Common practice to inform others on modifications made. After any modification has been made on the created part design, the practicing engineers in this study have explained their common practice in informing others about the modification that has been made. Based on the findings, there were many common approaches have been made by practicing engineers in this study. Commonly they will update the drawing revision number, adding the cloud mark on the changes area of the part, adding description notes on the title block notes section and other approaches. Most of the common approaches that emerged from this study are similar to the other companies' practices. As reported by Chen and Siddique (2005), after performing the design changes on the created part, the approach like adding the arrow with the dark box ends to represent the modification that has been made in the drawing is needed by the engineer. Based on work by Akcamete et al. (2008), they have highlighted the importance of engineers to apply a systematic method for tracking the changes and updating the design changes in the engineering drawing. This was due to the lack of updated information on design changes received by the downstream during the process of product development.

Conclusion

This paper discusses the findings of the study that explore the essential elements of contextual knowledge in the process of creating 3D model from practicing engineer experiences. Based on the present findings, three main elements of contextual knowledge emerged from this study. There are the elements of Realization, Design Intention and Normalization. These three elements play an important role in helping the engineers to contextualize their design work during the stage of creating a good 3D model for new product development. By utilizing the element of realization, it will help engineers to utilize the action of the imagination to manipulate the created product design that was earlier on vividly clear to the users' or manufacturers' application. Therefore, the element of design intention will help the engineer to plan on how to employ the manipulation process on the created design part during the product design development stage. Furthermore, the element of normalization will bring the creation model into conformity with standards and requirements after performing the manipulation process.

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Evaluation of Mathematical Competencies among Electrical Engineering Students

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Abstract
In universities, engineering students are often seen as a group of students with high level of intelligence. The engineering programme seeks applications from students with a strong command in Mathematics and Science. Therefore, it is believed that Mathematical Competencies (MC) are the element that plays a vital role in engineering education since there are plenty of applications of mathematical knowledge in engineering courses. This paper discusses mathematical competencies further, with emphasis on those demonstrated by the engineering students. MC consist of eight components: Thinking mathematically, posing and solving a mathematical problem, modelling mathematically, reasoning mathematically, representing mathematically, handling mathematical symbols and formalisms, communicating in, with, and about mathematics and using aids and tools. Unfortunately, many engineering students did not meet the required level as they did not perform well in the engineering course, whereby in this study, the focus was on the Electromagnetic Field Theory (EMT) course. EMT was chosen because the course contains high mathematical component. A qualitative method of ethnographic research design was selected as a mean to collect data, which was then analysed using thematic analysis. A set of EMT questions was developed for 17 participants from an electrical engineering programme. From the written work, it can be said that the participants demonstrated their MC based on their answers. It can be concluded that most of the participants with higher marks were able to demonstrate almost all of the MC components.

Keywords: Electromagnetic Field Theory, Mathematical Competencies, Evaluation.

Introduction

In higher education, the selected students enrolled in the engineering programme are among the ingenious ones. This is because the engineering programme is among the most challenging programmes in higher education as it requires bright students with good knowledge in Science and Mathematics (Pepin et al., 2021). However, when the students start to learn engineering courses, the problem encountered is bridging the mathematics knowledge so that it can be applied in the engineering field (Queiruga-Dios et al., 2018). A lot of engineering students face this difficulty in higher education. Typically, mathematics is taught by lecturers from the Mathematics Department, and the same goes for engineering courses taught by lecturers from the Engineering Department. Unfortunately, engineering students find it difficult to apply mathematical knowledge in engineering despite the good grades obtained in mathematics courses. Many lecturers complain that they have to reteach Mathematics knowledge, which consumes a lot of time (Willcox & Bounova, 2004a).

Moreover, the heavy syllabus of Electromagnetic Field Theory (EMT) makes it worst for engineering lecturers who struggle to finish the syllabus on time. Hence, the performance of the engineering students in EMT is not as expected by faculty. One of the main factors identified as the reason behind this is the Mathematical Competencies (MC) possessed by the engineering students (Niss & Højgaard, 2019). We know that Mathematics plays a big role in engineering, thus the foundation of mathematics in every one of engineering students should be adequate to support engineering programme's teaching and learning (Uysal, 2012). In this research, the focus was given on the mathematics competency endowed. MC constitute of eight interrelated elements and divided into two categories:- Posing and answering questions in and by means of Mathematics and Handling the language, constructs and tools of Mathematics (Niss, 2003). These elements are the ongoing process and require deep understanding of Mathematics (Willcox & Bounova, 2004b).

Mathematical Competencies

It has been clarified by the founder of MC, Morgan Niss, a researcher in MC who started this term back in 2002, in his numerous publishing included in SEFI, the European Society for Engineering Education, that to assess all of the MC's at one go are almost impossible since there is no specific tool that can be used. Researcher normally takes one or two of the MC and include them in their research. Therefore, in this study, the focus is on the evaluation of demonstrated MC with the purpose of studying or identifying which MC is the most acquired by the engineering students.

Engineering students are obliged to take several mathematics courses before taking few engineering courses. Therefore, some of the mathematics courses are made prerequisite for engineering courses. However, the engineering students do not frequently see the correlation between mathematics and other courses, and in this study, the EMT course (Queiruga-Dios et al., 2018). Engineering students need to be competent in mathematics as it plays a vital role in the engineering field as the engineering field is dynamically revolving (Gollish, 2019). The problem of linking mathematical knowledge into another context such as in engineering is called the "high road transfer". It means the problem to apply mathematics that the engineering students have learned before into different field or context (Salomon & Perkins, 1989). They often see that mathematics stands on its own and not related to any field. In contrast, mathematics actually plays a huge role in engineering practice (Flegg et al., 2012).

MC have various definitions. Mathematical competency is the ability of a person to react with actions towards mathematics (Niss, 2002). The person will be identified as a competent person in mathematics, therefore, there will not be a problem if the person possesses all the eight mathematical competencies (Niss, 2002). Engineering students are taught in a routine manner in mathematics courses that they have to take. This has hindered the possibility for the engineering students to develop fundamental skills in mathematics (Wedelin et al., 2015). Mathematics department should introduce a more non-routine or something that is closely related to engineering field when the engineering students are still undergoing the courses.

The mathematical competency is divided into two groups: Ability to ask and answer questions in and with mathematics and the ability to deal with and manage mathematical language and tools. The first group contains: 1. Thinking mathematically, 2. Posing and solving mathematical problem, 3. Modelling mathematically and 4. Reasoning mathematically.

Thinking mathematically is when an individual is able to understand and handle Mathematics whenever a concept was given, knows how to distinguish the variety of mathematical statements such as theorems, definitions, conjectures, etc. Posing and solving mathematical problem is anything about specifying, posing and identifying various kinds of mathematical problems. In modelling mathematically, it lies in analysing and developing models. It is the process of analysing the properties and foundations of present models, look up for range and validity, able to validate the model, monitor and control the whole process of modelling, etc. In reasoning mathematically, students are expected to follow and assess chains of arguments, able to prove a statement, know how it differs from each mathematical reasoning, etc.

Meanwhile in second group, it represents mathematical entities such as utilising and understanding the link between various kinds of representations of the same entity. It also requires the ability to choose and switch between representations. In handling mathematical symbols and formalisms, one should be able to decode and interpret symbols and other mathematical language, and able to convert it into natural language and vice versa. One should also be able to handle and manipulate expressions and statements consisting of symbols and formulae. Next MC is communicating in, with and about mathematics where one should be able to comprehend the written, oral or visual text in a various kind of linguistic form that contains mathematical content and express personal view about theoretical and technical precision at various levels such as in visual, written or oral form. The last MC is possessed by almost all of us which is making use of aids and tools including the information technology tools. One should be able to know the usage and properties of each aid and tool for mathematics activity and use it according to situations. All of these definitions are taken from the work of Niss (2003).

Methodology

This study adopted a qualitative approach which used an ethnographic design. Ethnographic design is to learn more about individual perspectives with the same interest, shared-values and beliefs (Creswell, 2012). The participants for this study were the engineering students from School of Electrical Engineering, Faculty of Engineering at a Higher Education Institution in south of Peninsular Malaysia. Purposeful sampling was used where the respondents were intentionally selected based on their Cumulative Grade Point Average (CGPA) and grades for their Engineering Mathematics II course. To be exact, the respondents were chosen from high achievers, medium achievers and low achievers (Creswell, 2012). The rational of choosing Engineering Mathematics II is because it is the last prerequisite course before taking EMT. The respondents comprised of engineering students enrolled in EMT course while the study was being conducted. They were also the engineering students who had taken three compulsory mathematics courses before they were allowed to register for EMT course. One set of EMT questions was developed especially for the participants and later being transcribed using thematic analysis. The participants were also interviewed once their marks were obtained to further understand their rational for each of the questions answered.

Data Analysis

In order to analyse the data collected via qualitative method, this study uses thematic analysis. Thematic analysis is widely used in psychology whenever there involves qualitative research. Some might find this method rarely acceptable since it requires a lot of work to be done to convince others to understand the gist of it (Tuckett, 2015). Thematic analysis is a process that happens within data for identifying, analysing and subsequently the data is usually being reported in patterns or so called themes (Braun & Clarke, 2006). Although it is widely used, the agreement on how researcher is going to do it, is still vague. It depends on the researcher on how to make every theme generated explainable and convincible to others to comprehend what they are doing.

There are six phases in thematic analysis as follows:

1. Phase One: Data Familiarising
2. Phase Two: Generate initial codes
3. Phase Three: Search for themes
4. Phase Four: Review themes
5. Phase Five: Define and naming themes
6. Phase Six: Producing report

In Phase One, researcher needs to understand very well the data that has been collected. They are the only one that knows well what they are doing and have full embrace towards the data as much needed. This can be done by reading the data repeatedly and at the same time attempt to find each meaning, pattern etc. In this phase, researcher tries to begin the process of coding by finding possible patterns or themes. The verbal data obtained such as interviews, need to be transcribed first. Since this study adopted a theory-driven data, the themes and code had both been pre-determined. The reference was taken from the work of Soheila, (Firouzian et al., 2014) where she came out with scoring rubrics that can be used in this study. The rubric is basically from the definition of mathematical competencies founded by Niss (2003). Table 1 shows the scoring rubrics that had been used in this study.

Findings & Discussion

This paper presents the findings on part of the study which focuses on the written work from the highest scored respondent. The written work of Respondent 1 was supplemented by an interview session for further understanding of the respondent. Referring to Figure 2, Respondent 1 had scored full marks for this question. A few questions were asked to Respondent 1 regarding the written work that had been completed. The main question was "How did you manage to answer the question correctly?". The gist of the respondent's response is summarised as follows:

The respondent did not know the definition of *Biot-Savart Law* as stated in the question, but the respondent memorised the equation and used it for further elaboration to come out with the definition.

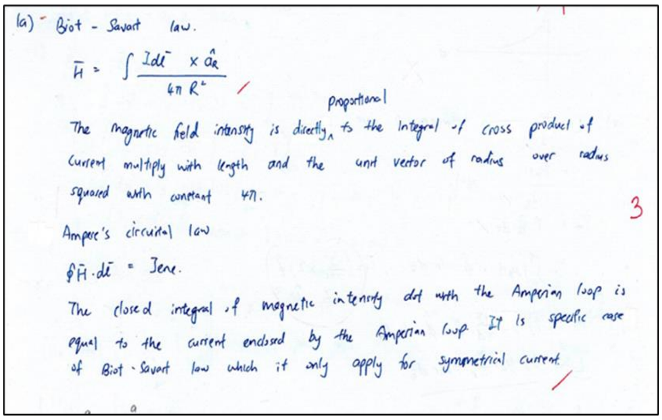

Figure 2. Written work of Respondent 1

The summary of the respondent's response had provided the reason on why the question had been answered correctly with full marks. This shows that the respondent had the thinking mathematically (TH1, TH2, TH3) competency where one can recognise the mathematical concepts, understanding and handling the scope or limitations of a given concept. The acquired MC is believed to be obtained during their previous knowledge and in this case, the learning of previous mathematics courses. The engineering students used the acquired MC to demonstrate it in written work. Hence, the respondent had managed to give the definition of Biot-Savart Law. Respondent 1 also had other sights of MC, which are to abstract or generalise the results (TH4) and to distinguish various mathematical statements (TH5) even in a different field. In this case, a law that contains highly mathematical threats can be elaborated into the scope of electrical engineering.

Table 1. Scoring Rubric

<table>
<tr><td>Group 1</td><td colspan="3">The ability to ask and answer questions in and with Mathematics</td></tr>
<tr><td colspan="2">Mathematical Competency</td><td>Sub-Competency</td><td></td></tr>
<tr><td rowspan="5">1. Thinking Mathematically</td><td rowspan="5">THM</td><td>1.1 Recognition of mathematical concepts</td><td>TH1</td></tr>
<tr><td>1.2 Understanding and handling the scope /limitations of a given concept</td><td>TH2</td></tr>
<tr><td>1.3 Abstracting / Generalising results to larger classes of objects</td><td>TH3</td></tr>
<tr><td>1.4 Posing questions and knowing the kinds of answers</td><td>TH4</td></tr>
<tr><td>1.5 Distinguishing various mathematical statements (including conditioned assertions (if-the), quantifier-laden statements, assumptions, definitions, theorems, conjectures and special cases)</td><td>TH5</td></tr>
<tr><td rowspan="3">2. Reasoning Mathematically</td><td rowspan="3">RM</td><td>2.1 Understanding and assessing an existing argumentation particularly a proof</td><td>RM1</td></tr>
<tr><td>2.2 Proving a statement</td><td>RM2</td></tr>
<tr><td>2.3 Reasoning Logically</td><td>RM3</td></tr>
<tr><td rowspan="4">3. Problem Handling</td><td rowspan="4">PH</td><td>3.1 Investigating various problems (identifying, posing and specifying pure or applied, open-ended or closed)</td><td>PH1</td></tr>
<tr><td>3.2 Solving various problems in different ways, if appropriate</td><td>PH2</td></tr>
<tr><td>3.3 Formulating various problems</td><td>PH3</td></tr>
<tr><td>3.4 Personal capabilities whether or not a question is considered as a problem</td><td>PH4</td></tr>
<tr><td rowspan="4">4. Modelling Mathematically (i.e. analysing and building models)</td><td rowspan="4">MM</td><td>4.1 Analysing/ validating existing models</td><td>M1</td></tr>
<tr><td>4.2 Decoding existing model (translating, interpreting model elements in "reality" modelled).</td><td>M2</td></tr>
<tr><td>4.3 Performing modelling (structuring, mathematising, solving a raised problem, interpreting results, in reality, validating the model)</td><td>M3</td></tr>
<tr><td>4.4 Monitoring and controlling the whole modelling process</td><td>M4</td></tr>
<tr><td>Group 2</td><td colspan="3">The ability to deal with and manage mathematical language and tools</td></tr>
<tr><td rowspan="3">5. Representing Mathematically</td><td rowspan="3">REP</td><td>5.1 Utilising and understanding different sort of representations (decoding, interpreting, distinguishing between)</td><td>RE1</td></tr>
<tr><td>5.2 Understanding and utilizing the relations between different representations of the same entity</td><td>RE2</td></tr>
<tr><td>5.3 Transforming representations (choosing and switching between representations)</td><td>RE3</td></tr>
<tr><td rowspan="2">6. Communicating Mathematically</td><td rowspan="2">CM</td><td>6.1 Understanding others' mathematical texts</td><td>C1</td></tr>
<tr><td>6.2 Expressing oneself about mathematical contents</td><td>C2</td></tr>
<tr><td rowspan="4">7. Handling Symbolism and Formalism</td><td rowspan="4">SAF</td><td>7.1 Understanding symbolic/formal language</td><td>S1</td></tr>
<tr><td>7.2 Handling/manipulating statements (using symbols and formulae)</td><td>S2</td></tr>
<tr><td>7.3 decoding and interpreting symbolic and formal mathematical language and its relations to natural language</td><td>S3</td></tr>
<tr><td>7.4 Translating from natural language to formal/symbolic language</td><td>S4</td></tr>
<tr><td rowspan="2">8 Using Aids and Tools</td><td rowspan="2">UAT</td><td>8.1 Knowing different tools and aids and their properties</td><td>U1</td></tr>
<tr><td>8.2 using reflectively such tools and aids</td><td>U2</td></tr>
</table>

As explained earlier, only part of the findings of this study is presented in this paper. It involves more than one respondent and more than one question as highlighted in this paper. It requires thorough analysis based on the respondents' written work to further strengthen the findings. In fact, the study can be expanded into a larger scope since there are eight MC altogether to be explored. Unfortunately, it is almost impossible to assess all the MC in one study since there is no exact tool or instrument to do the assessment as mentioned by Niss (2003).

Conclusion

This paper has presented the acquired and demonstrated MC among electrical engineering students with focus on those who enrolled in an Electromagnetic Field Theory (EMT) course. In this case, based on the respondent who had scored full marks for one of the given EMT questions, the MC demonstrated include thinking mathematically, abstracting or generalising and distinguishing various mathematical statements. Since there is no exact tool or instrument to do the assessment, it can be done by separating the MC's into few studies or some of it can be joined together depending on the scope of the study. Further work will be conducted to strengthen the findings that are expected to reveal a framework on narrowing the knowledge transfer gap between Mathematics and engineering courses.

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