2021
Volume 5
Issue 2

AJEE

ASEAN JOURNAL OF ENGINEERING EDUCATION

2021

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https://ajee.utm.my/

Editorial Brief

ASEAN Journal of Engineering Education (AJEE), managed by Universiti Teknologi Malaysia - Centre for Engineering Education (UTM CEE) and the Society of Engineering Education Malaysia (SEEM), was founded in 2012. The journal publishes manuscripts that bridge the world of theory and practice in engineering education, focusing on rigorous research on engineering education and scholarly practice sharing on innovations in engineering education strategies.

In early 2021, AJEE has moved to a new established platform - Online Journal System (OJS) that is managed under a reputable publication entity, Universiti Teknologi Malaysia Publisher (Penerbit UTM). We publish two issues of AJEE per year.

Under the new AJEE landscape, fifteen esteemed editorial board members from Malaysia, Singapore, Indonesia, Philippines, Saudi Arabia and Iran have been appointed, as listed below. We aim to make the AJEE a respected and referred engineering education publication by 2025. We would like to welcome authors from various parts of the world to submit engineering education papers for possible publication in the AJEE.

Editorial Boards

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Reflection on Contradictory Learning Methods and Identity Formation in a New Academic Life Setting

Article history
Received
1 November 2021
Received in revised form
6 December 2021
Accepted
7 December 2021
Published online
28 December 2021

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Abstract

Lecturers new to the academic life setting normally face similar types of challenges. These challenges were intensified for new lecturers starting their careers in the academic setting during the COVID-19 pandemic, when classes were conducted online. Student-centered learning has been the focus in engineering education recently, but many of the current lecturers have never experienced this method of learning as students, resulting in unfamiliarity and inexperience in conducting classes using this method of teaching. Our experiences as two new lecturers starting our academic careers during the pandemic using both the student-centered learning method and teacher-centered learning method in different classes are reported through collaborative autoethnographic methods. Both of our reflections revealed that stark differences can be seen as an effect of the teaching method, concluding that the student-centered learning method is superior to the traditional teacher-centered learning method. However, applying the former method also has some challenges. To overcome these challenges faced by new lecturers, some action plans have been listed for future improvement, which could be very meaningful and useful to other new lecturers as well as educators new to applying the student-centered learning method.

Keywords: Student-centered learning, active learning, new lecturer, teaching method

Introduction

Lecturers in higher learning institutions, regardless of field of expertise, have at some point been exposed to teaching before beginning their career, either through training or at the very least through personal learning experience as a student. Those with a doctorate are typically familiar with research in the course of acquiring a doctoral degree, but may not be exposed to teaching. Regardless, the transition from being a student or from working in the industry to becoming a lecturer is still daunting and challenging to most. Depending on the requirements that the institution has placed on the lecturers, many struggle with lack of knowledge and experience, especially when placed on the other side of the classroom or lecture hall.

In a very short time frame, many new lecturers are expected to acquire and master to some degree different skill sets, including teaching, supervising, research, consultancy, and time management (Felder et al., 2011). Even for institutions that have devoted attention to developing these new lecturers, challenges are still imminent, and an adjustment period naturally should be expected. New lecturers come from different backgrounds, equipped with diverse knowledge and experiences. In this work, our experiences as two new lecturers with different teaching backgrounds as first-time lecturers in the same university are collected and compared. The similarities between us are that we were both very new to the teaching environment, have only been exposed to Teacher-Centered Learning (TCL) method and both started working as a lecturer during the COVID-19 pandemic.

Traditionally, lectures in university are conducted in a passive manner, or TCL (Kaymakamoglu, 2018). In this manner, the focus of teaching revolves around one-way transfer of knowledge. However, better ways of teaching were proposed by a few theorists centering the learning process around students (Sahonero-Alvarez & Calderon, 2018). This method known as Student-Centered Learning (SCL) utilizes the learning by doing concepts where the lecturer acts as facilitator as opposed to instructor (Bhat et al., 2020). Nowadays, more and more exposure on a variety of teaching methods and implementation procedures were given to new lecturers in order to conduct a more effective classroom.

However, being products of TCL method from the start of our education up to our tertiary education level, as was the norm in Malaysia until not too long ago (Zabit, 2010), we were not accustomed to SCL method. This posed one of the biggest challenges to us as new lecturers, especially in classes that required us to use this method for teaching. On the other hand, as lecturers completely new to educating, we were able to clearly observe the differences between conducting classes using TCL and SCL methods, in terms of planning, delivery, and results. Therefore, the differences between these two methods, as well as other challenges we faced as new lecturers, are documented in this work through collaborative autoethnographic method. The collaborative autoethnographic method is a qualitative one, which would allow us to delve into our perspectives and reflect on our experiences in the cultural and societal context (Chang et al., 2016).

Being a lecturer in the current world with fast-paced advancements in technology and with information at our fingertips, the world is becoming smaller, and lecturers are constantly facing new challenges in delivering knowledge to students. Johnson (2008) discussed the pedagogical challenges caused by the language barrier with international students. Murugiah (2020) focused on the 21st century skills gap created by the Industry 4.0, concerned by the inadequacy of 21st century skills competencies of graduates. Yet another study by Naidu (2020) hits closer to home; she suggested that one of the main struggles faced by lecturers due to Covid-19 pandemic is the online mode of teaching. The challenges of implementing SCL method has also been explored in literature, such as the work done by Pedersen & Liu (2003), who explored the beliefs of teachers concerning the issues in SCL environment, and Wulf (2019), focusing on the willingness and motivation of students in SCL culture. However, to our knowledge, the challenges encountered by newly-hired lecturers during the Covid-19 pandemic with no prior exposure to SCL method has never been explored in depth.

This study is recorded in this paper to help other lecturers, especially new lecturers from a variety backgrounds, to assimilate into a new academic life setting, in particular when there are different teaching methods applied in classes. Through this paper, lecturers should also be encouraged to venture into more sophisticated teaching strategies, even if they may not be familiar with these strategies. There is a whole different world of teaching strategies that can be implemented in the classroom. Additionally, the challenges that both lecturers observed in this study could provide a meaningful insight into the problems typically encountered by new lecturers applying SCL, which would be significant to the educational committee, from administrators to lecturers. Differences between individual teaching and team supported teaching can also be obtained from this paper.

Methodology

As we started working in the same department in the same university within a few months of each others' starting date, the two of us felt a sense of camaraderie as we went through very similar experiences and challenges. Neither of us had been exposed to SCL method as students, and yet both of us had been thrusted into classes that used SCL method of delivery. Both of us also began our new academic lives amidst the COVID-19 pandemic, encountering another challenge that neither of us were familiar with; online learning. As of now, both of us have never had the privilege of teaching students in a physical class, and we share a sense of loss and confusion at having to deal with many unfamiliar situations at once.

Stemming from these similarities, we decided to use collaborative autoethnographic method to study and reflect upon the challenges that we faced, especially focusing on the contrast between the TCL and SCL methods. Autoethnography is a type of qualitative study where the author explores anecdotal and personal experience through self-reflection and writing, and then relates this autobiographical account to broader cultural, political, and societal meanings and understandings. Consecutively, the study of self-reflection, conferring to Ellis and Rawicki (2013) is a research, writing, story, and method that connect the autobiographical and personal to the cultural, social, and political.

By self-studying our similar experiences as new lecturers implementing different methods of teaching, we could collaboratively increase the depth of our study and moderate singular bias so that the experiences and challenges described are not so one-sided (Rodriguez-Simmons & Hira, 2021). Data collection spanning our lecturing experience from our respective starting dates to the end of our second semester was done through daily monitoring of tasks as well as weekly reflections detailing our experiences, observations and subsequent thoughts.

The scope of this study is confined within the reflection of our experiences during our first two semesters as new lecturers. We are sure that we experienced many hardships that all new lecturers face, but the additional challenges of starting as lecturers through online learning on top of suddenly implementing an unfamiliar teaching method may not be applicable to all new lecturers in the past. Yet, given the progress in technology, moving towards blended and online approaches (Martínez et. al, 2019), as well as the promotion of SCL method in engineering education (Hernández-de-Menéndez et al., 2019), we expect that many new lecturers in the future will encounter similar challenges.

The representation of this self-reflection is positioned as continuing professional development research (CPD). Beyond any initial training, CPD refers to the practise of recording and documenting the skills, information, and experience that you obtain both formally and informally while you work. It is a record of what you have done, what you have learned, and what you have put into practise. Kennedy (2005) structured CPD into nine categories namely training; award-bearing; deficit; cascade; standards-based; coaching/mentoring; community of practice; action research; and transformative. This study is closely related to the coaching/mentoring model, however with considerations geared towards new academia in this endemic area. Simultaneously, theories including social cognitive career theory and self-determination theory were also considered in this study.

Positionality

The first lecturer sharing his experience is Dr. Finn (pseudonym). Finn joined Universiti Teknologi

Malaysia at a time when the global pandemic had forced many universities worldwide to take upon emergency remote teaching methods to replace face-to-face classes (Chiroma et. al, 2021). Interestingly, joining the academic program during the pandemic time constructed a unique and different experience as classes were handled remotely compared to face-to-face teaching. Most of the tips and advice given by senior lecturers who typically perform face-to-face teaching became irrelevant or obsolete. Prior to becoming a lecturer, Finn worked as a process engineer at an oil and gas consulting company where the nature of work seems to be on a different spectrum. Finn has always envisioned being a lecturer in a reputable university. Thus, all his actions were geared towards equipping himself with relatable experiences to better guide the students. This action could be explained by the recently developed social cognitive career theory where environmental and behavioural factors have an indirect influence on human cognitive parameters (Liu et. al, 2020). The only formal teaching experiences Finn had was through a part-time tutoring job and informally via mentor mentee program during his undergraduate studies.

The other new lecturer whose experience was documented is Dr. Aria (pseudonym). Similar to Finn, Aria has no formal teaching experience, and additionally, she has no industrial experience. However, unlike Finn, Aria has guided students as a lab instructor and supervised final year students in doing their final year projects while she was working as a postdoctoral fellow in a previous university. Other than that, her experiences are close to Finn's where she has worked as tutors or through peer teaching beforehand. As a lab instructor, Aria had followed the conventional laboratory method as implemented by her department. In this case, students conducted experiments following the laboratory manual, analysed the data, interpreted the results and then prepared the report (Kapilan et al., 2021). Even as a tutor, Aria used the TCL method, where the educator takes an active role in presenting and explaining the learning material to students (Jalani et al., 2015).

Observations on new experiences as lecturers started towards the end of year 2020 for both lecturers in the Chemical Engineering department of the same university. While the university is encouraging non-traditional teaching methods, it is not made compulsory. Thus, implementation varies, with some lecturers embracing the SCL method while others cling to the TCL method. Aria entered in the middle of the semester and was able to experience teaching as part of a two-lecturer team in a SCL class. Her first semester is compared to her second semester as a lecturer, during which she taught a class on her own using mostly TCL methods, resulting in an experience contradictory to her first semester. On the other hand, Finn entered at the end of the same semester, and thus was not assigned any classes. He was later assigned to two classes in his second semester as a lecturer, one taught using the TCL method, while the other was taught using SCL method, causing him to undergo contradictory experiences. In short, both lecturers were able to easily observe the stark comparison between TCL and SCL approaches to teaching. It is worth noting that neither lecturers had been exposed to the SCL method of teaching before, and that these new academic life experiences occurred during the COVID-19 pandemic, which posed additional challenges to teaching.

Results

Aria's Experiences and Reflection on the First Semester with Team Teaching using SCL

On the first day I began my new academic life in the middle of the semester, I had only a very brief meeting with the lecturer I would be partnered with for the semester and had to join the class immediately after the meeting. The Introduction to Engineering (ITE) class offered to first year first semester Chemical Engineering students in the university is mostly conducted using the SCL method. Upon entering my first class, I was confused watching the students teach each other during the class. From my perspective, the other lecturer barely did anything beyond facilitating the session and offering some additional and conclusive comments after the students had finished presenting. I would later learn that this particular class session engaged the students in presenting their peer teaching notes, a method that requires students to delve into the learning material, seek additional resources and then relay their findings to their peers. The students have actually prepared and learned the particular topic before the class, and what I saw was the students teaching their fellow classmates what they had learned. This method has been shown to enhance metacognitive skills as well as lifelong learning (Stigmar, 2016).

Given the large number of Chemical Engineering students in the department, the students are divided into five sections, where each section is taught by two lecturers. However, unlike other subjects in the department, the lecturers in all five sections of ITE work as a team to plan and carry out the planned lessons in parallel. This allows us to conduct a complex problem using Cooperative Problem-Based Learning (CPBL), where students solve problems with different levels of difficulty using various resources deemed appropriate (Rodríguez González & Fernández Batanero, 2016). In the case of ITE, an extensive and broad problem based on a current sustainability issue is given to the students. This complex problem is broken down into three stages, some of which students solve using Cooperative Learning (CL). Students are assigned to groups at the beginning of the semester, using diversity as the factor in assigning students to each group, as recommended by Block & Guerne (2021). The stages, while broken down, are still complicated enough that students need to work together in order to complete the tasks at every stage, hence fulfilling the definition of CL (Antov et al., 2017).

While the sustainability problem, as well as many other elements in the ITE subject are coordinated together between the team of lecturers, each section does have some leeway in carrying out some parts of the classes. Most notably is the Basic Engineering Calculations portion of the subject, which I was put in charge of. Being completely unfamiliar with SCL, I delivered these lectures using the TCL method. I did challenge the students by asking them questions and inviting them to share solutions to activities in class, which engaged them in Active Learning (AL) as mentioned by Hernández-de-Menéndez et al. (2019). Even though the AL activities were not as imaginative or advanced due to my lack of knowledge or experience on the method, the students, who were already used to actively participating in class through SCL in the first five weeks of the semester before I joined the university, responded positively to the activities. The students were noticeably very proactive and engaged in the lessons, responding and discussing the topic in the class chat without prompting, which is something that I rarely saw in a student, even during my own time as a student when classes were conducted face-to-face, not online.

The ITE subject is integrated with another subject which I was also in charge of, called Industrial Seminar and Profession (ISP). The latter subject invites stakeholders to deliver seminars to the students as well as bring them to site visits, so that students are given the opportunity to hear from people in the industry themselves. These courses are integrated based on constructive alignment, so that the course and program outcomes can both be achieved, while the ISP subject acts as one of the resources from which students can draw from for their CPBL activities in ITE, as described by Zakaria et al. (2020). One of the assessments for the ISP subject is reflection journals, in which students need to reflect on the activities, processes and assignments from the two subjects. These reflection journals gave me a lot of insight into their progresses and struggles, especially regarding SCL, which many found to be time-consuming. However, they also shared numerous parts of the classes that they had enjoyed, and overall the students found the subjects to be useful despite the workload. Additionally, from these reflection journals, I could perform my own reflection on the things that the students have taken away from the classes and most importantly, how I can improve as a lecturer.

Aria's Experiences and Reflection on the Second Semester with Individual Teaching using TCL

Whilst still struggling to adapt to the new academic environment and preparing for the new subject that I would have to teach in my second semester, the new semester arrived abruptly, and the two-week semester break left me with barely any time to put together a good teaching plan for my second semester. At this point, I had joined an AL workshop, which gave me a clearer understanding of the concept. However, due to my own time management and inexperience in drawing up an SCL teaching plan, I did not manage to plan for the Transport Processes (TP) subject that I would teach in the second semester. It was then that I realised how important it was to properly plan a class that uses the SCL method. Even without utilizing the more advanced CL and CPBL methods, incorporating only AL in the class is not as simple as throwing random activities during the classes. According to Hernández-de-Menéndez et al. (2019), the activities need to be designed with the intended benefits in mind, so that the learning outcomes are well defined. The deployment of these activities also needs to be planned for the course of days, or hours. Not knowing that employing the SCL method would require this much planning at the time, I attempted to do some AL activities in the TP classes, but was not able to sustain it for long and eventually reverted back to the TCL method, which does not require as much planning, and is easy and familiar to me.

The few AL activities that I conducted during the first few classes were very simple ones, which mostly used a user-friendly online tool. These activities received moderately active participation from the students, in large part due to the fact that students could remain anonymous in their answers. Indeed, several studies show that many students are afraid of being wrong before their peers and instructors (Cooper et al., 2018; Lucke et al., 2017; Stehling et al., 2016). However, other than during the activities, most students remained passive during classes and rarely sought me out outside of class for deeper understanding and clarification until the end of the semester to plead for higher marks. This alluded to the low level of understanding and motivation that the students had, as many did not perform well in the class, and their inactivity in seeking out knowledge in the subject, both during and after classes. Due to the greatly diminished participation and feedback from the students, I did not feel the satisfaction that I experienced when conducting classes using the SCL method in the previous semester.

An important aspect worth noting for this TP subject is that while the students were also divided into different sections with different lecturers, just like in the ITE class of my first semester, the TP lecturers rarely conversed with each other regarding the subject. There was never a discussion between the lecturers. While there was a common project for all the students for the subject, managing the execution of the project was left to each individual lecturer. Some lecturers broke the project down to simpler, more manageable tasks, while others gave the students the whole project at once. Moreover, various information regarding the subject is sometimes given quite late during the semester by the subject coordinator, which did not give the new lecturers a chance to plan the subject properly. In hindsight, the common project, which is a cornerstone project, would have been perfect to be conducted using the CPBL method. However, I was only informed about the project in the middle of the semester. Implementing CPBL requires following a structured series of steps which would guide the teams of students to form functional learning teams, as described by Yusof et al. (2016). However, the development of functional learning teams takes time. Thus the process should have been started at the beginning of the semester. By the time I was informed of the common cornerstone project, the semester was halfway over, therefore, I was not able to conduct the project using the CPBL method. All these are a clear contrast to the ITE subject implementation in my first semester, where constant discussions occurred throughout the semester, and meticulous planning of SCL method implementation by all the lecturers allowed for a detailed teaching plan to be developed and carried out without putting the burden of planning onto a single lecturer. Clearly, the SCL method offers many advantages over the TCL method, but would require a deeper commitment and understanding to implement.

Finn's Experiences and Reflection on Individual Teaching using TCL

My journey into academic life began toward the end of a semester. I was not assigned to handle any classes on my own, but was tasked to help out in a laboratory subject. The lab sessions were handled in a remote learning environment, which was a totally new experience for me. My expectation of a remote laboratory is based on contemporary computer technology to simulate a real working environment as discussed by Stefanovic et. al (2011). Interestingly, in this lab session, the students controlled the experiments remotely whilst viewing the changes in the system live through an online meeting platform. During the short period of time, I observed frequent hiccups in communication and lag time between the lecturer's instruction and execution by the students. This experience then became my first impression on remote teaching. I expected that the students were having difficulties in comprehending the subject matter efficiently as they could not interact with the system directly. Thus, I planned to handle my future class one step at a time to ensure that students are able to follow the subject closely. I understood that I should not cut corners as the probability of misinformation is high (Carillo, 2019).

Within two months of entering academic life, I was entrusted with handling two classes on my own. One of the classes was Numerical Method and Optimization (NMO). A week before classes started, all lecturers who taught NMO were called to a meeting to discuss the course information and assessments of the subject. I was stunned for a moment as the discussion was centered toward the general direction of the subject and division of tasks for assessments. Lecturers were given freedom to carry on the classes as they see fit, as long as all the course learning outcomes are fulfilled. There was a minimum scaffold provided as a guide for new lecturers to handle the subject. As a new academician, I was hoping for a guideline that could cover the classroom time management, pedagogy methods, complexity of question and assessments. Lackner et. al (2014) summarized a few items to be addressed in preparing guidelines for massive open online courses such as main issues in planning, course structure, learner's expectation, media resources utilization and others. Availability of the guideline could be very useful for a new lecturer to plan their classes effectively. However, I am grateful that most of the lecturers were willing to answer my uncertainties and shared some lecture notes.

In-class experience of handling NMO class was monotonous throughout the class session. I implemented step-by-step teaching as planned based on previous observations. By the end of each class, I asked whether the students understood and if they were able to follow through the lesson. Few feedback from students indicated understanding of the subject matter. However, the majority of the students did not respond to the feedback. Similar situation could be noticed during the class session. When students were asked to give an opinion, only a handful would respond. And on occasion, some were not responding even when their names were called.

It finally dawned on me that I have conducted the class mainly using the TCL method after joining the AL workshop. The students were able to grasp the knowledge that was given, however, the attention span of the students was hindered via the meticulous step-by-step approach. Previous research also suggests instructors can encourage class motivation by manipulating their interest (Harnita, 2018). Later toward the end of semester, I attended a workshop on problem based learning and was exposed to many more teaching techniques that were available in order to ensure active participation from the students. Although I felt overwhelmed by all the complex activities that require a lot of preparation, I was also excited to conduct an engaging classroom session. Towards the end of semester I had successfully implemented group work that required students to mentor their peers, and the responsiveness of the class seemed to be improving.

Finn's Experiences and Reflection on Individual Teaching using SCL

Another subject that I was tasked to teach during the semester was Process Control and Instrumentations (PCI). This subject is a core chemical engineering subject with four credit hours that was offered to third year students. Indeed, the subject was detested by the students as many of the students struggled to cope with the materials. Common criticism includes that the CPBL teaching method is complex and confusing along with high workload. As a new lecturer, I was overwhelmed by the weight of the task at hand. In seeking consolation about the matter, I consulted a few senior lecturers, some who have experienced teaching the subject along with some senior students. The feedback that I received shattered my confidence. I doubted myself to be able to handle a CPBL classroom. However, among the feedback, some students sang praises for the improvement brought by CPBL as they were experiencing deeper engagement and understanding. Thus, it became clear that the lecturer plays an important role to facilitate engaging discussions and promote deeper understanding.

I was astonished by the team of lecturers that taught this subject. Early meetings were conducted a few weeks before class session began. I was briefly introduced to the CPBL techniques and its implementation in the PCI subject. Utilizing the CPBL techniques encourages students to work interdependently in a small team to overcome hurdles. This later became the foundation of the continuous learning community (Yusof et. al., 2011). Interestingly, the CPBL model, generally in engineering and especially in PCI has been continuously developed since late 1990 until recently (Woods, 2000; Yusof et. al., 2011; Hisham et. al., 2018). In order to encourage active students participation, early and detailed planning of the activities are needed. Even during the first meeting, a draft of activities were presented which covers the topics and planning up to mid semester break. The draft was improved upon discussion and finalized before sharing between the lecturers. It was a big relief for me to have some guidelines to rely upon when handling class. This method should be applied to different subjects as well, as a guideline and not compulsory to follow point by point. It would be very helpful in order to ensure all sections are being taught at the same level.

The first two weeks of handling CPBL class turned out to be a rocky situation. Although the teaching plan was laid out, the preparation work was still overwhelming for a new lecturer. In order to conduct a CPBL course effectively, the lecturer needs to be fully familiar with the subject matter (Sendag & Odabashi, 2009). Direction of students' learning could easily diverge and the students' doubts were open ended. Feedback from students indicated that they were confused about the direction of the class. To overcome this problem, I requested to join other lecturers' classes to increase my awareness of the student learning direction. The initiatives were continued throughout the semester, and thankfully I was able to facilitate the class towards self sustaining learners with proper boundaries. Contrary to the other subject I taught during the semester, the CPBL method seemed to be complex but guided. NMO classes offered more freedom in designing the class with easier to understand material, however, at the back of my mind, I always doubted the level and quality of teaching provided. I found it difficult to gauge the extent and depth of teaching needed to be done in each class.

Students' engagement in the SCL class was also at different levels as compared to in the TCL class. Students started in a similar situation, where limited resources were recorded in the beginning. However, throughout the course, more students were volunteering to contribute their ideas as they had experienced multiple peer teaching and presentation activities. Overall, the level of engagement and responses from students made all the efforts poured into preparation worth it.

Discussion

Considering the experiences and reflections of both Aria and Finn, it is clear that both of us regarded the SCL and TCL methods to be vastly different methods of teaching. Both typically require different levels of involvement by the lecturers, and allow for varying levels of problem and task complexity presented to the students. Table 1 summarizes the differences between SCL and TCL methods from our viewpoint as new lecturers, as well as from the students' viewpoint, in our opinion. The extensive planning required to implement the SCL method is better done as a team to lighten the burden but may be difficult if the lecturers involved do not share the same line of thinking. As the lecturers also work as a team to design an SCL teaching plan, a similar phenomenon called "storming" (Mocko and Linnerud, 2016) that can be seen in a team of students could possibly happen within a team of lecturers as well. We were also unfamiliar with the SCL method, and the lack of knowledge and experience in this method were highlighted when neither of us could sustainably implement the SCL method when teaching individually without a team to support them. Clearly, more training and personal practice are needed so that new lecturers can properly plan and confidently execute the SCL method.

Table 1. Differences between SCL and TCL

Perspective	Student-Centered Learning	Teacher-Centered Learning
Lecturers	Guided in a team of lecturers	Open ended depending on individual lecturer
	Unfamiliar approach	Familiar approach
	Complex problems to prepare	Easier problems to prepare
Students	Deeper understanding	Surface understanding
	Authentic problems	Non-authentic problems
	High level of engagement	Low level of engagement

Even without taking the unfamiliar SCL method into account, as new lecturers, both of us had other challenges to face. The first is one that most, if not all, new lecturers would encounter; recalling and remastering subjects that they have learnt many years ago. As lecturers in engineering have obtained their doctorate, several years would have passed since learning the subjects that they need to teach as lecturers themselves. While this is not impossible to achieve, it can be a challenge for new lecturers to recall and prepare resources for teaching purposes in the classroom almost immediately after beginning their academic career. Other than that, not all lecturers are accustomed to or comfortable with giving lectures. Therefore, controlling the voice, maintaining eye contact with students, and using the appropriate body language can make some lecturers self-conscious. These new lecturers may also feel anxious of being corrected by students. Some new lecturers may need more time to adjust to this than others.

In this case, we had begun our new academic lives during the COVID-19 pandemic, which posed challenges that even veteran lecturers struggle with. As noted by Ali (2020), information communication and technology (ICT) tools are vital to properly conduct online learning, the learning mode that has become essential during the pandemic. They also concluded that lecturers need to be able to use these tools effectively in class, and herein lies the crux of the problem. Many lecturers are unfamiliar with the ICT tools necessary for presentation and conducting classroom activities, resulting in classes disrupted by technological issues and lecturers resorting to TCL to avoid the complexity of using ICT tools. A study by Ahshan (2021) stated that the SCL method is effective in increasing student engagement, but also acknowledges that student engagement decreases in an online learning environment. After all, good practices include interaction among students, interaction between lecturers and students, as well as active learning, so that students can attain positive academic and personal development (Qiu, 2019). The effect of the absence, or a less effective version of this due to the inability to interact physically is exacerbated by students' varied personalities, especially those who are shy, reserved, and unresponsive. The institution, if made aware of these issues, can take preventive or corrective measures to alleviate the problems, especially for new lecturers.

After reflecting upon their experiences during their first two semesters as new lecturers, we were able to reflect on our shortcomings and the consequences of our styles of teaching. With these reflections, we were able to devise better plans as we continue our journeys as lecturers. As discussed before in the Reflection Section, early preparation is key to conducting classes using the SCL method. The use of this method is desirable, as it has been observed by both lecturers to promote student engagement and deep learning, as stated by Ali (2019) and Qiu (2019). To ensure effective SCL method planning can be done following constructive alignment, knowledge and training on SCL method are also necessary for the new lecturers, which can be attained through workshops and literature review. Moreover, practical knowledge by personally implementing the SCL method and seeking guidance from lecturers with more experience in the SCL method is key to carrying out the SCL method effectively and continuously. In addition to boosting knowledge and experience on the SCL method, knowledge, skills and experience in using ICT tools are also necessary for online classes. This reflection is closely related to self-determination theory. We can become self-determined when we master the subject matter, making connections with the students and being in control of our own behaviour (Gagné and Deci, 2005). If we are able to overcome the hurdles, we believe that we would observe a notable improvement in students' engagement and performance, as well as personal satisfaction and development of the lecturers.

Conclusion

Although both of us are new lecturers who are academically qualified, we experienced many challenges that are typical for many new lecturers embarking on their new academic careers. As students, we have only been exposed to the TCL method of learning, and had our first encounter with the SCL method after starting as new lecturers. The experience was jarring, and neither of us could implement the SCL method on our own due to lack of knowledge, support and experience. The regression back to the TCL method showed a difference in students' engagement and satisfaction in teaching as a result, concluding that the SCL method could augment students' engagement and performance, and consequently bring more satisfaction to the lecturers. Other than the gratification for the lecturers, most importantly, students can greatly benefit from the implementation of the SCL method, due to higher level of engagement, deeper understanding of the material and exposure to authentic problems, to name a few. Our reflections on experiences with different methods of teaching, as well as challenges that new lecturers usually face, including the added challenges of online classes, led us to devise some action plans to improve our styles of teaching in the future.

Acknowledgement

This section is used to acknowledge people who have aided authors in accomplishing the work presented as well as sources of funding.

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Validity and Reliability of Green Competencies Instrument for Automobile Technology Programme Using Rasch Model

Article history
Received
10 November 2021
Received in revised form
9 December 2021
Accepted
9 December 2021
Published online
28 December 2021

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Abstract

This article aims to determine the validity of developed constructs and check the reliability of the newly developed instrument named as Questionnaire on Green Competencies for Automobile Engineering Technology (QGCAET) for the Automobile Technology Programme in Nigerian Universities. The instrument consists of 170 elements measuring four constructs namely Technical Green Competencies; Managerial Green Competencies; Personal Green Competencies and Social Green Competencies and was administered to 299 respondents made of Lecturers, Technologists and Final- Year Students of Automobile Engineering and Technology programme in Nigeria universities. The Rasch model was used to examine the validity and reliability of the items. From the analysis point of view, the polarity of the elements indicates that the correlation of the point measure (PTMEA CORR) of 170 elements of green competencies is between 0.00 and 0.55. The summary statistics show that the reliability of the items and the separation of the items of the green competencies instrument are 0.98 and 6.46, respectively. Similarly, the item reliability of each construct is between 0.96 and 0.99, and the reliability of the person is between 0.79 and 1.97, respectively. In terms of item fit statistics, a total of 157 items are found to be fit to achieve the objectives of the study. The result also indicates that the range of fit for the four (4) identified green competencies constructs is between 0.61 and 1.49 signifying that all the constructs are in harmony in measuring the items in the constructs, so suitable in achieving the objectives of the research.

Keywords: Rasch Model; Sustainable Development; Green Competencies; Automobile Technology Programme; Validity: Reliability.

Introduction

Environmental pollution and other climate trends are bringing about damaging effects such as rise in sea level, persistent drought and changes in the weather pattern. These results of this changes have adverse effects, especially on sustainable development in terms of economic and social activities all over the world (Heong, Sern, Kiong, Mohaffyza, & Mohamad, 2016). Approaches such as the transformation of the economy to encompass sustainable development were the long-term practical measures taken by many developed countries like Japan, Germany and Britain to alleviate these environmental challenges. Industries are moving towards the use of non-polluting, low carbon emission materials, to a more efficient manufacturing process with limited use of unrenewable energy. The efforts to change the economy to a green economy model is making a rapid significant change in workforce demand in the labour market. Some entire new green jobs have been created in the industries and efforts are on going to transform the existing jobs in the industries to accommodate green concepts. For instance, in the automobile industry, engineers require green competencies to work with latest technologies in fuel-efficient green automobiles. The change of skill required in the opinion of Heong et al., (2016), is, pervasive, a general trend and it calls for a huge effort to revisit the programmes offered by the training institutions to embed “green” elements into the training curricula, because “green” job specification requires “green competencies” for effective production.

For this reason and in recent times, Adzmi et al. (2018) highlighted that, for greening the economy, attention was focused on green competencies in which industries and other firms introduced several ways to train their workforces for green practices. Consequent upon, factors like world economic downturn and ecological problem which automotive products are one of the contributing factors to the later pose many countries in the world to adopt the transition to greener economy by embedding green competencies into various occupations. More so, as a result of the authentication that follows the agreement on the green economy by world leaders during the Rio+ in June 2012, Nhamo, (2014) reported that the world is ready to apply the greener economy as a basis to achieve sustainable development, eliminate poverty and inequality and create jobs.

Accordingly, Strietska- Illina et al. (2012) reported a study conducted in 21 countries by ILO, which represent per cent of the world population indicated that economies shifting to greener production can create more jobs, if they deal effectively with the upcoming structural change and transformation of the existing jobs. Hence, the pace of competencies needs and change in labour markets is increasing by the shift to a green economy. With regards to this, Stroud, Fairbrother, & Evans, (2015) stated that, transformation to a green economy will not only produce new jobs but will also alter the scope of the current jobs. Stating further, Stroud et al., (2015) emphasised that green competencies that will match the green jobs will involve a review of the current curriculum of educational programmes, requirement standards and teaching programmes, retraining of instructors and trainers. To this effect, UNESCO, (2012a) also informed that sustainability cannot be achieved only by technological solutions or financial instruments but by changing the way people think and act. In other words, through education. This means that employers and trainers should work together on these changes. Therefore, these changes clearly show the need to link the green economy to sustainable development via developing green competencies in Automobile Engineering and Technology programme in Nigeria. The developed competencies set needs to be measured to assure its trustworthiness to fit as relevant green competencies for automobile technology programmes in universities in Nigeria. This current study addressed this issue.

To further stress on UNESCO's assertion, Acedo, 2014; Chikwendu, Okoroji, Ikeogu, & Ejem, (2018) shows that sustainable development cannot be achieved without education and without adequate relevant green competencies for jobs, with particular reference to the automotive sector. While Nigeria is lagging in global sustainability in most of the sectors of economy according to Uzoma, Nnaji, & Nnaji, (2012), the development of green competencies to increase the productive chances of students in workplaces becomes vital and essential as it helps in greening the economy. This calls for a proactive need to include green competencies into the educational programme curriculum in universities in Nigeria, especially, engineering education to enhance the chances of sustainable development in the nation Nigeria. Engineering and Technology Education has been exemplified by the great economies of the world as the engine room for the technological and industrial advancement necessary for economic and national development. The notion of engineering education according to Ekpobodo, (2014), is to prepare students' broad knowledge of new technology through engineering skills profession. Ekpobodo's opinion aligns with the submission of Borhan, (2012), who also emphasized that the aim of engineering education is to equip engineering education graduates with adequate knowledge and skills through the use of PBL. Engineers are visionary people who create things by making use of technology to integrate our environment and develop oneself and others. Engineering education simultaneously play an active role and contribute to sustainable development by creating learning environments for students. In Nigeria, Automobile Engineering and Technology Education is offered as one the engineering education programs. It is taught at both Universities and Polytechnics, and one of their specific goals is to: provide the technical knowledge, skills and attitudes necessary for industrial, commercial and economic development as it relates to the changes in the demands of the environment.

Building on the above, a report by the FME, (2019) & Federal Republic of Nigeria (2015) hinted on the thought of the need to integrate the principles of sustainability into the country's policies and programmes in a bid to achieve the goal of millennium development goals on sustainability (MDG). To prove their level of seriousness and importance placed on reversal of natural resources, a joint meeting between officials of the Federal Ministry of Environment and the Director of International Labour Organisation ILO in the capital city Abuja in 2016, was held to explore the possible avenues to create green jobs opportunities in Nigeria. The top agenda of the meeting was to develop three- year plan that would contribute to the creation of green jobs especially in production and manufacturing sectors, renewable energy and waste management (ILO, 2016). The effective realisation of this programme will however, require the integration of green competencies into the training programme to train competent personnel that will facilitate the running of green jobs, especially in the automotive sector. This study therefore developed a set of green competencies required to train automobile technology students in universities in Nigeria. The developed green competencies have to undergo screening processes to ascertain its validity and reliability, that is what the use of Rasch analysis in this study has helped to achieve.

Green Competencies

The International Labour Organization ILO, (2015) defined green competencies as, the technical skills, knowledge, values, and attitudes essential by the workforce to develop and support sustainable development in businesses, for industry and the society. In the same vein, Corral-verdugo, (2002) described green competencies to be comprised of two key elements, i.e., environmental knowledge and environmental skills, which need to be employed by the ecological requirement demanded by the society. In general, green competencies can be seen as sustainability competencies relating to the knowledge, values, attitudes and the technical skills needed in the workforce to support and develop sustainable development (social, economic and environmental outcomes) in various organisations and the entire community.

At this juncture therefore, having explained what sustainable development meant and the role that should be played for integrating green competencies concepts in terms of knowledge, skill and attitudes into the programme of automobile technology in Nigeria, it is pertinent to classify green competencies to be included into the automobile technology programme. With regards to the above, Pavlova, (2014) came up with the following description of green competencies, they include cognitive competencies (**Technical-** for example, environmental awareness and a willingness to learn about sustainable development, systems and risk analysis, skills to assess, interpret and understand both the need for change and the measures required, Innovative skills to identify opportunities and formulate new strategies to meet ecological challenges); Interpersonal skills (**Managerial-** e.g., coordination, management and business skills to promote holistic and interdisciplinary approaches covering economic, social and ecological goals, and to discuss conflicts in complex environments; Intrapersonal competencies (**Personal-** to help workers learn and apply new technologies and process adaptability and transferable skills required for green work, using low-carbon technology to provide Opportunities for entrepreneurial skills); and **Social** competencies- i.e Communication and negotiation skills for discussing issues of interest, marketing skills to promote products and more environmentally friendly services).

UNESCO (2016) recognised Technical Green Competencies (**TGC**) to include the following; knowledge of new materials, technologies, and energy efficiency to proffer technical solutions; knowledge cutting across energy issues, knowledge of automotive designs to adapt eco-friendliness, knowledge of automotive manufacture for environmental protection, quality standards; renewable energy legislation and environmental protection. Similarly, Gudanowska, Alonso, & Törmänen (2018) expresses that Technical Green Competencies provides an understanding of and proficiency in an activity, especially one that consists of methods, processes, procedures, or techniques; specialized knowledge, the analytical ability within that specialty, and facility in the use of the tools and techniques of the specific discipline. The above statement makes technical green competencies to be vital in both new and existing jobs.

Given the aforementioned and in aligning Technical Green Competencies to automobile engineering and technology programme, NUC-BMAS, (2016) have highlighted the relevance of technical competencies to the automotive industries. Being defined as the knowledge and enabling abilities required for prospective jobs in automotive industry, Technical Green Competencies include plant/ equipment operation, basic knowledge of sciences, automobile fundamentals, practical skills, service and maintenance, manufacturing and construction, automotive design. To add up to these facts, the United States Department of labour, (2016) have summed up the list of technical competencies for engineering education, defining it as knowledge, skill and abilities which are needed in various industry, its components are; engineering design, foundations of engineering, operation and maintenance, manufacturing and construction, sustainability, society & environmental impact, quality control & Assurance, Safety, Health, Society & Environment. They function more as critical work performance tasks.

Zolkifli, Kamin, Bin, Latib, & Buntat (2016) noted that the workforce in this era of green technology should have green competencies such as management skills, leadership, teamwork, problem- solving and decision making skills, which would allow them to be better people in their jobs and for jobs inclined to sustainability. Hence, Management can be seen as an act of planning, organising and coordinating the activities of an organization including directing the efforts of its employees to accomplish its objectives through the utilization of available capital, material, technological and human resources. To align managerial skills to green technology, Ploum, Blok, Lans, & Omta (2017) established that managerial green competencies (**MGC**) encompass an individual's abilities to create an efficient organization, team building, delegate responsibilities and capable of motivating others in a workplace. Ploum et al (2017) also mentioned strategic thinking, leadership and planning, project management and team management as important green competencies needed for green jobs.

Personal green competencies (PGC) are among the green competencies suggested by researchers that are required to combat the range of sustainability challenges in the economy, the environment and society. Defined by Kolmos, Hadgraft, & Holgaard (2016) and Gudanowska et al., (2018) as the set of competencies that portray the ability of an individual to be conscious of their values; adhere to professional ethics; plan their career path; reflect on experience; improve their future practices and engage in lifelong learning. Described by the United States Department of Labour (2016) as foundational competencies that covers a group of competencies, and apply to multiple career fields, personal effectiveness competencies are practical capabilities such as interpersonal skills, initiative, adaptability & flexibility, dependability & reliability, lifelong learning, teamwork. Others include; self-reliance, creativity, problem-solving and decision making skills and integrity/ honesty. The department further emphasized that personal effectiveness competencies are generally learned in the home or community and are refined over a while at school and in the workplace.

Social Green Competencies (**SGC**) are any set of competencies that facilitate interaction and communication with others where social rules and relations are created. Several researchers such as Kolmos et al (2016); Ploum et al, (2017); Gudanowska et al., (2018) believed that social competencies are vital in building a relationship between an organisation and customers, and also enhance cooperation and exert influence within the cooperation. Regarded in some instances as a transversal skill, it embraces competencies like self- discipline, enthusiasm, perseverance, self- motivation, compassion, integrity and commitment. Others include global awareness, respect for diversity, conflict resolution and respect for sustainability, marketing skills and communication skills. These identified four (4) Green Competencies constructs with several items that make up the study instrument shall be tested to ascertain its validity and reliability.

Validity and Reliability Using the Rasch Model

Validity refers to the degree that a developed test instrument can accurately estimate a quantitative data. In this manner, determining the accuracy of a test tool can guarantee the effectiveness of the sample study (Yasin, Yunus, Rus, Ahmad, and Rahim, 2015). In the interim, reliability is the extent in which research test instruments can be expected to get a consistent result when repeated or perform consistent outcome when replicated (Rachman and Napitupulu, 2017). Rasch model methodology is attempted to look at the legitimacy and unwavering quality of the instruments utilized. Lately, the model Rasch is likewise described as Theory of Item-Response (IRT). It has been giving an alternative means of understanding the estimated measurement and also procedures for appraising the quality of a test instrument or questionnaire (Othman, Salleh, Hussin, and Wahid, 2014; Yasin et al., 2015). Applying Rasch Models may positively produce a valid and reliable quantitative data tool. Rasch Measurement Model likewise can prove the validity and reliability of a test instrument to a great extent. This is on the grounds that the utilization of Rasch Model gives an answer to any problem pertaining to validity of an instrument and also tenders valuable measurements and provides an uncommon chance to explore the validity of the instrument (Linacre and Linacre, 2008; Rachman and Napitupulu, 2017). Moreover, the Rasch model application in an investigation can work with and give more productive, solid and substantial measurement instrument. A study to recognize the validity and reliability of the quantitative data tool is vital to keep up with the exactness of the test tool (Othman et al., 2014). It is important to guarantee that the instrument can accurately estimate a quantifiable data.

Referring to this technique, Bond, (2010) specifies that Rasch models can be utilized as a strategy to develop new assessment instrument, evaluate an already existing test instrument and also to provide construct validity evidence of an assessment instrument. Linacre and Linacre, (2008) drew out five fundamental steps of the analysis employing the use of Rasch model. They are calibration/ alignment and estimation/assessment of abilities of items; the item polarity within the limits of the Measurement Model; the capacity of the items and instrument to function; establishing the relationship between the items and the respondents, likewise to items and respondents Infit/ Misfit. In view of this, the utilization of Rasch model in the validation of this instrument is to provide an evidence of the validity of the constructs in the QGCAET instrument, create more comprehensive data concerning the test instrument and bring out the meaning of the measured items. The criteria for reliability and the values for the Cronbach Alpha as it guides the study is found in Table 1.

Table 1. Rasch Model Benchmark for Reliability and Validity of Instrument

Criteria	Statistics Data	Minimum Requirement	Source
Validity	Item Polarity	PTMEA CORR >0	(Bond, 2010; Bond, Fox &Lawrence 2001)
	Infit/ Outfit	Infit and Outfit Mean Square (MNSQ) limit of 0.6 – 1.4 for Polytomy Data Z-Standard (ZSTD for -2 to 2)	(Bond, 2010)
	Separation Index (SE)	Items shows ≥ 2	(Bond & Fox, 2015)
Reliability	Person Reliability	Value > 0.8	(Bond & Fox, 2015; Rachman & Napitupulu, 2017)
	Item Reliability	Value > 0.8	(Bond & Fox, 2015; Rachman & Napitupulu, 2017)
	Cronbach Alpha	Value > 0.7	(Bond & Fox, 2015; Creswell, 2014; Creswell & Creswell, 2018)

Research Method

In this Quantitative study, the determination of the Green Competencies for Automobile Technology program was acquired by utilizing Questionnaire on Green Competencies for Automobile Engineering Technology (QGCAET). The instrument was designed to address the Green Competencies that are relevant for Automobile Technology programme in Nigerian Universities. Being a Five-Point Likert scale instrument with response rating of Not Relevant NR(1), Slightly Relevant SR(2), Moderately Relevant MR(3), Very Relevant VR(4) and Highly Relevant HR(5). The instrument comprises of four constructs, with a sum of 170 items. There are 70 items in the Technical Green Competencies construct (TGC), 50 items in the Managerial Green Competencies construct (MGC), 34 items in the Personal Green Competencies construct (PGC), and 16 measurement items in the Social Green Competencies construct (SGC). Examples of items for each constructs are as shown in Table 2.

For this reason, the instrument that is utilized to acquire the necessary information ought to be validated. The testing of the instrument is understood to be essential. This study plans to validate the instrument and measure its reliability by utilizing the Rasch model. By utilizing the model, the constructs built in QGCAET and their connected assessment can be evaluated in terms of consistency, dependability, and precision. The validity and reliability tests are performed on these key features of Rasch Analysis: (i) test reliability and the separation of the items and the respondent, (ii) recognize the polarization of the items measuring the constructs, and (iii) test the fit/ conformity of the items in the instrument (Linacre and Linacre, 2008). To achieve these, the procedures of using Rasch model to test validity and reliability are as follows: (i) calculate the reliability index of the test and the degree of separation between the item and the respondent, (ii) calculate the polarized PTMEA CORR value of the construct-based measurement item, and (iii) Calculate the fitness or conformity of instrument items developed based on MNSQ and ZSTD values (Bond and Fox, 2015; Rachman and Napitupulu, 2017). The Rasch model considers the potential of the respondents to respond to item questions and the difficulty level of the items itself. Item suitability analysis (item fitting) evaluates whether the instrument items can measure what they should measure. When an item is inappropriate, reframing or total removal of the item is considered. The benchmark for establishing the effectiveness and trustworthiness of the instrument are shown in Table 1.

Table 2. Excerpts of constructs and items from QGCAET

	Items	Responses				
		NR (1)	**SR (2)**	**MR (3)**	**VR (4)**	**HR (5)**
Technical Green Competencies	**Basic Sciences**					
	Knowledge of General Chemistry					
	Alternative Energy					
	Knowledge of application of alternative energy- Biofuels, Biomass, Ethanol					
	Waste Management					
	Ability to select and use recyclable materials & products to minimise waste					
Managerial Green Competencies	**Communication Skills**					
	Ability to Communicate with people from various background					
	Entrepreneurial skills					
	Anticipate technological developments by interpreting surrounding, societal & economic trends					
Personal Green Competencies	**Creativity & Innovative skills**					
	Ability to design new products from scraps					
	Adaptability & Flexibility					
	Adjust to new ideas and changes					
Social Green Competencies	**Self- confidence**					
	Strong determination to complete task/ achieve objectives					
	Perseverance & Stress Management					
	Ability to work at extra hours					

The total number of the respondents are 299 and they are chosen by utilizing purposive sampling strategy. In the current study, the respondents are the Lecturers, Technologists and Final –Year students of the Automobile Technology Program in Five Universities in Nigeria. The students are in the fourth or fifth year of their study program and had undergone training in the required competencies in their various areas of specialization of engineering education. The analysis by the Rasch model was carried out by the use of version 3.72.3 of Winstep Software. The table of distribution of respondents and their institution is found in Table 3.

Findings and Discussion of Results

Person and Item Reliability and Separation Index

The statistics as analysed for the reliability and separation of items based on the developed instrument is examined in this part of the article. In Table 4, with 299 person measuring 170 items based on the quantitative instrument, the QGCAET instrument item reliability is 0.98 and item being separated at 6.46. This indicates that QGCAET instrument items could perhaps be categorized in 6 groups. Equally, the value for person reliability for the QGCAET instrument stands at 0.79 with separation of person value of 1.97. 1.97 value is a demonstration that the respondents' ability to answer the questions in the instrument can be classified into 2 groups. Person reliability interpretation measured against Alpha Cronbach (KR-20) produced a score of 0.82 which is slightly higher than the person reliability. Table 4 itemizes the obtained item reliability and separation index for each constructs in the QGCAET instrument. Item reliability value as indicated for a good number of the constructs is above 0.7 (0.96-0.99). These values indicate a high level of acceptability of each of the constructs (Bond & Fox, 2015). The item separation ranges from 4.85 to 11.30. Majority of the item separation indexes are equal or greater than 2, hence, considered as highly valid for Rasch model. Similarly, Table 5 and 5.a provides the statistical summary of instrument reliability of items and person measured for extreme and non- extreme value. Table 6 tabulates the summary of item and person reliability and separation based on real root mean square error.

Table 3. Distribution of Respondents of the Study

S/N	Institution	No of Lecturers	No of Technologists	No of Students
1	Abubakar Tafawa Balewa University - **ATBU**	16	7	60
2	Federal University of Technology Minna – **FUT- Minna**	13	6	47
3	Modibo Adama University of Technology Yola- **MauTech**	15	7	48
d4	Benue State University Makurdi –**BSU**	13	5	25
5	Elizade University Akure **EU**	10	4	23
Total	5	67	29	203
Grand Total	299			

Table 4. Item/ Person Reliability and Separation Index for QGCAET Instrument

Constructs	Total Items	Item Reliability	Item Separation Index	Person Reliability	Person Separation Index
Technical Green Competencies	70	0.96	4.85	0.74	1.69
Managerial Green Competencies	50	0.99	11.30	0.72	1.02
Personal Green Competencies	34	0.99	8.97	0.69	0.83
Social Green Competencies	16	0.99	8.52	0.66	0.52

Table 5. Summary of Item and Person Reliability from QGCAET Analysis Table Summary of 299 measured Person

	Total Score	Count	Measure	Model	Infit		Outfit	
					MNSQ	ZSTD	MNSQ	ZSTD
Mean	508.5	108.0	3.74	.22	1.01	.0	1.00	.1
SD	11.1	.0	.52	.03	.23	1.3	.28	1.2
Max	525.5	108.0	4.69	.29	1.61	2.9	1.69	2.6
Min	474.0	108.0	2.47	.17	.65	-2.4	.54	-1.9

Real RMSE .24 True SD .46 Separation 1.97 Person Rel. - .79
Model RMSE .23 True SD .47 Separation 2.06 Person Rel. - .81
SE of Person Mean - .03
Person raw Score-to-Measure Correlation - .98
Cronbach Alpha (KR-20) Person Raw Score "Test" Reliability- .82

Table 5.a. Summary of 99 Measured Item

	Total Score	Count	Measure	Model Error	Infit		Outfit	
					MNSQ	ZSTD	MNSQ	ZSTD
Mean	1399.9	299.0	.00	.14	1.06	.1	1.00	-.2
SD	83.5	.0	1.06	.05	.34	3.3	.31	3.1
Max	1485.0	299.0	3.48	.32	2.02	8.6	1.90	9.1
Min	990.0	299.0	-2.23	.07	.44	-9.0	.41	-8.6

Real RMSE .16 True SD 1.05 Separation 6.46 Item Reliability - .98
Model RMSE .15 True SD 1.05 Separation 6.89 Item Reliability - .98
S.E of Item Mean = .11
Global Statistics:
UMean - .0000 USCALE = 1.0000

Table 6. Summary of Item and Person Reliability and Separation based on Real Root Mean Square Error

Item Reliability			Person Reliability		
No of Items	Reliability	Separation	No of Persons	Reliability	Separation
170	.98	6.46	299	.79	1.97

Item Polarity

In this part of the article, the effectiveness/ validity of the items is measured by the Point Measure Correlation (PTMEA CORR). Described as the rate of the instrument element polarity (item polarity). The polarizing items inspection is designed to determine if the constructs have been drafted to attain the goals of the study. If the PTMEA CORR value is positive (≥ 0), the item is said to measure what it should measure. On the contrary, a negative (≤ 0) value of the item is an indication of the inability of the item to measure the variables it was designed to estimate, hence, the item need to be revisited and/ or taken out as the case may be. This is because the item is not in focus or it is difficult for the respondents to answer. As found in Table 7, the constructs had a favourable coefficient of correlation from the output of the result which therefore establishes the validity of the measured competencies regarding item ability. (Linacre & Linacre, 2008; Suhairom, 2016). There are no items that need to be dropped based on polarity requirement because items are moving in one direction with the constructs.

Table 7. Polarity of items on QGCAET Instrument

Constructs	PT-MEA CORR				Total Item
	Min	Item	Max	Item	
Technical Green Competencies	0.08	TGC11	0.55	TGC20	70
Managerial Green Competencies	0.00	MGC26	0.42	MGC34	49
Personal Green Competencies	0.00	PGC21	0.36	PGC27	33
Social Green Competencies	0.00	SGC7	0.43	SGC12	16

Table 8. Item Polarity Based on PTMEA CORR for QGCAET Instrument

Constructs	Entry Number	Total Score	Total Count	Measure	PTMEA CORR	Item
Technical Green Competencies	*11	1423	299	+0.04	0.08	TGC11
	**21	990	299	+3.11	0.55	TGC20
Managerial Green Competencies	*29	1495	299	-6.10	0.00	MGC28
	**36	443	299	+8.15	0.42	MGC34
Personal Green Competencies	*23	1495	299	-5.96	0.00	PGC21
	**30	1195	299	+3.17	0.36	PGC27
Social Green Competencies	*6	1495	299	-5.90	0.00	SGC7
	**14	1145	299	+2.53	0.43	SGC12

*Minimum Value ** Maximum Value

From Table 8, it can be shown that each construct (with two items result for minimum and maximum value) produced a favourable PTMEA CORR value. Thus, no item in the instrument was removed because they all have obtained the least requisite PTMEA CORR score of ≥ 0. Furthermore, from Table 8, Technical Green Competencies, that is, the item 21 (TGC20) having a value measured at +3.11 means that the respondents found it most complex to be approved, so also is item 11 (TGC11) is 0.04 pointing out that the item is the most uncomplicated to be attempted by the respondents. Similarly, item 36 (MGC34) for Managerial Green competencies with a measured value of +8.15 shows that the respondents found the item too complex for their ability in answering the question, whereas, item 29 (MGC28) measures value of -6.10 is the easiest item to be answered by respondents. The logit value for item measures Personal Green Competencies in item 30 (PGC 27) is probably the item the respondents finds most difficult, in like manner, item 23 (PGC21) with value at -5.96 was considered easiest to answer by the respondents. Lastly, item 14 (SGC12) on Social Green Competencies with a measured value of +2.53 points to the direction of the most difficult item considered by the respondents and its corresponding minimum measure value is item 6 (SGC7) measuring -5.90 is considered the easiest item approved by the respondents. The high- value of PTMEA CORR gotten from the results of the respondents delineates the different ability levels of the respondents.

Item Fit Statistics

The suitability and appropriateness of items often referred to as fit statistics or item fit is the value of the Infit and Outfit Mean Square MNSQ. The observation of the MNSQ value is developed based on the item (fitting) in the construct measurement. Based on some suggestions in literature (Bond, 2010; Linacre, Linacre, 2008; Rachman & Napitupulu, 2017); Rachman & Napitupulu, 2017) to ascertain the applicability of the developed items, the Infit and Outfit MNSQ parameters must be 0.5 To 1.5 (Linacre and Linacre, 2008) (for multi-point data) and 0.7 to 1.3 (for two-point data). (Bond and Fox, 2015; Rachman and Napitupulu, 2017). When determining the harmony of the elements of the construct, more emphasis should be placed on the MNSQ of outfit rather than MNSQ of Infit. If the result shows rate beyond the range of 1.5 MNSQ, it indicates a complex item structure or is out of focus. However, if the result shows that the logit value is less than 0.5, it also signifies that the respondents probably found the item to be simple and uncomplicated to be answered. (Linacre, 2012). Similarly, the Infit and Outfit ZSTD (z-standard) rate normally falls between the limit of -2.0 to +2.0. Notwithstanding, in case the values of Infit and Outfit MNSQ falls in the acceptable range, ZSTD value can be ignored (Bond and Fox, 2015; Suhairom, 2016).

Table 9 shows that the minimum and maximum Infit and Outfit MNSQ value for all the constructs met the requirements i.e 0.5-1.5 MNSQ range. It therefore means all the constructs are in harmony in measuring the items in the constructs, so suitable in achieving the objectives of the research.

Table 10 also shows that there are thirteen (13) items which have not met the requirement for the Infit and Outfit limit value of ≥0.5 or ≤1.5. six (6) of the items exceeded the limit value of outfit (≤1.5), while six (6) has not reached the minimum MNSQ value of ≥0.5. Likewise, Infit ZSTD value for item PGC16; SGC4; TGC31; TGC40; TGC55; PGC5 is obtained at a level significantly greater than (≥2.0), therefore, a review of the items for possible removal from the instrument and alternatively, for amendment of the items were viewed. However, in this study, a total of 157 items are found to be Fit based on the analysis of the Rasch Measurement Model hence, these valid items are maintained since they are able to achieve the objectives of the research, which is to measure automotive technology programme green competencies.

Table 9. Item and Person Fit Statistics for each constructs on QGCAET instrument.

Constructs	Item				Person			
	Infit MNSQ		Outfit MNSQ		Infit MNSQ		Outfit MNSQ	
	Min	Item	Max	Item	Min	ID	Max	ID
Technical Green Competencies	0.61	TGC66	1.48	TGC31	0.61	68	1.90	32
Managerial Green Competencies	0.73	MGC37	1.23	MGC41	0.49	39	1.81	43
Personal Green Competencies	0.65	PGC15	1.49	PGC18	0.37	17	2.23	20
Social Green Competencies	0.68	SGC5	1.46	SGC4	0.25	6	3.07	5

Table 10. Item fit for QGCAET Instrument

	Infit		**Outfit**	
Items	**MNSQ**	**ZSTD**	**MNSQ**	**ZSTD**
PGC28	0.75	-1.9	0.40	-3.7
PGC16	1.77	7.9	1.90	9.1
SGC4	1.68	7.3	1.69	7.5
PGC11	0.92	-0.2	0.38	-0.2
PGC22	0.92	-0.2	0.38	-0.2
TGC31	2.02	8.6	1.71	5.9
SGC11	0.76	-1.6	0.49	-3.1
TGC40	1.91	6.9	1.54	4.0
TGC55	1.92	7.0	1.58	4.3
PGC5	1.76	5.5	1.74	4.9
SGC6	0.76	-1.3	0.35	-3.4
SGC3	0.86	-0.6	0.44	-2.7
TGC42	1.54	3.3	1.43	2.4

Conclusions

The study draws the following conclusions:

1) The research instrument for determining the green competencies of automotive technology using QGCAET is highly reliable, standing at a 0.82 coefficient of reliability from Cronbach's Alpha benchmark requisite cut-off score of 0.7. In like manner, all the developed items have a high reliability and separation index of between 0.96 – 0.99. Therefore, this instrument could be replicated in another study following all the laydown procedures and standards and obtain the research expected outcome.

2) The value of PTMEA CORR for measuring item polarity is within the range of 0.00 and 0.55 for all items in the four constructs. Therefore, the effectiveness of the items was ascertained from its ability to quantify the unit variable it ought to measure. Hence, the instrument was able to achieve the objectives of the research.

3) The minimum and maximum Infit and Outfit MNSQ value for all the constructs met the requirements i.e 0.5-1.5 MNSQ range. However, 13 items have not met the requirement of the Infit and Outfit ZSTD Values. Their Infit and Outfit ZSTD range is above the defined threshold of -2.0 to +2.0. Based on the standard recommended as a solution to misfit items, the 13 misfit items can be deleted, or revised taking into consideration the objective to be achieved by the study. In addition, all the constructs are in harmony in measuring the items, so suitable in achieving the objectives of the research.

4) Employing the Rasch model, the outcome of the present study took a look at proposing that the instrument employed to determine the validity and reliability for measurement of the relevant green competencies for Automobile Technology programme within the framework of QGCAET.

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Ramblings of a Chemical Engineer: A Book Review

Article history
Received
9 December 2021
Received in revised form
17 December 2021
Accepted
17 December 2021
Published online
28 December 2021

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Abstract
Ramblings of a Chemical Engineer is significantly influenced by the author's personal experiences as a chemical engineer who has worked in a variety of chemical companies. It encompasses his college years, time as a university researcher, and professional career; it is told in a fast-paced way via a succession of vignettes that capture the highlights of the events that formed him into the professional chemical engineer he is today. It was his intention to present information about a profession in chemical engineering to potential students seeking degrees in chemical engineering. It also acts as a guide for aspiring chemical engineers and future engineers, emphasizing what they should aim for and how much fun this profession can be.

Keywords: chemical engineering, engineering student, process engineer, professional engineer

Ramblings of a Chemical Engineer starts with a foreword by Zaki Yamani Zakaria, academia and author of several papers on chemical engineering and engineering education. With several papers in engineering periodicals over the years, the author has established himself as a widely recognised and highly respected practitioner in the chemical engineering profession. He established Chemical Engineering World blog in 2006 because he recognized that there was a paucity of information or sharing about real chemical engineering careers, experiences, and exposure from practising engineers. Since then, he has used his blog to express his thoughts, opinions, and feelings about his numerous professional developments over the course of his career. He has examined his own professional growth trajectory, which began as a high school student and progressed to engineering school, then to becoming a practising engineer, and eventually to becoming a licenced professional engineer.

Ramblings of a Chemical Engineer is drawn heavily from the author's own experiences as a chemical engineer who has worked in research and development, the oil and gas industry, and the oil and fat industry. A foreword section also explains the authors' motivation for writing this book. He aimed to create a simplified version or a guide for engineering students and young engineers interested in chemical engineering. It was his desire to provide prospective students pursuing degrees in chemical engineering with information about a career in chemical engineering.

The book begins with an intriguing narrative of a chemical engineering student's educational path in the United Kingdom. Zaki has had a passion for chemical engineering since he was 14 years old, and he graduated with a bachelor's degree in Chemical Engineering in 1999. He offers a plethora of anecdotes that address the essential parts of students' lives that engineering students tend to find the most difficult to deal with in their studies. In this book, there was a sprinkle of humour, as well as a smattering of nice recollections recounted about being an overseas student in the United Kingdom. This book is an excellent human-interest narrative about a chemical engineering student who maintains a positive attitude throughout his education. He holds the view that everyone can learn anything if they are sufficiently motivated to do so. In order to succeed, one must put out the necessary effort despite the chance of failing. Perhaps most importantly, it is realising that making mistakes does not necessarily suggest that one has failed; rather, it signifies that one has the opportunity to learn and develop. Also, he emphasizes that a person's potential for growth is not limited by their own efforts. Rather than that, it is driven to manifest through effort. By choosing to cultivate a growth mindset, you are choosing growth over the fear of failure in life. If you believe you have the ability to improve, your "failures" will merely point you in the direction of a new path to success. Zaki encourages readers to take an introspective look at the type of student they aspire to be and demonstrates how having a growth mindset may help them reach the next level of achievement.

The following section of the book is based on Zaki's experiences as a master's and doctoral student at a local university. A brief background of his journey into the research and development field has been included. Given his enthusiasm for the chemical engineering knowledge, research is no longer a burden but rather enjoyable when he realised that he was working towards a worthwhile goal. He cherished every hour he spent in the laboratory and was grateful of the opportunity to learn from others in his social learning circle who were more experienced and informed than he was. He initiated the process of acquiring and absorbing new information, as well as developing intrinsic motivation to do so. Thomas Edison once claimed that genius is one percent inspiration and ninety-nine percent perspiration when it comes to reaching achievement. Perspiration entails more than just working hard; it entails working tirelessly and with great passion. His doctorate journey has made him more resilient and given him a positive outlook for the future. His journey would arouse and pique the interest of engineering students, inspiring and motivating them to pursue careers in the research field.

The initial career of Zaki has been an intriguing one, beginning with chemical technologies at a local oil and gas servicing company, where he ascended to the post of project engineer within a year of joining the same company. A special emphasis is placed on this section, which narrates the story of the chemical cleaning method used to reduce corrosion activity in the downstream pipeline. Pipelines, like any other industrial equipment, require routine maintenance to function properly. Pipelines can corrode when exposed to both internal and external conditions, resulting in contaminant build-up, structural damage, and product contamination. Cleaning activities that are scheduled on a regular basis can be used to extend the useful lifespan of pipelines. However, there is another side to the pipeline chemical cleaning process. For pipeline cleaning, blending chemicals is a daunting task. Nonetheless, he manages to explain the procedure in a straightforward manner. Maintaining the reader's focus on the task at hand. It is surprising how interesting a technical story can be. Then he took us all on his journey to work far away from land. If you've never been offshore, you might be interested in this. Maintaining an oil rig operational 24 hours a day requires engineers to be at their best at all times. The book is an easy read that follows a chronological narrative and is quite helpful for anyone interested in learning about working at an offshore platform.

The following section of the book offers a compelling insight of what it was like to work in the oil and fats industry. The book offers an inside look into the oil and fats industry through the eyes of engineers who work in it, as well as how chemical engineering has affected his career. Zaki rapidly established himself and began practising chemical engineering principles in specific areas such as unit operations, process control, and instrumentation. The book contains a plethora of scenarios that cover the critical aspects of unit plant operation that engineering students and early-career engineers frequently struggle to understand. Then he led us all down the path of making decisions and problem solving. The book discusses heavily on technical problems, and how he was forced to come up with solutions to the problems that arise. What is even more impressive is that you end up absorbing a bewildering number of technical problems that he faced in the industry without even realising it. He used his engineering expertise to discover solutions to the problems that he was experiencing at the time. Problem-solving has always been a hallmark of engineering. To be a successful engineer today, you need to be able to solve problems creatively and effectively in order to effectively communicate your ideas to others. The difficulties and setbacks that he has encountered in the industry are presented in an engaging manner through the use of stories and the sharing of personal experiences. He creates real-industry stories that bring engineering to life in a subject that could otherwise be considered dry and uninteresting. Thus, this book is an excellent read about the life of a chemical engineer and his journey through the oil and fats industry, emphasising the lessons learned from both failures and good decisions along the way.

There are a beautiful combination of science and engineering that is sprinkled throughout the book, and the importance of engineering thinking is emphasised on numerous occasions throughout. Engineers do have distinct ways of thinking and acting, and these distinct ways of thinking and acting are referred to as 'habits of mind' (Lucas and Hanson, 2016). It is a concept founded on the belief that engineers frequently make things function or perform better. Throughout his time in the workplace, he was able to demonstrate engineering habits of mind. He is adept at incorporating systems thinking, creativity, optimism, teamwork, communication, and ethical considerations into all aspects of his work. He emphasises that in order to be a successful engineer, one must develop certain dispositions and habits of mind. Engineers require learning dispositions such as curiosity, optimism, resourcefulness and resilience. Learning never cease, and this is especially true for engineers. This book emphasises numerous times that engineers must be constantly learning, constantly upgrading their skills, and constantly adapting to new situations. What is vital is that engineers treat their jobs as dynamic entities that requires continuous improvement of the quality to work effectively. As a consequence, he is always improving his abilities and skills, he is dissatisfied with his own level of knowledge, and he is very curious about finding the truth about everything. According to the book, one need to understand how successful engineers think and act when faced with difficult problems. This book reminds us that being an engineer is not about what you do, but how you do it. Zaki asks readers to take an introspective look at the kind of engineer they will be in the future and shows them how improving professional skills can get them to the next level.

Something that makes this book particularly enjoyable is the way it brings chemical engineering into a very personal context. When Zaki writes, he concentrates on the people and events that have affected his life, and he includes a lot of colourful detail that is sometimes amusing, sometimes heart breaking, but always intriguing. He does a wonderful job of describing some of the most fundamental yet crucial abilities that are rarely taught to most engineers, particularly those new to the industry. He performs a good job of educating the reader on the value of professional skills, dispute resolution, leadership abilities, and mentorship, among other things. He highlights the need of developing those skills in order to create a happier and more productive workplace. One cannot advance engineering career purely on the basis of own technical abilities. Effective engineers must be able to communicate well with others. However, many engineers are woefully unprepared to deal with the inevitable interpersonal conflicts that arise when they work alongside other engineers and engineering managers. Nevertheless, it is refreshing to know that Zaki also does not shy away from conflicts. He identifies some issues that are impeding his progress and implies strategies to avoid or solve the conflicts as they arise. Zaki discusses how our relationships affect our success as individuals and as members of a team. He shared wisdoms for becoming a better engineer, team member, and leader by improving our interpersonal effectiveness. This book may be of interest to anyone looking to improve their skills as an engineer, but also as a team member, regardless of their level of experience.

In a nutshell, this book follows the journey of a chemical engineer, making it unique and personal. It spans his academic years, his time as a university researcher, and his professional career; it is narrated in a fast-paced manner through a series of vignettes that capture the highlights of the events that shaped him into the professional chemical engineer he is today. It also serves as a guide for aspiring chemical engineers and future engineers, demonstrating what they should strive for and how much fun they can have in this field. The engineering knowledge infused throughout the narrative is authentic and done with finesse, owing to the Zaki's experience in chemical engineering. For those searching for some light reading that puts a human face on the field of chemical engineering, this is the book to read.

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Continuous Improvement in the IMSE Program of Kuwait University

Article history
Received
13 December 2021
Received in revised form
20 December 2021
Accepted
20 December 2021
Published online
28 December 2021

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Abstract

Continuous improvement of an engineering program is essential and a critical process. Development and implementation of such a process is not only required by the Accreditation Board for Engineering and Technology (ABET), but it is also a necessary condition for the maturation and development of any engineering program. This paper describes the process employed by the Industrial and Management Systems Engineering (IMSE) program at Kuwait University to continuously improve its program. The employed process includes identification of the lowest score among the seven student outcomes specified by ABET. Next, the courses in the IMSE curriculum addressing this student outcome are identified, and the instructors teaching these courses took remedial actions. In the following semesters, this outcome was measured, and it was found that there is a significant improvement on this outcome. Other engineering programs can benefit from the process described in this paper.

Keywords: Student outcomes; quality; ABET; industrial engineering program; continuous improvement .

Introduction

Quality is a crucial parameter which differentiates an organization from its competitors. Quality plays as a key to survival in all standard of organization. Quality is the single most important factor for long-term success and survival. There are numerous recognized programs that set requirements for quality and excellence, e.g. the Baldrige National Quality Program (BNQP 2014), (EFQM), Six Sigma, ISO 9000 Quality Management System (QMS), and Customer Service Excellence (CSE) program. Regular enhancement is a pivotal criterion in all quality and excellence models; a system that has no progress will become obsolete and eventually not be in use. Several productions on the application of numerous quality programs in higher education are by Furst-Bowe and Bauer (2007), Ruben (2007) on BNQP, EFQM (2003) and CEHE (2008) on EFQM, Mazumder (2014) on Six Sigma, Kasperaviciute (2013) and Caraman et al. (2008) on ISO 9001 QMS, Elves (2014) on CSE and Haseena and Ajims on IISTE (2015). The function of quality in education has expanded over the years. Global competitiveness has led to educational establishments seeking to apply excellence and quality programs that have the same fundamentals to ensure harmonization and mutual recognition. Furthermore, expectation for superior graduates is increasing. The emergence of developmental diversity in the organization and various significant transformations related to communication and technology impacted around all aspects of education, e.g. Patil and Codner (2007) and Christoforou and Yigit (2008).

Accreditation is a quality assurance process that colleges, universities and education institutions or programs undergo to confirm that they meet a strict and recognized set of service and operational standards. Regular accreditation of programs fosters the continual improvement of education. To establish excellence, quality, and harmonization in Engineering Education within academic institutions, accreditation agencies were established worldwide. Accreditation is assessed by private, nongovernmental accrediting agencies that have been created specifically to review education institutions and programs. Examples are the Accreditation Board for Engineering and Technology (ABET) of the USA, Japan Accreditation Board of Engineering Education (JABEE), the Accreditation Board for Engineering Education of Korea (ABEEK), the Engineering Accreditation Council of Malaysia (EAC) and the Canadian Engineering Accreditation Board (CEAB). The Bologna Process has been instrumental in establishing a mutual accreditation framework (Augusti, 2006) which led to the establishment of a non-profit organization European Network for Accreditation of Engineering Education – ENAEE (Augusti, 2007). The International Engineering Alliance (IEA) promotes a set of graduate attributes and qualified competency profiles for engineers, engineering technologists, and engineering technicians (IEA, 2013). This supports mutual recognition among accreditation bodies and facilitates the advancement of outcome-based accreditation criteria. The ABET accreditation program is the most widely used for engineering programs; initially its utilization was defined to the evaluation of engineering programs in the USA, but in the 1980s the scope extended to non-

USA programs. Formerly, the international engineering programs were determined in terms of substantial equivalency, and later they were awarded the same designation as their peer programs in the USA. Therefore, engineering programs worldwide have sought to administer the ABET principle, e.g. Christoforou and Yigit (2008), Al-Nashash et al. (2009), Abu-Jdayil and Al-Attar (2010), Aqlan, Al-Araidah, Al-Hawari (2010), Abdulaal et al. (2011), Harmanani (2016), Nath and Agrawal (2020), and Ahmad and Qahmash (2020). It should be emphasized that a realistic model for assessment and continuous improvement must be dynamic and be able to evolve as learning and improvements take place, Crossman and Verma (2006).

It is vital to note that ABET criterion 4 stipulates that, "The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained. The results of these evaluations must be systematically utilized as input for the program's continuous improvement actions. Other available information may also be used to assist in the continuous improvement of the program". The Industrial and Management Systems Engineering (IMSE) program at Kuwait University (KU) has been accredited by ABET since 2001. This paper focuses on improvement effort and demonstrates how various qualitative and quantitative analysis approach have been enforced to continuously improve its program program.

Student outcomes

The IMSE program has adopted the ABET's revised Student Outcomes (SOs) 1 to 7. The seven SOs described below are the same as those listed under the Criterion 3 of ABET's general criteria. Attainment of these SOs prepares graduates to enter the professional practice of engineering. The stated 7 SOs are:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. an ability to communicate effectively with a range of audiences.
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

It should be noted that ABET 1-7 SOs were recently introduced. The earlier ABET Student Outcomes were SOs a-k. The earlier and newer versions of SOs were mapped by ABET using the mapping given in Table 1. We also used the same mapping.

Table 1. Mapping between SOs 1-7 and SOs a-k.

SOs (a to k)	SOs (1 to 7)
a, e	1
c	2
g	3
f, h, j	4
d	5
b	6
i	7
k	Implied in 1, 2, 6

Continuous Improvement

ABET general criterion 4 states that "The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained". Table 2 lists all the appropriate assessment tools used to evaluate the extent to which the SOs are being attained for the process of continuous improvement. This process is documented and repeated annually. The criterion also states that "The results of these evaluations must be systematically utilized as input for the continuous improvement of the program." Section 3.1 describes the continuous improvement based on evaluations of the assessment results. Moreover, the criterion states that "Other available information may also be used to assist in the continuous improvement of the program". Section 3.2 describes the continuous improvement of the program based on other available information. Figure 1 shows the assessment process of development, evaluation, and improvement of the SOs where the definitions of the notation on the figure are given in Table 2.

The assessment process of the SOs is generally handled through a series of steps that starts with the Assessment Secretary who receives the assessment data generated from the tools shown in Table 2. Then, the data is analyzed and presented to the Undergraduate Program Committee (UPC) which evaluates the results of the analysis and recommends actions to the department chairman. The chairman then introduces relevant recommendations to the department council, which makes the final recommendations. Once these recommendations are approved by the council, they are communicated for implementation by the chairman to the relevant party either inside or outside the department.

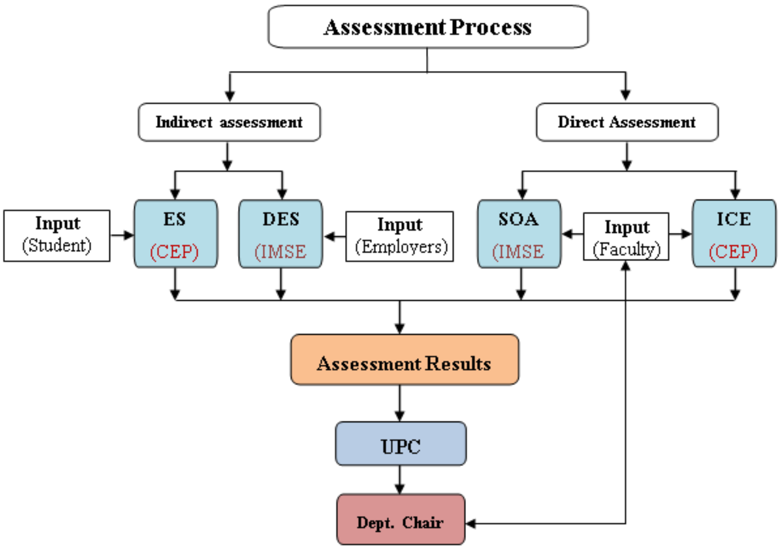

Figure 1. The assessment process of development, evaluation, and improvement of the SOs

Table 2. Assessment tools used for student outcomes

Assessment Tools	Conducted by	Assessor	Direct/Indirect	Frequency
Instructor Class Evaluation (ICE)	CEP	Faculty	Direct	Every Semester
Exit Survey (ES)	CEP	Student	Indirect	Every Year
Student Outcome Assessment (SOA)	IMSE	Faculty	Direct	Every Semester
0660-496: Design in Industrial Engineering - Employer Survey (DES)	IMSE	Employer	Indirect	Every Semester

Continuous Improvement Based on Assessment Data

The IMSE faculty members meet at least once a semester to discuss different issues related to curriculum, laboratory facilities, assessment information and accreditation. In addition to these meetings, faculty provide input to the UPC coordinator concerning equipment, facilities, and other concerns via e-mails and informal conversations. The UPC coordinator summarizes this information and discusses them with the Department Chair.

The role of the faculty members in the assessment and continuous improvement plan is as follows:

a. Faculty members are responsible for establishing course objectives and assessing whether they are being met.

b. Faculty members complete the course assessment forms ICE and SOA which measures student performance for each of the SOs.

c. Faculty members are responsible for implementing any curricular changes as a result of program review during the assessment process.

Assessment data helps and guides faculty in making curricular changes. Any low score on a particular SOs attainment raises a red flag and faculty members try to get to the root cause of the problem. If the issue affects other courses within the program, the issue is raised in the UPC meetings.

The assessments results of the SOs have been averaged over 5 semesters up to Spring 2018 to establish an intuition of the observed values across all the outcomes and courses. From the analysis of the two direct assessment tools used by IMSE department for the evaluation, namely, Instructor Class Evaluation (ICE) and Student Outcome Assessment (SOA), the results of SOA indicated that, based on the assessment results over the 5 semesters, the outcome 1 had relatively lower score compared to the other outcomes even though the performance of the outcome 1 was much higher than the threshold value of 60%. Figure 2 shows the resulting averages for the SOA results for all the SOs 1 to 7.

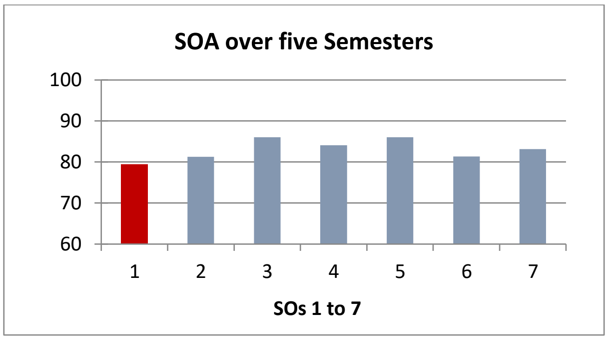

Figure 2. Average SOA over five semesters.

Since outcome 1 has the lowest score among all the SOs, it has been the focus of an improvement effort. To address this issue, the UPC committee realized the necessity to pay attention to outcome 1. This outcome is addressed by 24 courses in the curriculum of IMSE program. The courses that address outcome 1 are listed in Table 3. The first 12 courses are compulsory, and the remaining are department electives.

Table 3. Compulsory and Elective courses relevant to outcome 1

No.	Course No.	Course Name
1	660-221	Introduction to Industrial Engineering
2	660-321	Work Design & Measurement
3	660-351	Engineering Statistical Analysis
4	660-352	Production Cost Analysis
5	660-361	Operation Research I
6	660-372	Project Management & Control
7	660-434	Facilities Planning & Design
8	660-454	Production Planning & Inventory Control
9	660-457	Quality Control
10	660-461	Operation Research II
11	660-481	Systems Simulation
12	660-496	Design in Industrial Engineering
13	660-381	Data and Decision Analysis
14	660-395	Industrial Engineering Internship
15	660-445	Manufacturing Systems
16	660-446	Computer Aided Manufacturing
17	660-451	Reliability and Maintainability Engineering
18	660-456	Productivity Improvement Methods
19	660-458	Design of Experiments
20	660-459	Quality in Health Care
21	660-464	Optimization Methods
22	660-470	Supply Chain and Logistics
23	660-487	Expert Systems in Industrial Engineering
24	660-494	Industrial Engineering in Process and Service Systems

The compulsory courses are offered every semester. Moreover, a set of at least four elective courses is offered each semester. By considering the academic year 2015/2016, the performance in the courses that addressed outcome 1 is shown in Figure 3. The lowest scores of outcome 1 are for the following courses:

0660-321: Work Design & Measurement
0660-351: Engineering Statistical Analysis
0660-352: Production Cost Analysis
0660-461: Operations research II
0660-481: Systems simulation

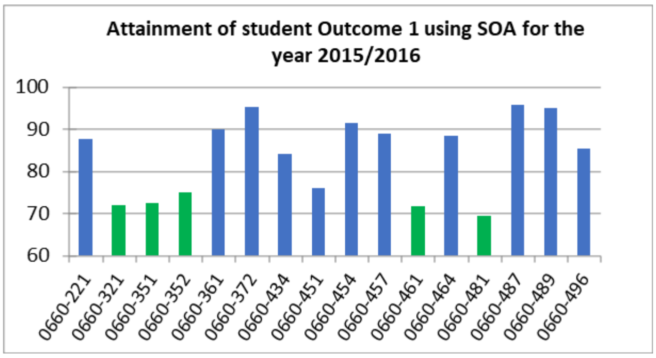

Figure 3. Attainment of Student Outcome 1 using SOA in 2015/2016

In Spring 2016, the UPC committee decided after this evaluation to take action through the department chair by notifying faculty members about putting more emphasis on outcome 1. Recall outcome 1 states that students should have an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. Faculty members, specially to the faculty members teaching the above four courses with relatively low scores, were requested to put more emphasis on this outcome.

After the end of the academic year 2017/2018, the UPC committee evaluated the results for those low performed courses in student outcome 1 using both the assessment tools (ICE and SOA) for two academic years. Figure 4 and Figure 5 show the comparison of evaluation results attained for outcome 1 between (Fall 2015 - Spring 2016) and (Fall 2016 - Spring 2018) using SOA and ICE, respectively.

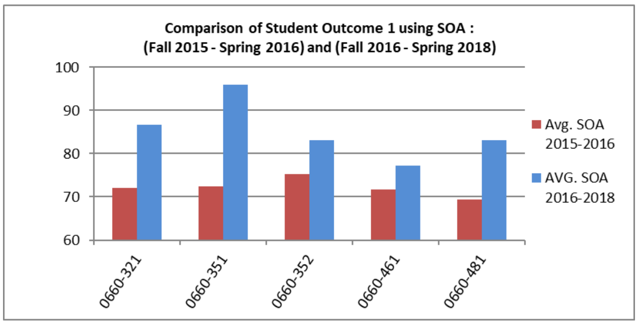

Figure 4. Comparison of evaluation results attained for Student Outcome 1 using SOA

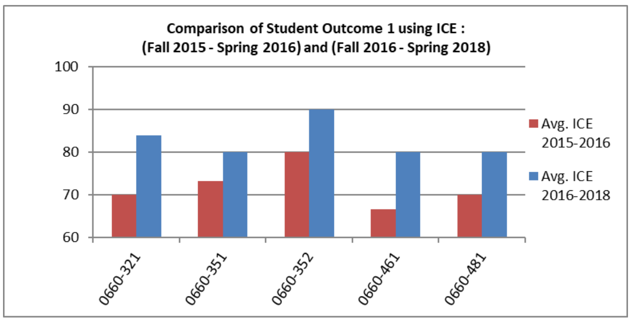

Figure 5. Comparison of evaluation results attained for Student Outcome 1 using ICE

From the results of both assessment tools (ICE and SOA) as shown in Figure 4 and Figure 5, it was found that the five courses with the relatively low performance in outcome 1 have improved considerably in the following two years (2016/2017 and 2017/2018).

Faculty members, teaching courses addressing student outcome 1, were requested to put more emphasis on this outcome. Putting more emphasis on student outcome 1 in the related lectures resulted in a higher score in outcome 1.

The UPC committee has also investigated the average of evaluation results of all the courses for outcome 1 and compared the results for the 5 semesters (Spring 2014 – Spring 2016) with the two years 2016/2017 and 2017/2018. It was found that the overall average results have also been improved in both assessments ICE and SOA as showed in Figure 6.

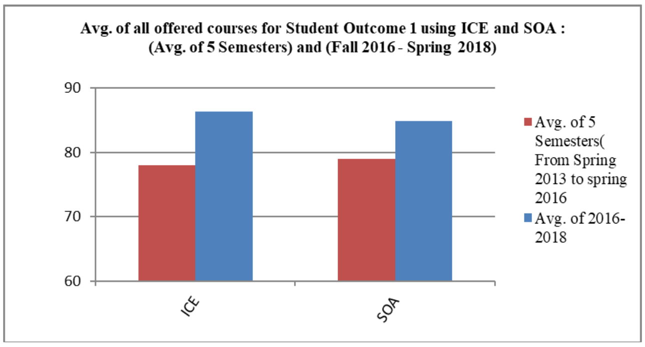

Figure 6. Comparison of avg. evaluation results from all the relevant courses for outcome 1 using ICE and SOA

Continuous Improvement Based on Other Information

This subsection describes the continuous improvement of the program based on other available information. These are summarized as follows:

a. All the student outcomes have been measured each semester by each assessment tool described earlier. It has been observed that conducting the "Student Outcome Assessment" for all outcomes each semester was cumbersome. Therefore, it has been decided to measure four of the outcomes in every Fall semester and the other three outcomes in every Spring semester such that within an academic year all outcomes are covered.

b. If the result for any of the outcomes from any of the tools falls below 70% (even if it is above the threshold value of 60%) for two consecutive years, a notification shall be sent by the department chairman to faculty members urging them to undertake remedial actions to improve performance on this outcome. If necessary, the relatively weak performing outcomes may be discussed in the department council meeting for actions. Implementation of this change shall reduce the efforts and time required of faculty and provide focus on specific SOs.

c. The total number of required credits for the program was 144 until Spring 2015, which generally required 5 years of study. As per the directive of the CEP to all engineering programs, the IMSE program reduced the 144 credits to 132. This change was motivated by a number of factors including the fact that many notable universities require four years of study which amounts to less than 132 credits. Additionally, the major employers in Kuwait, including oil and gas, banking, and government, do provide extensive orientation and training programs for new employees; e.g. in the oil and gas companies, the orientation and training duration typically extends to more than one year. Hence, a modified curriculum with 132 credits was approved and implemented starting Fall 2015.

d. The faculty members have been concerned about the weak performance of some students with respect to Mathematics and English language. Although these students are required to take remedial courses, their performances could not be improved beyond certain levels. To address this issue, the college adopted a new admission policy which took effect in the 2014-2015 academic year. According to the new policy, those students who do not pass Mathematics and English aptitude tests conducted by the university, are not admitted to the college programs. The students who pass the English test marginally still have to take remedial English course. The new policy also stipulates higher minimum admission score. Moreover, the high school GPA has a lower percentage in calculating the admission score.

e. It was observed that some of the common engineering courses and introductory IMSE courses were being delayed by many students as a result of some prerequisite requirements. For example, some students would take 0660-361: Operations Research I and 0660-461: Operations Research II before taking 0660-221: Introduction to Industrial Engineering. Another example is some students would take 200-level college courses such as Thermodynamics (0600-208) in the last semester. In order to overcome these issues, the UPC committee suggested modifications to some of the prerequisites of some courses. Table 4 shows the modifications.

Table 4. Modifications to the prerequisite of some of the courses

IMSE Course Name	Old Pre-requisite	Proposed/ Approved Pre-requisite
0660-312: Industrial Engineering Labs	0600-304: Engineering Probability and Statistics 0660-221: Introduction to Industrial Engineering	0600-207: Electrical Engineering Fundamentals Lab 0600-304: Engineering Probability and Statistics 0660-221: Introduction to Industrial Engineering
0660-321: Work Design and Measurement	0600-304: Engineering Probability and Statistics 0660-221: Introduction to Industrial Engineering	0660-312 (Concurrent)
0660-325: Safety and Health for Engineers	0600-304: Engineering Probability and Statistics	0600-202: Statics 0600-208: Engineering Thermodynamics 0600-304: Engineering Probability and Statistics
0660-361: Operations Research I	0410-111: Linear Algebra	0410-111: Linear Algebra 0600-307: Applied Numerical Methods 0660-221: 0660-221: Introduction to Industrial Engineering
0660-481: Systems Simulation	0600-304: Engineering Probability and Statistics 0660-351: Engineering Statistical Analysis	0660-351: Engineering Statistical Analysis

The UPC committee discussed the pre-requisites of IMSE courses 0660-321: Work Design and Measurement and 0660-312: Industrial Engineering Labs. Both of these IMSE courses have 0600-304: Probability & Statistics and 0660-221: Introduction to Industrial Engineering as their prerequisites. Therefore, in order to force students to take the course 0660-312 early on in their studies and not delay it until the senior year, it was suggested to require 0660-321 to be taken either concurrently or after 0660-312.

It has been noticed in the past that many students take 0660-361 very early in their studies before many IMSE or even general engineering courses and delay 0660-221. By having 0660-221 and 0600-307: Applied Numerical Methods and Programing for Engineers prerequisites to 0660-361, it is hoped that students would take the courses during a more appropriate time frame in their studies.

Another minor modification to the prerequisite of the IMSE course 0660-481: Systems Simulation was removing the course 0600-304: Engineering Probability & Statistics. This is because 0660-481 has 0600-304 and 0660-351: Engineering Statistical Analysis as its prerequisites and 0660-351 has 0600-304 as its prerequisite. Therefore, it can be seen that there was a redundancy in the list of prerequisites of 0660-481 and it was removed.

Some Engineering Management (EM) elective courses have 0660-471: Engineering Management course as their prerequisites. Currently, 0660-471: Engineering Management is one of the courses that students typically leave until the very last semester before taking it. This is because 0660-471: Engineering Management is not a prerequisite for the 0660-496: Senior Design course and has 0660-352-Production Cost Analysis as its prerequisite. Therefore, when offering EM elective courses, there is the potential of not having enough students that are eligible to take them. To overcome this problem, first, it was suggested to allow the EM elective courses 0660-473: Quality Management and Organizational Excellence and 0660-479: Law for Engineers to be taken concurrently with 0660-471. Second, it was recommended to remove 0660-352 as a prerequisite to 0660-471: Engineering Management and replace it with 0600-209: Engineering Economy, which allows students to take 0660-471 earlier in their studies to leave enough time for taking two or more EM elective courses. Then, as a result of the change in 0660-471 prerequisites, the course number was changed from 0660-471 to 0660-371.

Conclusion

This paper described the process employed by the IMSE program at Kuwait University to continuously improve its program. Using a continuous improvement framework, the paper demonstrated how continuous improvement can be performed based on evaluations of the assessment data. ABET general criterion 4 states that "The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained". The framework described in this paper to achieve this goal can be used by other engineering programs while going through ABET process.

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A Book Review on *Fifty Strategies to Boost Cognitive Engagement*

Article history
Received
6 December 2021
Received in revised form
23 December 2021
Accepted
26 December 2021
Published online
28 December 2021

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Abstract

Along with research-based and state-of-the-art reviews, book reviews can be found in language teacher periodicals. However, less attention has been given to reviews on academic books emphasizing on the issues of cognitive engagement. As such, this paper seeks to review the book entitled, *Fifty Strategies to Boost Engagement: Creating a Thinking Culture in the Classroom (50 Teaching Strategies to Support Cognitive Development)* by Rebecca Stobaugh. Generally, this book adds to our understanding of how an educator needs to improve on the skill of engagement particularly through the cognitive domain.

Keywords: Engagement, educator, cognitive domain, book reviews.

Introduction

Fifty Strategies to Boost Cognitive Engagement: Creating a Thinking Culture in the Classroom (50 Teaching Strategies to Support Cognitive Development) is an inside look from the perspective Rebecca Stobaugh, an associate professor at Western Kentucky University. Other contributors are Lauren Tanner and Alicia Wittmer, whom are experienced school teacher at Kentucky. The book which was published by Solution Tree Press in 2019, contains eight chapters that elaborated the strategies from the point of view of cognitive domain of the revised Bloom's Taxonomy by Anderson & Krathwohl (2001).

The first motivation of this book was based on the *Future of Jobs Report* (World Economic Forum, 2016) which outlined the top skills needed for employment. It has been clearly mentioned by Hart Research Associates from their survey that, 93% of employers agreed that a job candidate’s would need to demonstrate the capacity to think critically, communicate clearly and solve complex problem–all of which would be more dominant compare to merely achieving good academic results.

The second motivation was based on a study conducted by Adobe Systems Incorporated (2018) whose findings revealed that 76% of educators did not have sufficient knowledge and training to design creative problem-solving activities. In addition, Ingvarson et al. (2008) highlighted the differences between those who had undergone proper academic teaching and those who had not undergone the process being the ability to plan the transition curriculum to produce deep learning outcome. Thus, this book guides educators on enhancing their competence to design high-cognitive activities.

The structure of the book consists of eight chapters as follows:

- Understanding Cognitive Engagement and the Thinking-Based Classroom.
- Applying a Taxonomy to the Thinking in Your Classroom.
- Developing Critical-Thinking Skills and Fostering Engagement.
- Implementing Strategies for Understanding-Level Thinking
- Implementing Strategies for Analyze-Level Thinking
- Implementing Strategies for Evaluate-Level Thinking
- Implementing Strategies for Create-Level Thinking
- Cementing a Culture of Thinking

Stobaugh summarizes each of the eight chapters (excluding the final chapter) by explaining the definition of each strategy, followed examples of the classroom activities, the steps to perform those strategies, modifications of implementation of the strategies, additional content-area of examples using the strategies and finally discussing what could be raised from the strategies and a list of actions for extra activities in the classroom using the strategies. The final chapter summarizes the suggestions and provides an overview of the entire skill. Also included in the final chapter is Stobaugh’s proposal that the echo-system in education would not be able to work well without the development of a culture of thinking. As it deals with many hands-on strategies for the classroom activities, the book is suitable for educators who have basic theoretical knowledge on pedagogy.

Method

This review seeks to basically answer the following questions as recommended by Lee et al. (2010) and Lewis (2020): (1) What is the central issue the book addresses?; (2) What does the theoretical perspective from the author work?; (3) How is the book organized and what major arguments does the book include?

As a prerequisite of learning, student engagement is a vital aspect in education. Theoretically, student engagement can be divided into behavioral, cognitive and emotional engagements Chiu (2021). Since the dominant keywords in the book title are cognitive engagement, hence our next discussion will be focusing on the cognitive issues. Research has indicated that those who have lack environment can influence an in-effective learning experience and suppressed the student cognitive and emotional engagement (Chiu, 2021).

Throughout Chapter 1 until Chapter 7, Stobaugh offers on how to implement the strategies from Level 1 of the revised Bloom's Taxonomy by Anderson & Krathwohl (2001), for example, the first strategy in Chapter 4, describes the relationship between physical activity and students' memory across all age groups. The classroom example demonstrated for school-grade class learning ten vocabulary words; however, in variations section, Stobaugh suggests that this method can be modified by asking the students to create a video and learn the new term inside the video. Stobaugh was influenced by the original method proposed by education expert Eric Jensen (see p. 29) while developing the first strategy. In this strategy, Stobaugh also aims to highlight how significant hand-gesture approach and vocabulary can help students to improve their *remember* and *understand* domains.

Chapter 5 presents 18 instructional strategies at the *analyze* level of the revised Bloom's Taxonomy by Anderson & Krathwohl (2001). Some of these strategies also cover the students' domains of *remember*, *understand*, and *apply*, for example, in the seventh strategy known as concept attainment. In this strategy, students are required to apply a structured-inquiry process to determine the attributes of a group. Students will compare two ideas and sort out the information via classifying and performing the connections among the two ideas for further deep understanding. The educator gives students two pictures about one theme and after that, the students will be required to fill in the table of themes. Stobaugh brings together in this approach the existing body of current situation by applying the pictures and relates the situation with the concept the students learn in the classroom.

Chapter 6 exhibits the 19 instructional strategies at the *evaluate* level of the revised Bloom's Taxonomy by Anderson & Krathwohl (2001), for example, the 27th strategy known as questioning protocols in which Stobaugh draws conclusion from the quantitative research conducted by Fisher et al. (2018) which found that 58% of students sampled had felt comfortable when questions were being asked. Two simple questions that could be distributed to the students to boost their cognitive level are as follows: (1) What evidence support ___________?; and, (2) What is another perspective on _________________ ? Stobaugh also recommends in variations section modifying the strategy title as question continuum which is asking the students to refine the quality of their questions with the aim to trigger more challenging discussions and finally stimulate new ideas.

Chapter 7 suggests seven more instructional strategies which emphasize on learning at the *create* level of the revised Bloom's Taxonomy by Anderson & Krathwohl (2001), for example, the 47th strategy known as scamper which is an ordinary brainstorming technique that empowers students to produce alternative ideas via a seven process, namely: substitute, combine, adapt, modify or magnify, put to other uses, eliminate or minify and rearrange or reverse. In variations section, Stobaugh suggests that the process of scamper can be implemented one element at a time.

Lastly, in Chapter 8, Stobaugh ultimately stresses the highpoint that the strategies cannot be effectively absorbed if the culture of thinking is not developed. This is a significant characteristic to ensure that the students really benefit from the impact during the learning process and not just having fun participating in the activities. Additionally, a few stems or tables were provided for free in reproducible version for some of the strategies, for example, the 32nd strategy known as critiquing which consists of telling, asking, and giving (TAG) sentence stems, peer-review template, oral-presentation rubric and physical education self-assessment. By doing this, Stobaugh encourages readers to fully utilize her suggestions for operation purposes.

Findings and Discussion

We believe that Stobaugh's book has filled the gap in current experiential learning by providing a hands-on approach and contributed to a reliable body of knowledge. Contributions made in terms of the recommended strategies particularly relating to the cognitive level domain from the revised Bloom's Taxonomy by Anderson & Krathwohl (2001) can indeed inspire educators. As educators ourselves, we attempted an implementation of the 18th strategy in our Technical Reporting course as illustrated in Figure 1. This strategy helped our students define the source of their problems in e-learning study. Based on the suggestion in Stobaugh's book in variations section, students need to brainstorm additional problems in e-learning study in order to identify the possible cause(s) of the problems. As stated in the first step of this strategy:

> *Identify the materials that challenge students to determine the cause of a problem or issue. This might be by using a video, readings, scenario, or past student work that needs correction.*

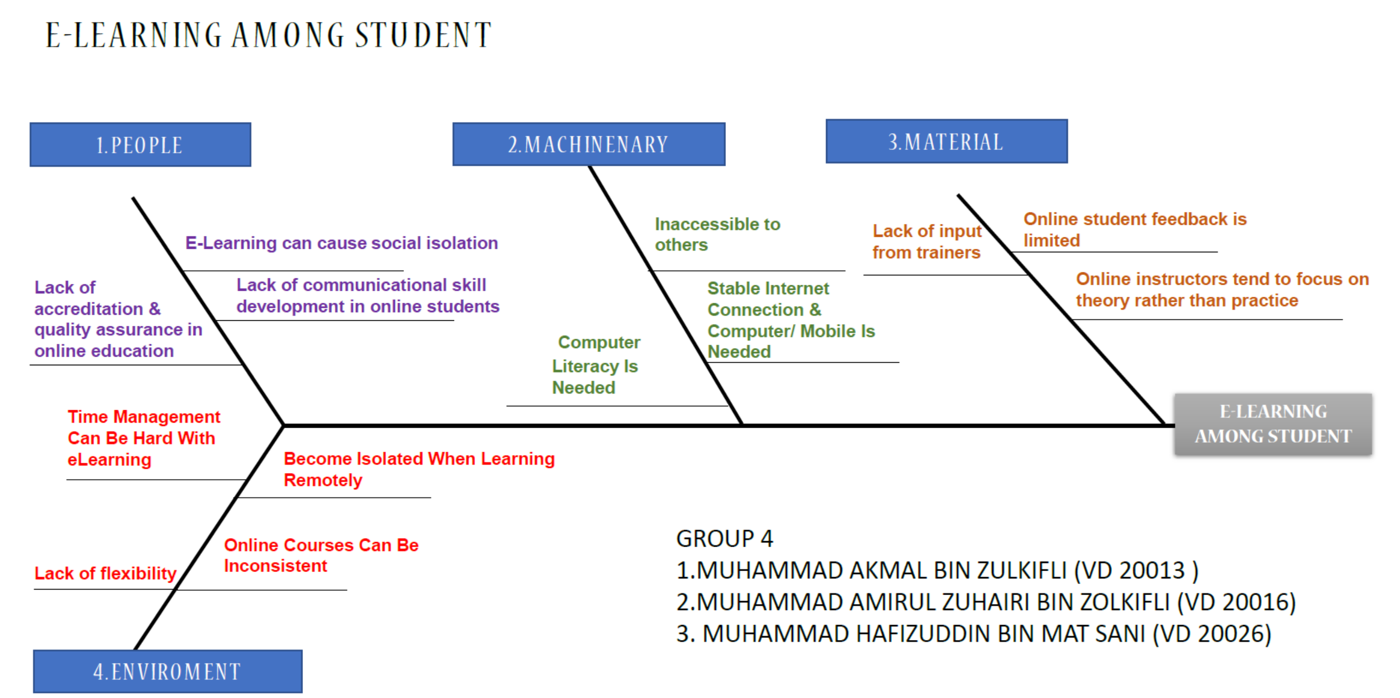

Figure 1. Sample Fishbone diagram for Technical Reporting Course

Because the students in this course were adult students many of whom were diploma holders and some of them had working experience, their prior knowledge in different learning environment and working experience made the discussion more valuable and meaningful.

Conclusion

This paper concludes that the book review has provided evidence of Stobaugh's *Fifty Strategies to Boost Cognitive Engagement* to be a suitable material for educators to boost their skill. The book emphasizes on the important quality of the cognitive domains from the *understand* level to the *create* level of the revised Bloom's Taxonomy. As suggested in the last chapter of this book, in order to attain the students' optimal potential, the eco-system of the thinking culture needs to be ready and provided by the institution. Hence, the process to embed this thinking culture into the students' mind begins with the educators' mind. This can be implemented by developing the thinking culture among educators.

During the current pandemic Covid-19, the cognitive strategies need to be adapted to the changes taking place based on the needs and requirements of the e-learning environment. This will involve more redevelopment and refinement of tasks and upskilling on the part of the educators especially ones that relates to computer literacy proficiency. It also demands the educators to be familiar with the devices and tools that will enhance their ability to manage the classroom and build the trust among the students. Educators' lack of skill to control devices and tools will negatively affect the students' perception and perspective on the educator's handling and delivery of teaching materials. It is hoped that Stobaugh will make room for improvement in her next edition.

Acknowledgement

Authors would like to express their gratitude to the team from the Centre for Engineering Education, Universiti Teknologi Malaysia. Main author is also indebted for the valuable experience and knowledge gained during postgraduate study and postdoctoral research in the field of engineering education made possible from the collaboration with the centre.

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Concerns Fronting Engineering Education in Sudan: A Review

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Article history
Received
26 December 2021
Received in revised form
27 December 2021
Accepted
27 December 2021
Published online
28 December 2021

Abstract
For decades Sudan, like most of Sub-Saharan African countries, has been facing profound engineering education issues, namely: poor funding, outdated curricula, ineffective teaching and learning methods, inadequate human capacity, poor research/publishing condition, inappropriate facilities, inadequate educational technology and ICT environment, weak university/industry relationship, lack of academic freedom, and missing of quality control and accreditation measures. The paper discussed these issues, and proposed solutions such as redesign of flexible curriculum, adopting learner-centered approach, and developing hiring structure that focuses on recruiting and retaining qualified educators, with the goal of graduating a high rate of qualified engineers, ready for the 21st century.

Keywords: Engineering Education, Sudan, Sub-Saharan Africa.

1. Introduction on Engineering Education in Sudan

Sudan is one of Sub-Saharan African (SSA) countries. It is located in Northeast Africa, and has boarders with seven countries: Egypt, Libya, Chad, Central African Republic, South Sudan, Ethiopia and Eritrea, in addition to the Red Sea coastline. Ethnoculturally, the country is amid of North Africa/Middle East Arab countries and the SSA countries.

The country is known of its abundant natural resources, which include: water, land, agriculture, forestry, livestock, crude oil, and minerals. In 2020, Sudan Natural Capital (NC) rank was 78 out of 180 countries. NC reflects the country's ability to sustain the population and the economy, now and into the future. However, globally Sudan is ranked very low in both Sustainability Competitiveness Index (SCI) and Intellectual Capital Index (ICI). Sudan is considered one of the lower-middle-income countries, and its GDP per capita is about $1990 (Sudan GSCI, 2020).

Since the country's independence in January of 1956, Sudan political system has been engaging in what is known as a 'Vicious Cycle', which consisted, of three cycles, of multi-party democracy, followed by a military coup, and ended with transitional period due to people uprising 'Intifada' against the military regimes. The sum of all democratic ruling, including transitional periods, were only 13 years, while military regimes ruled the country, with an iron fist, for more than 53 years. The resultant of these disastrous political practices, which include corrupt politicians, misallocation of limited resources, and exploitation of natural resources by both national and international corrupt companies, led to the country's significant social instability, civil war and great economic depression, in spite of the country's abundant natural resources. However, deterioration of all aspects of life on the country- socially, economically, and politically- has been attributed, to great extent, to the last military regime, which lasted for 30 years since June 30th of 1989. However, after throwing it out of power in April of 2019, the hope is high on the current transitional civilian government to lead the country into a proper democratic system, and hence, a prosperous country (UNDP Report, 2020; Sudan: a country study, 2015).

Schools of engineering prepare most of their graduates for employment in various industries as professional engineers; however small part of engineering graduates may seek other career paths as researchers and/or academicians. Hence, engineering education is different from vocational training; the latter prepares students to work as apprentices in many professions (Goodhew, 2010).

Accordingly, engineering education in Sudan is provided by higher colleges and universities. These academic institutions must be recognized and accredited by Ministry of Higher Education and Scientific Research (MoHESR), and all engineering graduates must be licensed and registered by the Sudanese Engineering Council (SEC).

To better-understand the situation of engineering education and its related issues, the evolution of engineering education in Sudan may be split into three periods. The first period was during the British Colonialism, from the actual start of engineering education in 1939 to 1956; the second period was from the independence of the country, in January 1956 to 1989; and the most recent period, lasted for 30 years between 1989 and 2019. The higher education in general, and engineering education in particular, have gone through very distinctive transformation during each of these three periods.

The first period, the inception of engineering education was in 1939, as part of the high school programs, to provide the British Colonial Government (BCG) with technical skills, for municipality functions.

Soon after, engineering college (EC), as part of Gordon Memorial College (GMC); and Khartoum Technical Institute (KTI) were established to offer their graduates bachelor of science and diploma in engineering, respectively. Both of EC and KTI were characterized by their limited enrolment and engineering graduates (Khojali, 2014).

The second period, after the independence of the country in January 1956, the EC has become part of University of Khartoum (UofK), which was known as GMC. EC has been expanding, and by 1976, its engineering programs included: mechanical, civil, architecture, electrical, chemical, surveying and agricultural engineering programs (Khojali, 2014; Osman, 2014; Berry, 2015). During the same period KTI has become Khartoum Polytechnic Institute (KPI). KPI has been offering both diploma and bachelor of engineering in electrical, electronics, mechanical, surveying, textile, and civil engineering (MoHESR, 1984-85 Census Data). The expansion of EC and PTI has resulted in gradual increase in engineering programs, enrolment, which passed 5000 engineering students by 1988, and engineering graduates that reached 624, by 1989. Additional two engineering colleges have been established as part of University of Juba and Jazeera University. They were established in 1975 (MoHESR, 1988-89 Census Data; Berry, 2015).

The third period has lasted for 30 years, between 1989 and 2019. During this period, engineering education, like all other social and economic sectors, has been influenced significantly by the autocratic government that took over in June of 1989 via a military coup. For quick political gain the government has organized a higher education conference, which was developed into what is known as 'Higher Education Revolution'. Thereafter, drastic changes were implemented to resolve the issue of limited capacity of higher education in the country. Accordingly, the number of public universities has increased by 9 folds, or from only 4 in 1989 to 36 public universities by 2018. Around 26 out of them have engineering programs. While the number of the private universities has increased from just 2 in 1989 to 13 private universities, or an increase of 6.5 times. Eleven of the them offer engineering programs. During the same period, technical institutes have increased by almost 7-fold, or from 12 to 83 technical institutes; about 25 out of them granted their graduates diploma in various engineering programs. As well, the capacity of these academic institutions has expanded significantly. The increase in tertiary enrolment, between 1989 and 2018, was increased 9 times, or from 57,000 to 680,000 students. At the same period, engineering students has increased by more than 20 times, or from 3000 to 61,600. Still engineering students, in 2018, made about 9% of the total tertiary enrolment. While the number of engineering graduates increased from 624 (in 1989) to more than 10,000 (in 2018) (Elhadary, 2010; Gasim, 2010; World Bank, 2012; Osman, 2014; Ettridge and Sharma, 2020; World Bank and MoHESR, 2020).

Nevertheless, the quality of engineering graduates has been compromised due to many reasons, of them are: Poor infrastructure of the engineering education, low government expenditure in education sector, and students under preparedness (El-Hassan, 1992; Gasim, 2010).

2. Engineering Education Issues in Sudan

For many decades, the issues of engineering education in SSA countries have been the focus of many researchers. In 1993, the World Bank described the state of engineering education in SSA as, 'a sorry state.' To put this in perspective the reports states, '… developed countries graduate 166 times more engineers per capita than do the countries of SSA, and the quality of training, already low, is deteriorating as a result of budget constraints' (World Bank, 1993). On top of that, many research papers proved the situation is worsening rather than getting any better (UNESCO, 2010 and 2019; Idris, 2012; Mohamedbhai, 2014). Many researchers have been investigating challenges facing engineering education in Africa, such as: insufficient funding, outdated curricula, inappropriate facilities, lack of adequate human capacity, brain drain due to absence of academic freedom, as well as unattractive working environment in SSA, and missing of quality control and accreditation measures (Kumar et al., 2004; Afonja et al., 2005; Falade, 2008; UNESCO, 2010; RAE, 2012; Mohamedbhai, 2014).

The situation of the Sudanese engineering education is, more or less, similar to the situation in other SSA countries, except SA; and for decades, the deterioration rate has been accelerating, rather than improving (Elhadary, 2010; Gasim, 2010). Moreover, Sudan has never been included in the Engineering index (EI) ranking that was developed by the Royal Academy of Engineering (RAE), based on eight engineering indicators: Employment in engineering related industries, human capital investment in engineering, number of engineering businesses, the quality of infrastructure, the gender balance of engineers, the quality of digital infrastructure, wages and salaries of engineers, and exports of engineering-related goods. This is because of the country's weak performance related to all these engineering indicators (Ettridge and Sharma, 2020). In Table 1, the researcher summarizes the current issues of engineering education in the country.

The quality of engineering education depends on the role of the academic administration, at the institution level, in setting and monitoring efficiently the elements of engineering education, namely: curriculum, teaching and learning methods, capacity building, faculty and engineering environment (Smith, 2006; Webber, 2016; Osman, 2014). Any effort to improve engineering education in Sudan should start

Table 1. The Current Issues of Engineering Education in Sudan

List of Current Engineering Education Issues	
i.	Poor Funding
ii.	Outdated curricula
iii.	Ineffective teaching and learning methods
iv.	Inadequate human capacity
v.	Students' under preparedness for College
vi.	Inadequate number and quality of facilities
vii.	Issues of quality control and accreditation measures
viii.	Other Issues:
	o Absence of academic freedom
	o Brains drain
	o poor research/publishing condition
	o inadequate educational technology and ICT environment

with addressing the inadequate elements of engineering education as summarized in Table 1. Below is a brief about each of these issues:

i. Poor funding

Poor funding, which is due to the country's poor economic situation, could be considered the main reason for the most engineering education issues in Sudan. However, the root cause of this economic situation is due to bad political practices since the independence of Sudan. These political practices include corrupt politicians, misallocation of limited resources, and exploitation of natural resources by both national and international corrupt companies. Of course, engineering education sector, similar to all other social and economic sectors, has been facing severe financial crises. This financial crisis is evident by the education sector low share of only 2.7% of the GDP (in 2008), which has been decreasing until it reached 1.4% in 2014 (World Bank and MoHESR, 2020).

ii. Outdated Engineering Education Curriculum

Since the beginning of this century engineering profession has been undergoing another wave of innovation, which include, sustainability, radical resource productivity, whole system design, biomimicry, green chemistry, industrial ecology, renewable energy, and green nanotechnology (Hargroves et al, 2005). In-line with the same engineering innovation, Rugarcia et al. (2000) have predicted seven challenges that would face engineers of the 21st century. These challenges are: Proliferating information, multidisciplinary technological development, globalized market, endangered environment, emerging social responsibility, participatory corporate structures, and rapid changes.

Nevertheless, Sudanese engineering programs have not yet experienced significant changes to match the notable current wave of engineering innovation, along with the evolution of engineering education. Furthermore, at the very least, engineering programs in Sudan could be considered outdated, traditional programs with rigid curricular structure, heavy loaded with theoretical math and science courses; and even, teaching applied and design courses, which makes less than 10% of the engineering curriculum, has been affected by inadequate facilities (UofK website; World Bank and MoHESR, 2020). These theoretical courses are not aligned with the industry needs, and they are far from graduating qualified engineers, ready for the 21st century, in terms of knowledge and competencies. Lack of connection between the traditional engineering curriculum and the engineering as a professional career has been the main concern of engineering educators and researchers for more than 100 years; for instance, C. Mann (1918) said, '... engineering education will never be satisfactory until theory and practice are taught simultaneously. …'

On top of that, traditional curriculum does not consider diverse engineering students, in terms of different styles of learning and prior knowledge; and it lacks differential entry points and flexible progression pathways. According to Grayson et al (2013), there are five transition points that engineering students must pass during their bachelor program '1. From high school to university; 2. From basic sciences to engineering sciences; 3. From acquisition of knowledge to design; 4. From knowledge of discrete subjects to analysis of systems and integration of knowledge; and 5. From short, lecturer-led courses to extended student-led projects.'

iii. Ineffective traditional Teaching and Learning Methods

The traditional engineering curriculum, in Sudan, has been taught following the traditional teacher-centred philosophy (Osman, 2014). Prince and Felder (2006) defined teacher-centred method as, '… deductive instruction, which implies that: the lecturer explains, to his/her students, general principles and applications of a certain topic; gives students an opportunity to practice these principles by solving a set of homework problems; and finally assesses students' abilities to resolve similar problems. This ineffective teaching method does not promote active learning, deep understanding, based on learner's prior knowledge and learning style (Demirel, 2004; Prince et al., 2006; Felder, 2017).

iv. Inadequate Human Capacity- Academic and non-Academic Staff

Academic staffing of engineering programs in Sudan is two-fold issue: one is the low instructor-to-student ratio, which was estimated (in 2018) to be 1:34 compared to the required ratio, by regulatory agencies of the engineering education, of 1:15 (MoHESR, 2017-

18 Census Data). The other fold is the pre-service and in-service training of academic staff. According to Gasim (2014), about two third of all engineering academic staff have no doctorate degree in their discipline; add to that the inadequate professional development programs for engineering educators. (Osman, 2014; World Bank and MoHESR, 2020)

Poor financial compensation and the lack of academic freedom, between 1989 and 2019, have been the main reasons for brains drain; hence the shortage of highly qualified academicians in engineering education (Khojali, 2014; Osman, 2014).

v. Students Under Preparedness for College

Redesign of engineering curriculum has to consider the level of preparation of high school graduates, which has been influenced mainly by: the 11-year general education ladder, instead of 12-year standard general education, low education budget, inadequate curriculum, obsolete teaching methods, and lack of qualified schoolteachers (The Federal Ministry of Education, 2004; Osman, 2014; World Bank and MoHESR, 2020). Although engineering freshmen have a good knowledge of math and science, still they lack meaningful scientific concepts. This is due to missing components of technology and engineering within precollege education (World Bank and MoHESR, 2020).

vi. Issues of quality control and accreditation measures

There are two engineering and engineering education regulatory bodies, in Sudan: the MoHESR and the Sudanese Engineering Council (SEC). While SEC has been in charged with licensing and registering of all engineering graduates, in the country, MoHESR has been dealing with recognition and accreditation of engineering education programs based on rigorous accreditation procedures. In addition, in 2003, MoHESR established an academic, technical, and administrative accreditation and evaluation unit, with the following goals: i) to improve the quality and the performance of the higher academic institutions, ii) establish self-evaluation units within academic institutions, iii) upskilling the human resources, and iv) adopt and disseminate a culture of quality (World Bank and MoHESR, 2020). However, none of engineering programs has even applied for an international academic accreditation, such as ABET. This means that all quality control and accreditation measures of engineering programs should be revised from international accreditation perspectives.

vii. *Inadequate Facilities for Engineering Education*

The low number and poor quality of engineering facilities (libraries, laboratories, equipment, instruments, and supplies) are far less than the need of engineering colleges. As well, shortage of supplies and consumables is a real obstacle for conducting practical and hands-on work necessary for teaching and training engineering students.

viii. Other issues

Absence of academic freedom and brain drain, between 1989 and 2019, have been attributed to the autocratic government during this period. Fortunately, and due to the ‘December 2018 Revolution’, academic institutions have started claiming their academic freedom (World Bank and MoHESR, 2020).

Poor research/publishing conditions is the main reason for too low research and publishing activities, especially in engineering with H-index of 34, which based on only 138 documents (in 2020), (Kenoma.com. World Data Atlas; SCImago Journal & Country Rank).

3. Engineering Education Research in Sudan

While searching graduate studies programs at UofK and Sudan University of Science and Technology (SUST), known as KPI, in addition to the google scholar, the researcher found a wealth of information about Sudanese general education (K-12). These studies split into: (i) descriptive research, without proper frameworks or models for evaluating the general education; and (ii) at a lesser extent, studies based on some learning theories and/or educational frameworks/models. Searching SCOPUS over the last 20 year, only 21 engineering related documents were found compared to more than 900 all education documentation, see Figure 2.

In addition to general education research, many descriptive studies were found about the tertiary education in Sudan; nevertheless, only a limited number of them were based on learning theories and frameworks. Examples are: ICT integration in technical and vocational education and training, Sudan (Ramadan et al., 2018); investigating the success of business intelligence in aligning higher education and labor market (Elhassan, 2020); barriers for implementing ICT for higher education in Sudan (Suliman et al., 2007); bridging higher education and market dynamics in a business intelligence framework (Elhassan & Klett, 2015); barriers facing English language teachers in applying the learner-centred approach; a business intelligence-based framework to align higher education output with labor market in Sudan (Elhassan, 2020); investigation of the ‘Learning Modes’ and its Learner-Centeredness in Higher Education Institutions in Sudan (Arman, 2020); investigated the challenges of implementing performance measurement systems (PMS), by one of the public Sudanese university (Alboushra et al., 2015); higher education in Sudan- a situational overview (Elhadary, 2010); change and development of higher education in Sudan (Mohamed & Abdul Rahman, 2020).

However, none of the above examples were addressing engineering education. In fact, only limited descriptive studies were related to engineering education, for instance: role of technical scientific research education in sustainable development and conservation in Sudan (Omer, 2011); trends in electronic teaching and learning in engineering education, (Taha, 2013); engineering education for sustainability and economic growth in developing countries, the Sudanese case (Abu-Goukh et al., 2013); biomedical engineering education challenges and opportunities in Sudan (Elhadary, 2010); and none of them were based on educational theories and/or proper frameworks. Without a proper framework, no one would be able, objectively, to identify factors that, negatively or positively, impact the engineering education in Sudan, and to lay out the foundation for designing learning environment capable of advancing the engineering education, as a whole, within the context of Sudan.

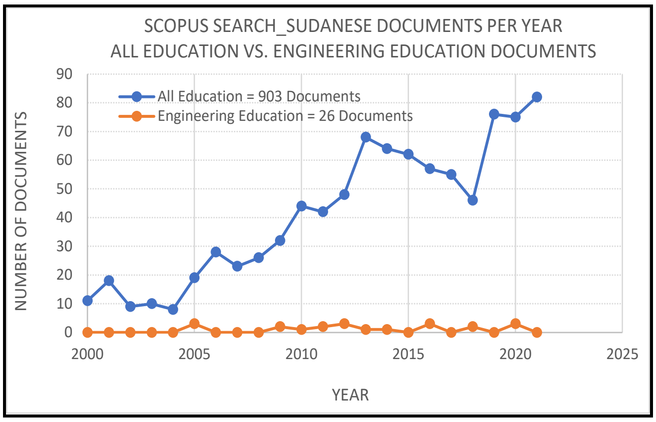

Figure 1. Sudanese Documentation- All Education vs. Engineering Education

Clearly, there is a big gap as far as engineering education research in Sudan is concerned. Therefore, there is a need for a lot of research efforts to fill the gap. This study is just a step in bridging this gap, and hence building better engineering programs for prosperous Sudan.

4. Proposed Solutions

The issues of the Sudanese engineering education are very deep and complex. Therefore, efforts for resolving them must be creative, patience, and inclusive, with input from all stakeholders. As well, solutions must consider the 21st century development in the areas of engineering profession and engineering education.

i. Curriculum Renewal

To graduate a high throughput qualified engineers, ready for the 21st century, with the right sets of knowledge and competencies, curriculum must be redesigned and must undergo continuous revisions. Curriculum renewal could be underpinned on the principle of flexible and extended curriculum:

Flexible curriculum should extend over a six-year period that includes 5-year engineering program in addition to an extra foundation year. The foundation year is to help students, who need it, to make a smooth transition from high school to college atmosphere. The foundation year may cover additional math, sciences, and pre-college engineering courses. However, the design of the curriculum should permit capable students to complete the engineering program in 4 years. In addition to foundational courses, the curriculum should include developmental courses to help engineering students to get through above-mentioned transitional points.

Overloading of engineering students with too many courses might not necessarily a good recipe for graduating knowledgeable and skilful engineer, ready for the 21st century. Therefore, re-design of a flexible curriculum should specify just required topics, including attributes, to graduate qualified engineers; then distribute all these topics over a 5-year program, with a logical sequence of concurrent courses, horizontal coherence, and successive courses, vertical coherence.

ii. Teaching and learning approach

Redesigned curriculum goes hand on hand with a suitable, learner-centred teaching and learning approach (T&L). In order to promote students' progression in engineering program, and to well-prepare engineers for facing 21st challenges, T&L approach could be underpinned on the following principles:

Constructivism: Biggs (1996) noted the significance of constructivism in improving the tertiary education because constructivism sees learners actively construct meaning by using individual and social activities. Constructivism is a widespread theory, which deals with human constructing their knowledge through experience and learning through active process (Newstetter, 2014). With the learner in control, he/she create and stores mental models (Bartlett, 1932; Dewey, 1916; Piaget, 1973 &1978; Glasersfeld, 1989). These learned models (constructions) vary among learners based on their prior experiences. Moreover, Price & Felder (2006) consider Problem-based Learning (PBL), Project-based Learning (PjBL), and Collaborative learning (CL) as strategies that most of the time follow constructivism framework.

How People Learn (HPL): HPL is based on three learning principles: active learning- learner in control (metacognitive skills) and educator act as a facilitator; learner constructs and stores models (cognitive) based on learner's prior knowledge; in depth knowledge (deep understanding); and student-centred learning philosophy.

Outcome-Based Education (OBE): Outcome-Based (OBE) was developed by W. Spady in 1994. Since then OBE has been adopted effectively by many countries worldwide. He believed that the purpose of school is to prepare learners for their role in life after school years, which could be achieved following what is known as transformational.

Constructive Alignment (CA): Biggs introduced CA to ensure that OBE is following constructivism theory, and to fill the gap between learning outcomes and teaching/learning activities. CA aligns assessment and teaching activities with learning outcomes (Biggs, 2011).

iii. Academic and non-academic staff

Teaching and learning, in tertiary education, are complex and hard because of a faculty multiple role in instruction, course and content design, material construction, mentoring and advising, etc. (Fink, 2008; Simonson et al. 2021); it requires three levels of appropriate faculty preparation: i) content knowledge, ii) general pedagogical knowledge, and iii) content pedagogical knowledge. The former content knowledge is based on a proper pre-service qualification; however, the latter two levels of professional knowledge are achieved through proper professional development programs, in-service training (Fink, 2008).

Therefore, the starting point to resolve the issue is to revise any malpractices, during 1989-2019, with the goal of identifying and eliminating all types of wastes related to staffing issues; then to develop and implement a hiring structure that focuses on recruiting and retaining qualified educators, with proper pre-service qualification, and linking their pay scale and promotion to professional development programs, in-service training.

iv. Research and publishing condition

Improving extremely poor research and publishing condition requires establishing research and publishing infrastructure: from publishing and printing materials, and organizing biannual Sudanese engineering and engineering education conference, to issuing Sudanese scientific and engineering journals. In addition, Sudanese scholars should research and publish topics that relate to Sudan, in local, regional and international forums.

Conclusion

There are many concerns fronting engineering education in Sudan. However, poor funding represents the main concern, which is directly affecting the infrastructure issues (inadequate human capacity, poor research/publishing condition, inappropriate facilities, inadequate educational technology and ICT environment, weak university/industry relationship), and indirectly affecting the issues of outdated engineering curricula and ineffective teaching and learning methods. The paper discussed and proposed solutions to increase the rate of well-trained engineers ready to face the 21st engineering challenges. Enough number of qualified engineers is a necessary condition for a sustainable development of any nation.

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Epistemology in Engineering Education: An Overview

Article history
Received
5 December 2021
Received in revised form
24 December 2021
Accepted
27 December 2021
Published online
28 December 2021

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Abstract
Epistemology is a branch of philosophy, a study of how a person knows and knowing. Engineering epistemology is one of the new disciplines in engineering education research. Unfortunately, little research has been done on engineering education. In this paper, epistemology is discussed in the general context then, specifically for the engineering education context. Furthermore, the engineering epistemology framework and instrument to investigate engineering epistemology among engineering educators and students have been presented. Theory for knowledge development has been discussed in general and how that developmental model is important for higher education. Finally, epistemology in teaching and learning has been introduced in the context of engineering educators and engineering students. In summary, engineering educators' epistemology will shape future engineers based on their class design. Therefore, developing engineering students from dualists to commitments of the relativist is very important. Finally, suggestions for engineering faculty management in developing engineering educators and engineering students for a better teaching and learning experience are provided.

Keywords: Epistemology, Engineering Educators' Epistemology, Engineering Students' Epistemology, Critical Thinking.

Introduction to Epistemologies

One of the branches of philosophy is epistemology. Epistemology comes from Greek words 'episteme' and 'logos' where episteme can be defined as 'knowledge' or 'understanding' or 'acquaintance' whilst logos brings a meaning of 'account' or 'argument' or 'reason'. Therefore, epistemology is a study of knowledge and knowing that concerns the nature and justification of human knowledge (Hofer, 2001; Hofer & Pintrich, 1997). The interest in epistemology is to know what knowledge is, how a person acquires it and what does a person knows.

Research related to epistemology was initiated by Piaget (1950) where he inquired about the individual development of the conception of knowledge and knowing. He used the term genetic epistemology and his work has grown with different terms such as epistemological belief, ways of knowing, epistemology reflection, epistemic belief, and reflective judgment.

A person who knows what knowledge is must be able to justify the knowledge as well as belief in it. To make justification, good quality, logical and reasonable evidence are required. Therefore, the two branches of epistemology are empiricism and rationalism (Ezebuilo, 2020; Shah et al., 2020). Empiricism obtained true knowledge from sensory for example by observation and experience. Nevertheless, rationalism is primarily based on reasoning such as rational and logical human minds.

As mentioned before, epistemology is a branch of philosophy but why it is important in the engineering field? Based on the definition of epistemology itself, a study of knowledge, epistemology in engineering is important in discussing the limits and possibility of creating and reporting new knowledge. Moreover, epistemology and pedagogical implication give a big impact in transforming the current engineering curriculum towards a holistic curriculum. As mentioned by Fatehiboroujeni (2018), an educator needs to have a conception of the field as a whole, of the aims, methods, and standards (Scheffler, 1973). For that reason, engineering educators should not only deal with skills and engineering knowledge only but need to equip themselves with a method to deliver the knowledge to non-practitioners, novices, or students. Hence, formulation of overall conceptions, methods, and standards of engineering and delivering those components to the curriculum of educator training is a task of philosophy of engineering (Fatehiboroujeni, 2018).

This paper is presented as follows. In the next section, engineering epistemologies are introduced. After that how knowledge is developed is discussed in the Developmental Model section. Then, epistemology in teaching and learning has been discussed in the context of engineering educators and engineering students. Finally, this paper is concluded by suggesting action that can be taken by engineering faculty management in improving better teaching and learning experience for engineering educators and engineering students.

Engineering Epistemologies

Barker et al. (2006) reported the five research areas for the new discipline of Engineering Education as engineering epistemologies, engineering learning mechanism, engineering learning systems, engineering diversity and inclusiveness, and engineering assessment. Engineering epistemologies are defined as research on what constitutes engineering thinking and knowledge within social contexts now and into the future.

A conceptual framework of engineering epistemology adopts from Yu & Strobel (2011, 2012) as shown in Figure 1. Engineering epistemology was renamed as engineering beliefs which consist of epistemological beliefs, ontological beliefs, and epistemic beliefs. The definition of epistemological belief is the same as mentioned before, but the knowledge will be in the context of engineering. Ontological is a branch of metaphysics that brings the meaning of the nature and role of reality. Therefore, in the context of engineering epistemology, the definition is defined as a belief in the reality that engineering deals with. Kitchener K. S. (2002) defines epistemic belief as a belief of knowledge. Yu & Strobel (2012) refer the knowledge as discipline and practice in engineering. In other words, epistemic belief in engineering epistemology based on Yu & Strobel (2012) can be defined as a belief what the discipline and practice in engineering.

The dimensions for each belief are listed in Table 1 (Yu & Strobel, 2011, 2012).

Table 1. Dimension of engineering beliefs

Engineering Beliefs	Dimensions
Epistemological Beliefs	• Certainty of Engineering knowledge • Simplicity of engineering knowledge • Source of engineering knowledge
Ontological Beliefs	• Realism • Pragmatism • Idealism
Epistemic Beliefs	• Human Sciences • Basic Sciences • Design • Crafts

The epistemological beliefs were adopted from Hofer & Pintrich (1997) that contain two areas: nature of knowledge and nature of knowing. Two domains within the area of nature of knowledge are certainty of knowledge and simplicity of knowledge while two domains within the area of nature of knowing are the source of knowledge and justification for knowing. However, Yu & Strobel (2012) incorporate justification for knowing into a source of engineering knowledge.

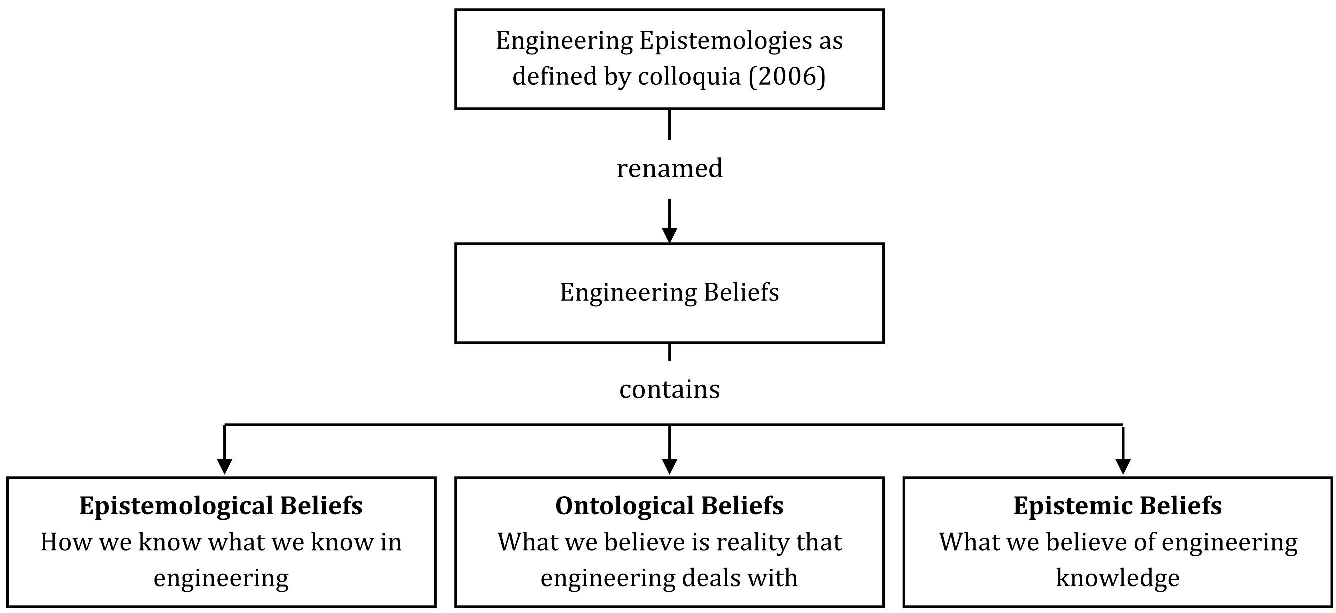

Figure 1. Engineering epistemology conceptual framework

The ontological beliefs were developed based on a unidimensional scale on the continuum (Yu & Strobel, 2012). Realist educators will deliver knowledge beyond textbooks and belief curriculum as a universal curriculum. They will educate their students centered on reality regardless of students' individual context. This is in contrast to idealism educators, that consider different student will have different realities. Therefore, idealism educators will use the approach as a facilitator. Moreover, pragmatism educators are more natural and apply multiple techniques in their class.

The epistemic belief, the domain-specific belief was adopted from four dimensions of engineering knowledge which are basic science, social science, design, and practical accomplished (Figueiredo, 2008). It is linked as a transdisciplinary view in engineering epistemology which combines engineers as a scientist, sociology, designer, and doer.

Faber et al. (2016) used the epistemological beliefs questionnaire developed by Yu & Strobel (2012) to measure epistemic beliefs among biomedical engineering students. Suggestion have been made by Faber et. al. (2016) to improve the questionnaires developed by Yu & Strobel (2012).

Furthermore, the instrument developed by Yu & Stroble (2012) should be tested on the reliability and validity since it is not widely used in the engineering field. As for now, epistemic beliefs resulting from the mutual interpenetration of the four dimensions as in Table 1 are not further investigated. Where epistemic belief can be general domain or specific-domain. For instance, in domain-specific, epistemic belief in electrical engineering students might differ from mechanical engineering students. In addition, engineering educators should be familiar with the terminologies, because the terminologies used are different among scholars based on their operational definitions.

Developmental Models

Each individual has a pattern in developing their beliefs about knowledge and knowing. Hofer & Pintrich (1997) discussed five models in a sequence starting with "the Perry Scheme" (Perry, 1970, 1981), "women's ways of knowing" (Belenky *et al*., 1986; Goldberger *et al*., 1996), the Epistemological Reflection Model (Baxter Magolda, 1992), reflective judgment (King and Kitchener, 1994) and Kuhn's attention to the levels of epistemological perspective which underlie argumentative reasoning (Kuhn, 1991).

Perry is considered by many as the pioneer of epistemological development studies of college students (Hofer & Pintrich, 1997; Muis, 2004). Using open-ended questions, Perry (1970, 1988) conducted two longitudinal studies in which he interviewed male college students about their perceptions of what influenced their college experience. He noticed changes in the students' thinking processes (Perry, 1970), and these changes occurred in patterns as they progressed through college (Perry, 1988). Using these patterns, Perry (1988) mapped the students' college experiences and developed the foundation of his epistemological development theory.

Perry's theory consists of four broad classifications that represent the students' overall views: in dualism, knowledge was based on one right answer from an authority figure, in multiplicity, knowledge was based on differing opinions, in relativism, knowledge was dependent on a given scenario, and in commitment in relativism, knowledge was a decision based on known information.

In engineering education, a number of researchers have explored students' epistemology (Faber et al., 2016b; Saavedra-Caballero et al., 2019; Zhu et al., 2019). Therefore, higher education is associated with the level of the developmental process. From the first year until the fourth year of study, engineering students are introduced to 21st century skills to prepare them to be able to integrate various knowledge in the problem-solving process.

Epistemology in Teaching & Learning

Engineering educators require a theory of knowledge to assist them to make sense of what they are doing and to give them control over their own inquiry processes. The theory of knowledge can be said as engineering educators' practical knowledge which means primarily an experiential form of knowledge developed by educators through their professional experience. Educators' practical knowledge can be categorized into three basic aspects which are sources, content, and process (Gholami, 2009). Therefore, engineering educators' practical knowledge relies on different backgrounds.

Engineering educators' knowledge can be measured by asking "whats, hows, and whys" of knowledge. The "whats" refers to the content, "hows" associated with the delivery methods, and "whys" reasoning between content and delivery methods to be tailored to specific disciplines. Unfortunately, engineering educators lack of pedagogical and philosophical knowledge (Pluskwik et al., 2020). Therefore, engineering educators have difficulty constructing activities to develop students' knowledge which causes current engineering students as dualist thinkers (Hamzah et al., 2012).

Epistemology is concerned about the way knowledge is delivered to the students and analysis of the concept in the educational environment that offers students the best learning experience (Saavedra-Caballero et al., 2019). Theory in epistemology is very helpful for engineering educators because it helps to reflect on the nature of knowledge which develops to criticize and reflect different ideas. This thinking can be implemented in the classroom to develop engineering students from dualism, to multiplicity, to relativism, and finally to commitment in relativism.

One engineering student, for example, will act on that knowledge and has a significant impact on society. Additionally, the engineering philosophy needs to examine the engineering knowledge and further analysis for deeper understanding. Based on (Kant & Kerr, 2018), engineering epistemology can be outlined in five themes such as the relationship between scientific and engineering knowledge, engineering knowledge as a distinct field of study, the social epistemology of engineering, the relationship between engineering knowledge and its products, and the cognitive aspects of engineering knowledge.

On the other hand, Frisque and Chattopadhyay state that through epistemic investigation the analysis of the social constructivist epistemology for students from two different computer programming classes can be identified. It aids students with debugging their conceptual understandings, which form the foundation of their cognitive models. At the same time, the study also allows them to spot flaws or limitations in that mental model prior to the real knowledge that they have. In the end, this promotes students to ensure that they successfully self-reflect upon what they are learning (Frisque & Chattopadhyay, 2017).

Another field implementation of epistemological development is done by (Zhu et al., 2019) which focuses on project-based learning (PBL) based on Perry's theory. In this work, demonstrations of students' relativistic thinking in PBL and factors related to students' relativistic thinking were investigated. The findings show students' epistemological thinking is represented in their ability to solve problems within restriction, conduct feasibility evaluations, demonstrate commercial awareness, and broaden their thinking. Meanwhile, factors such as professional mentoring, peer collaboration, communication with other stakeholders, project complexity level influenced their epistemological thinking.

Conclusion

This paper explored the epistemology in engineering education. Epistemology is important in engineering education because it will affect the way engineering educators design their content delivery (Saavedra-Caballero et al., 2019). After all, epistemology relates to the way educators deliver the content of the course. Therefore, the epistemology of engineering educators is influenced by knowledge of the course content and knowledge to deliver the course content. Senior engineering educators might have problems in delivering the course content only but new engineering educators might have problems with the course content as well as delivering the course content. As a result, current engineering students cannot criticize and reflect on the course content. They are focusing on identifying right or wrong answers for a given question or problem.

Engineering faculty management plays a vital role in transforming engineering students learning experience. As a suggestion, engineering faculty management should plan engineering educators for certain course and provide training related to the course content and delivery method. Developing engineering educators' knowledge related to the course content and delivery method up to commitment in relativism is vital before the engineering educators can deliver the content in a better way to the students. Dualist engineering educators cannot produce relativist engineering students. Another suggestion is to introduce team teaching, pairing senior engineering educators with junior engineering educators to develop a better teaching experience for junior engineering educators.

Acknowledgment

This work is supported by RUG vote 4C458.

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Designing Online Class using Discord based on Community of Inquiry Framework

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Article history
Received
27 December 2021
Received in revised form
27 December 2021
Accepted
28 December 2021
Published online
28 December 2021

Abstract
COVID-19 pandemic changes the landscape of education, where online learning becomes very important and can not be avoided. Therefore, this article discusses how a gamer's platform, Discord can be used as an interactive online class. A comparison of Discord with other online platforms is spelled out in a tabular form. The principle used to design the online class using Discord is based on Community of Inquiry (CoI). CoI consists of three elements which are teaching presence, social presence, and cognitive presence for a better educational experience. The design discussed in this article are Discord features design for the online class and class activity using Discord in developing the three elements in CoI. Data collection is done using open-ended surveys. They are 58 respondents with engineering and non-engineering students. Most of the students are familiar with Discord and agreed that Discord can be adapted for an online class. Thematic analysis is conducted to analyze the open-ended questions. The themes that can be identified are parallel channels, structure, all-in-one platform, facilitation, and learning environment. Another analysis is message counts in each student group to show how active the students in online class using Discord. In conclusion, Discord is the best platform to make students active and construct knowledge with peers.

Keywords: Community of Inquiry, Online Learning, Constructivist Theory, Discord.

Introduction

Online classes can be categorized as full online classes or blended online classes. Whereas, full online class means all students are remote while blended online class refers to mix in-person group of students and online students (Innovation, 2020). The COVID-19 outbreak had affected the education landscape where all traditional classrooms need to be conducted online. Most of the educators and students are not ready physically and mentally. Although online learning has long been introduced, not all educators had implemented it before the outbreaks. Therefore five challenges have been identified which are self-regulation challenges (SRC), technological literacy and competency challenges (TLCC), students isolation challenges (SIC), technological sufficiency challenges (TSC), and technological complexity challenges (TCC) (Rasheed et al., 2020).

Students easily feel isolated and alienated because they do not have face-to-face interaction with their new peers in online classes. In addition, lack of confidence, poor writing or language barrier, connection difficulty, and lack of trust in the online community will make them fall into isolation and alienation as well (Rasheed et al., 2020). As a result, they will hesitate to participate in online classes.

Bao (2020) suggested six instructional strategies to improve online classes delivery methods for a smooth transition from the traditional classroom to online learning which are 1) prepare for unexpected problems during online classes; 2) develop teaching content that last around 20-25 mins; 3) emphasizing "voice" because limited body language can be used during online classes; 4) working with teaching assistant to help unprepared students; 5) maintain active interaction outside class to provide feedback and 6) combining synchronous and asynchronous learning method.

The Community of Inquiry (CoI) framework has been introduced in education (R. Garrison et al., 2000) and identifies crucial aspects for a successful online class. Figure 1 shows the elements in CoI.

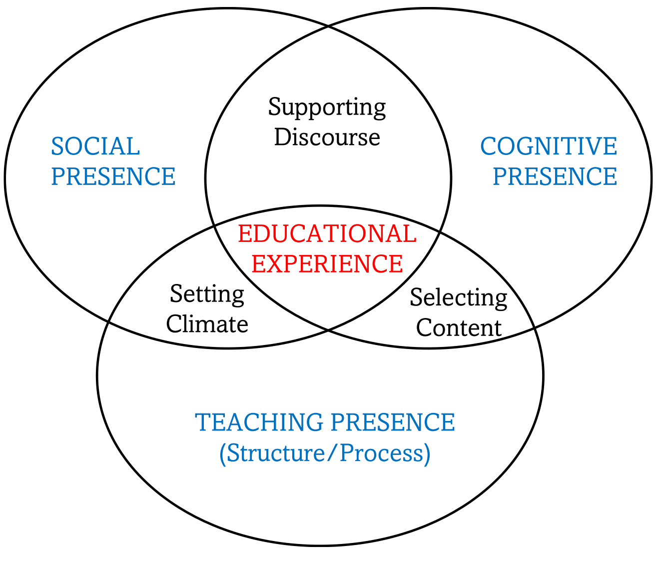

Figure 1. Community of Inquiry framework

CoI consists of three essential elements which are social presence, cognitive presence, and teaching presence that develop educational experience. Social presence creates open communication, group cohesion, and a trusted environment. Cognitive presence relates to learners who are able to construct and confirm meaning through the developmental phases of inquiry – a triggering event, exploration, integration, and resolution. The third element, teaching presence is linked with the design facilitation and direction of a community of inquiry. In summary, CoI is where "students listen to one another with respects, build on another's ideas, challenge one another to supply reasons for otherwise unsupported opinions, assist each other in drawing inferences from what has been said, and seek to identify one another's assumptions" (Lipman, 2003, p.20). CoI framework is based on the collaborative and individually constructivist learning experience.

The focus of this article is SIC. To overcome the challenges, CoI framework is referred therefore class design using Discord based on CoI framework is the main discussion in this article. The theory used is constructivism theory and will be discussed in the next section. Then, the introduction of Discord is introduced in the Discord section. After that, students' feedback will be discussed in the Findings & Discussion section before some concluding remarks.

Constructivism Theory

Constructivism is a learning theory that is based on the process of reflection and active construction in the mind to develop knowledge (Mascolo & Fischer, 2005). The key people who have contributed to the constructivism theories are Jean Piaget and Lev Vygotsky.

Piaget proposed individual cognitive structure where the focus is on the individual's reaction to the experience and to the process through which understandings are formed. Piaget believed that the new information is developed based on the learner's existing knowledge and modification of that existing knowledge.

Vygotsky introduced social constructivism which the focus is the interaction with others; knowledge is entirely viewed as a negotiated human construct. He believed that the origin of understanding is social. Vygotsky's theory is based on two main principles which are the More Knowledgeable Other (MKO) and the Zone of Proximal Development (ZPD).

Social constructivism may occur in online classes through both synchronous and asynchronous using video conferencing, breakout rooms, forums, and class groups. CoI emphasis achieving social constructivism in online classes based on cognitive presence, social presence, and teaching presence. Yet educators play a big role to demonstrate versatility and ability in online classes to tailor with the course outcomes because the quality of teaching can not be compromised.

Discord

The COVID-19 outbreak had affected Malaysia when the first case was reported in January 2020 and the number rose abruptly in early March 2020. Consequently, the Malaysian Government announced a Movement Control Order (MCO) on March 18, 2020 to help the Ministry of Health keep the spread and deaths under control (Shah et al., 2020).

Due to that reason, educators need to conduct online classes. In Mac 2020, the online classes had been conducted using Google Meet, Moodle, and WhatsApps. The synchronous class was conducted using Google Meet, all learning materials were posted in Moodle and WhatApps to connect with all the students asynchronously. Based on that practice, the problem with these technologies is that no social presence during synchronous class. Sometimes educators feel alone talking on Google Meet. Furthermore, when everybody goes online, Moodle servers always have a problem to be accessed. Therefore, educators need to plan for a backup situation. WhatApps group is created for each class but missing community features like conversation moderation, a stated commitment to inclusion, and expert assistance (Farah & Eagle, 2021). Due to this deficiency, Discord was suggested by a student in class feedback and reflection for interactive online learning.

Discord had been explored since June 2020 and it is found that Discord was introduced in 2015 for the social gaming platform. It is a free application incorporating text chat, voice, and video. It can be accessed via desktop app, mobile app, and web app. Comparative online platforms that are commonly used for online classes are spelled out in a tabular form in Table 1.

Based on Table 1, two interesting Discord features are a multiplayer screen and a parallel channel. The multiplayer screen feature allows more than one person to share their screens thus students can easily share screens and compare their works. On the other hand, the parallel channel feature makes the conversation between students-students and students-instructor become never-ending and educators can observe as well as assist each group of students throughout the semester. Due to this reason, it is believed that teaching presence, social presence, and cognitive presence can be achieved.

Discord features have been listed in Table 2 while Figure 2 illustrates multiplayer screen features and parallel channels.

Table 1. Comparative features of different online platforms

Features	Zoom	Webex	Google Meet	WhatsApp	Telegram	Facebook	Discord
Desktop + Mobile Messaging	√	√	√	√	√	√	√
Individual text message	√	√	√	√	√	√	√
Multiplayer screen	X	X	X	X	X	X	√
Parallel channel	X	X	X	X	X	X	√
Restriction on the number of users	Depend on package	X	X	256	200k	X	X

Table 2. Discord features

Features	Functions
Servers	Spaces that can be used as an online classroom.
Category	Allows managing multiple channels in the same category.
Channels	
Text	Spaces to post messages, upload files, share images and can be assessed at any time.
Voice	Spaces to conduct an online class and students can talk and collaborate.

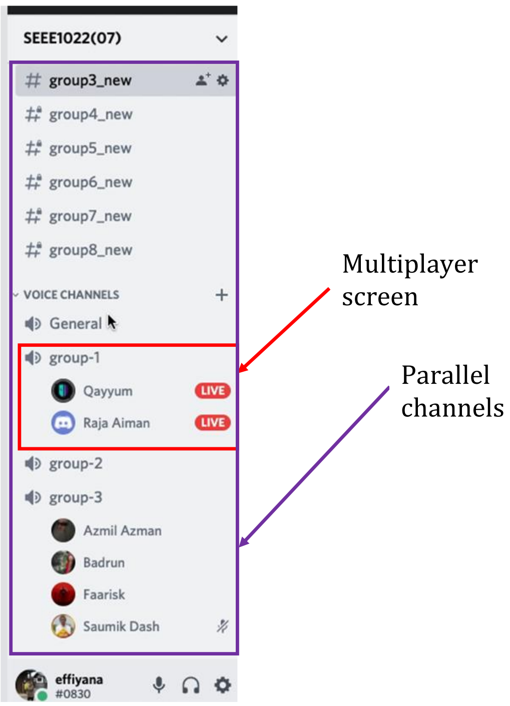

Figure 2. Advantages of Discord

Class Design

In this section, the implementation of Discord in the online class from October 2020 until present day will be shared. The improvements that have been made will be discussed. Discord was first implemented in Introduction to Scientific Programming, Capstone, and Graduate Success Attributes courses in Semester 20202021-01. Then, continued in the following semester for Electromagnetic Field Theory course and now in the Signals & Systems and again Graduate Success Attributes courses.

In the first year of implementation, Discord is used to replace Google Meet and WhatsApp groups. All learning materials were posted in Moodle. Figure 3 shows the Discord display in the Introduction to Scientific Programming online class.

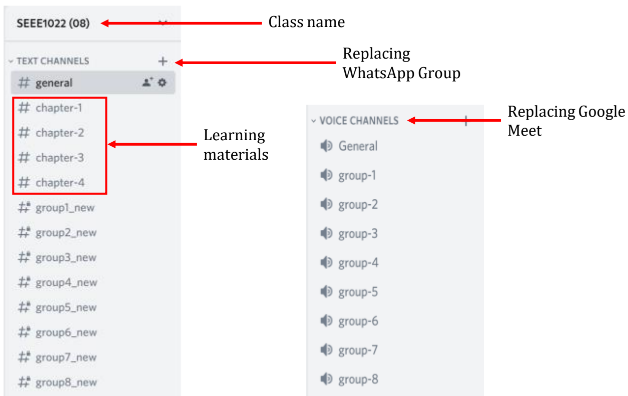

Figure 3. First-semester implementation

As can be seen in Figure 3, the Class name SEEE1022(08) is known as Discord server. Under this class, text and voice channels were created for each students' group, labeled such as group1_new for the text channel and group-1 for the voice channel.

The text channel for each group acts as a WhatsApp group and now easy for an educator to monitor all their students. Compared to the previous semester when the WhatsApp group was used, only one group was created for all students thus students created their own

WhatsApp group for group assignment. A problem occurred, when there is a member who did not contribute to the group assignment. It was difficult to show evidence and monitor on this issue throughout the semester. On the other hand, Discord is more organized compared to WhatsApp.

Other channels were created named as chapter-1 until chapter-4 for discussion based on the chapter. However, it did not work as no students posted in that channels. Nevertheless, they love to discuss within their small groups.

After a year of implementation, improvement has been done and a model is proposed in Figure 4. Discord is combined with Google for teaching and learning activities during online classes. One class server consists of several categories as depicted in Figure 5.

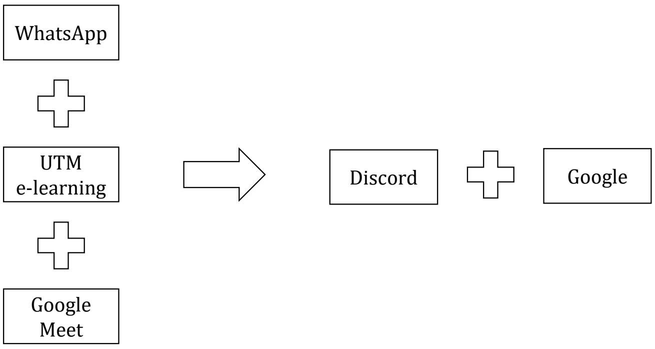

Figure 4. Online learning model using Discord

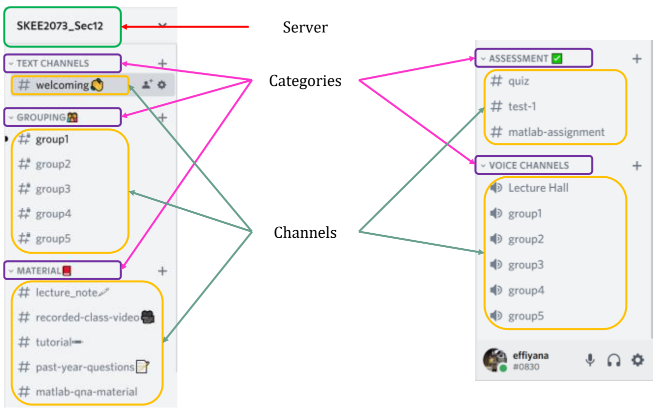

Figure 5. Class design in Discord

As can be seen in Figure 5, four text categories are created; Text Channels, Grouping, Material, and Assessment. Emoji has been added to make the appearance interesting compared to the first design in Figure 3. Due to this, Moodle is not the main platform to share the learning materials. Furthermore, class planning is not affected anymore because everything can be controlled by an educator.

In the welcoming channel, all students who entered the server will be greeted (Figure 6).

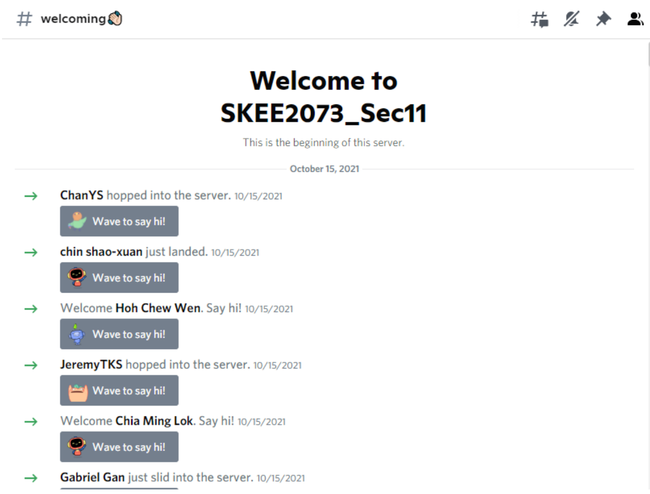

Figure 6. Welcoming message in class server

Under the grouping category, private groups for each students group have been created. Each group channel is set to private, thus only members of the group can view the channel. In this case, five groups are created, and each group consists of three to fours students as illustrated in Figure 7. An educator can view all the channels because the educator is the admin of this server. A teaching assistant can be assigned as admin in the class server as shown in Figure 7.

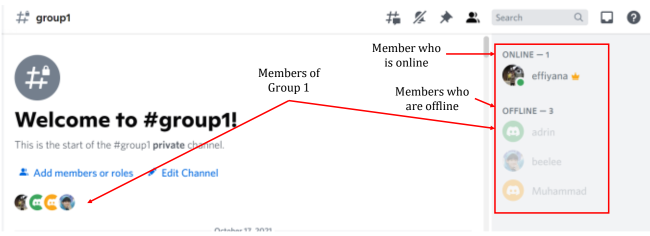

Figure 7. Private group

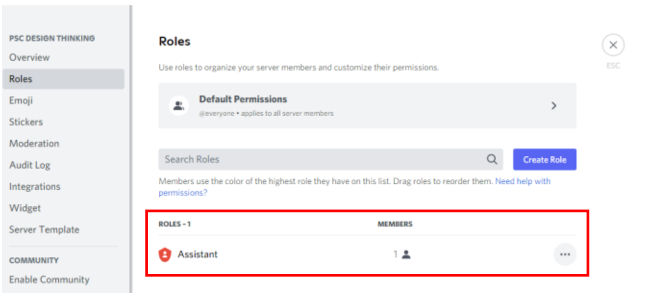

Figure 8. Adding another admin to the class server

In the material category, five channels are created related to the course materials and the students do not need to log in to the Moodle platform anymore. In the assessment category, channels related to assignments such as quiz, test and assignment are created. During the assessment, students will focus on the specific channel to get information about the question, the password to open the question, and the Google form link for assessment submission. Therefore, the information does not mix up with others, even structured.

In the voice channel category, one voice channel is created as a lecture hall for lecturing, and another five group channels for each students group. The voice channel is opened so that students are free to move from one voice channel to another voice channel for discussion. This is how Discord is designed for an interactive online class.

The activities that have been implemented in the online class to support teaching presence, social presence, and cognitive presence have been tabulated in Table 3.

Findings and Discussions

Data were obtained from 58 students who use Discord in class and participated in a brief survey. Only 19 respondents were new to Discord; 10 non-engineering students and 9 engineering students. Non-engineering students thought it was difficult to use Discord for the first time but engineering students felt fun and comfortable using it. From this finding, it is suggested to prepare an introductory video to help the new users to use Discord for the first time especially for students who are non-engineering backgrounds. Respondents who had experience with Discord before joining the class, usually use it for gaming and entertainment such as watching movies together with their peers. One respondent commented, "I never think that this gaming platform can be used for the online classroom."

Open-ended questions have been included in the survey. The questions are:

1. Do you think that Discord is useful for teamwork experience? Why?
2. Do you think that Discord helps you to engage with your instructor and peers? Why?
3. Do you think that Discord motivates you during online classes? Why?

Thematic analysis has been used to analyze the open-ended questions. Table 4 demonstrates the themes and codes identified.

Table 3. Activities design to support CoI

CoI Elements	Activity	Description
Social presence	Ice-breaking	In the first meeting with the students, they will be informed about teaching philosophy and the role that is expected from them in that course. After that, they will be assigned into a group consisting of three to four students and the group are permanent throughout the semester. In Discord, they are assigned to the private text channel based on their group number. Then, the students need to introduce themselves to their group members using group voice channels and creating group rules in Jamboard. After they finish this round, they will randomly join other voice channel groups to virtually meet with their peers.
Cognitive presence	Tutorial	The students are given questions that from books, quiz, test, or past year final examinations. Sometimes the same questions are given to all the groups and sometimes two groups are assigned with the same questions. Each group needs to prepare the answer in Google Docs or Google Slides. After each group is done with their solution, they moved to another group for discussion to check whether their understanding is correct or not. The educator joined the discussion and checked their understanding. If they have a misconception, the educator can help the students by prompting questions that can help them to construct a correct understanding. The educator tries to avoid giving solutions or answers directly. After each session, students need to write their reflections based on the activities and understanding.
Teaching presence	Design and organization	Teaching presence is related to design and organization, facilitation, and direct instruction (D. R. Garrison, 2011). Discord and all the activities are designed to support teaching presence, where the educator act as a facilitator rather than giving direct instruction to the students. Furthermore, the educator created one Google Drive for each group and shared the link in each private group text channel, then the link is pinned. It is easier for the educator to facilitate students' works or activities and students have easy to access them too. All elements can be organized systematically in Discord.

Table 4. Theme and codes identified

Themes	Codes
Parallel channels	• Group class activity • Private group discussion • Group class monitoring • Media sharing in the channel throughout the semester • Join or leave a group without interrupting the whole class • Easy to chat and listen at the same time • Reactions for selected messages in the text channel
Structure	• Easy to navigate • Less group created • Creating guideline channels • Organize in different categories
All-in-one platform	• No need to create a meeting link • Join a meeting, send documents and images, and discuss in Discord
Facilitation	• Easy to talk with the instructor • Instructor join group channels to give suggestions or recommendation • Immediate ask instructor in the private group channel • Use tagging to call instructor for help • Instructors can monitor all groups at the same time • Track assignment progress • The instructor makes sure students are on track
Learning environment	• Easy to communicate with peers • No more free riders • Feel like a classroom • Class more fun • Feel relaxed because can do homework while listening to the music • Community of people in the server • Motivate to study when realizing other members in the channel

The themes and codes identified in Table 4 shows teaching presence, social presence, and cognitive presence are created during the online class (D. R. Garrison, 2011). In addition, the educators do not feel lonely anymore in the online classes.

Another data that is analyzed is message counts in each group in the Signals & Systems course. The reason is to share how active the students communicate during synchronous and asynchronous classes. This group discussion is better than a forum in Moodle because it is a casual discussion.

The data was collected from mid-October until mid-December 2021 and reported in Figure 9 for Section 12 and Figure 10 for Section 11.

Besides monitoring group discussion, individual messages in the group can be analyzed in Discord. Therefore, the educator can detect who is not communicating with other members of the group. Then, private message will be sent to the student personally, asked his/her problem, and will be adviced accordingly.

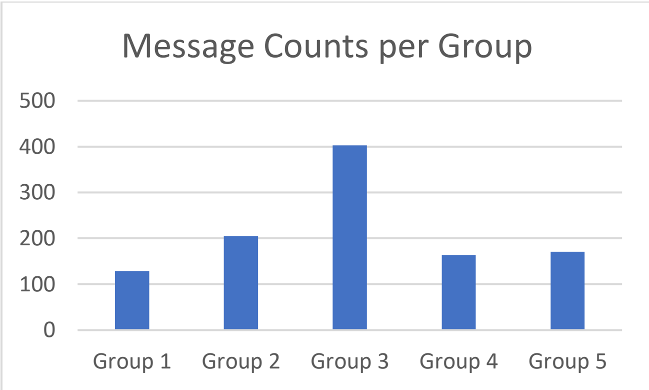

Figure 9. Message count in Section 12

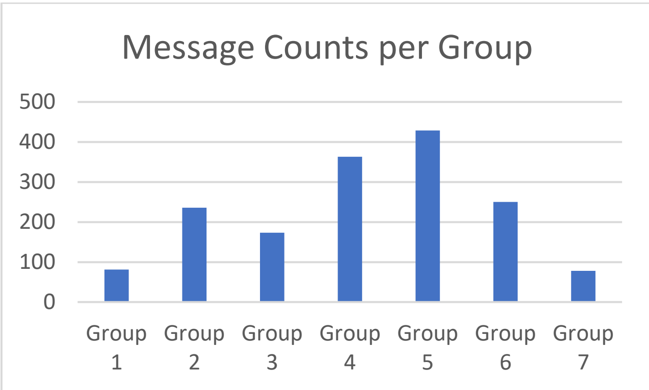

Figure 10. Message counts in Section 11

The message counts reflect the class attendance. Groups that have less than 100 messages are facing a problem with members who are always absent from the class. By knowing this, the educator can contact those students privately and monitor their improvement.

Conclusion

Online learning is different from traditional learning. Therefore, it is not simply converting traditional class activities into online class activities. An appropriate theory of learning should be referred to.

CoI framework has been used to design Discord for online classes. The CoI framework is based on constructivism theory. It means that a platform that can help to construct students' understanding based on social interaction is needed. Based on the two interesting Discord features which are multiplayer screen and parallel channels, Discord is chosen for the online classes.

Based on the findings, Discord is an all-in-one platform that makes educators' and students' online classes more interactive and fun. The learning environment in Discord makes students feel as in a class.

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