Online STEM mentoring program for service-learning experience among first year engineering technology undergraduates

Aliza Che Amran[1*], Muliati Sedek[2], Rozilawati Mohd Nor[1], Dayanasari Abdul Hadi[1], Saleha Mohamad Saleh[1]

[1)] Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia
[2)] Pusat Pembelajaran Bahasa, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

[*]Corresponding e-mail: aliza@utem.edu.my

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ABSTRACT – Due to the pandemic, school and university education have been shifted to digital learning in order to comply with Movement Control Orders imposed by the government. This paper explains the design and implementation of an online mentoring program conducted by undergraduate students to teach and facilitate learning among secondary school students particularly in science, technology, engineering, and mathematics (STEM) related topics. This online mentoring program was implemented under a realization of a project called as STEM Mentor Mentee project. It was conducted systematically for one of the engineering technology courses and had embedded a community service pedagogy as part of the course curriculum. This program had provided opportunities for the students to gain new experiences beyond conventional lectures and laboratory sessions particularly in servicing the community.

1. INTRODUCTION

The COVID-19 pandemic has changed the education landscape dramatically and this had led for school and university education to shift into digital learning in order to comply with Movement Control Orders imposed by the government. Based on Circular by Ministry of Education, home-based teaching and learning or *Pengajaran dan Pembelajaran di Rumah* (PdPR) will be carried out by teachers and school students at their homes respectively [1]. The digitization transition phases i.e., online learning is challenging not only to the educators, but also to the students at any all levels of education including universities. Therefore, undergraduates do not have a choice but to attend to their classes fully online including their final examinations. Eventually, when the pandemic is becoming under control, the university will start to be opened to all students. For Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik (FTKEE) of Universiti Teknikal Malaysia Melaka (UTeM), the faculty has decided to allow first year students to enter the university for their face to face laboratory sessions in Semester 2 of academic year 2020/2021.

The Science, Technology, Engineering and Mathematics or STEM online mentoring program is a community service learning program has been designed and implemented for first year FTKEE students who enrolled BEEI 1323 Electrical and Magnetism course in Semester 2 of academic year 2020/2021. BEEI 1323 is a three-credit course where the total notional hour or student learning time is 120 hours for the semester (14 weeks). This is the first time where the course has diffused and adopted an innovation in the course teaching method that is community service pedagogy through STEM Mentor Mentee Project 2021.

For program funding, this program managed to allocate a funding from a grant awarded by Ministry of Science, Technology, and Innovation (MOSTI). The grant was allocated for Universiti Malaya (UM) STEM Center and National STEM Association (NSA) under a project called as STEM Mentor Mentee Project 2021. Moreover, the main author of this paper is a member of the grant, and she was appointed as the university coordinator and expected to achieve the project deliverables in the given timeline set by the sponsors.

Previously, STEM Mentor Mentee Project 2019 was implemented physically. All mentors were among UTeM's undergraduates and their involvement are based on a voluntarily basis. However, in 2020, the project was postponed due to the pandemic and for 2021, the implementation of the project is re-designed from face-to-face mode to fully online.

Mentoring is potentially one of the most effective promotional measures in pedagogy [2]. Offline mentoring programs face several problems that online mentoring or e-mentoring programs can address because geographical distance, for instance, often restricts the frequency of meetings between mentor and mentee. Kram's (1983) original work in mentoring research focused on classical (i.e. hierarchical) mentoring, and its model mentoring divides mentoring functions into career-related and psychosocial [3]. The same applies for this mentoring program.

This paper intends to report on how STEM Mentor Mentee Project 2021 was designed and implemented. A survey was designed and conducted to identify the perspective of STEM mentees towards the program. Also, observations done by course lecturer on mentors during the program were also described.

2. DESIGN OF STEM ONLINE MENTORING PROGRAM

Ministry of Higher Education (MoHE) has promoted and encouraged an e-SULAM approach for the public universities to adapt to. "Service-Learning

Malaysia-University for Society" or SULAM is a concept in which the university students will address local community needs and issues using their knowledge and skill [4]. This community engagement initiative not only benefits the community, but also will benefit the service providers, i.e., the students themselves, in developing their well-being and soft skills. In 2021, SULAM is rebranded to e-SULAM, indicating the service-learning is changed from fully face to face to partially or fully online or electronically through the internet.

The integration of service experiences into curriculum offers teachers or lecturers a powerful pedagogy. As for students, service learning provides an opportunity for students to learn in an active and participatory way [5].

As mentioned earlier, there are two main stakeholders need to be addressed in this program. They are the STEM Mentor Mentee 2021 project grant providers and BEEI 1323 course implementation under the faculty program requirement. After some consideration and endorsement by the faculty, e-SULAM approach will be applied to deliver BEEI 1323 course. At the same time, the course implementation will also be used to achieve STEM Mentor Mentee project deliverables. The following will list processes involved in designing the program. It will cover four important elements in instructional design (ID) [6], i.e.

(1) Who is the design for?
(2) What will the learners learn?
(3) How will the subject content be taught?
(4) How to evaluate whether the learners achieve the goals?

To distinguish better, ID for primary learners or mentors (BEEI 1323 undergraduate students whom provide the community service) is at course and faculty level. Meanwhile ID for secondary learners or mentees (the Form 3 secondary school students whom receive the community service) is at class and school level.

2.1 Who is the design for?

The sponsors have named two rural secondary schools to be involved for this program. They also set a minimum number of students to participate per school. Therefore, the minimum number of participants for the STEM Mentor Mentee project is about 140 mentees and including only Form 3 classes. The mentoring sessions will be designed to facilitate them in understanding STEM related topics i.e. electricity and magnetism.

Meanwhile, at the BEEI 1323 course level, there are three first year programs enrolled for the course and the faculty has agreed to choose only one programs to be involved, that is BEEA program. The total number of studnets involved is 54 studentwith a variety of academic backgrounds, i.e., most are polytechnic diploma holders and matriculation graduates, and small percentage are STPM school leavers.

2.2 What will the learners learn?

Both learners will learn about STEM on electricity and magnetism because these are the topics that have similarites when comparing BEEI 1323 syllabus to Form 2 Science syllabus from the KSSM textbooks. Then, to refine the topics, Yearly Lesson Plan or *Rancangan Pengajaran Tahunan* (RPT) from the schools' Science teachers are used to design for mentees' objectives. The RPTs are very helpful to tone down and simplify university syllabus to school level, as specified in the textbook or KSSM curriculum.

For example, in the electromagnetic topic which is one of the topics under this mentoring program, mentees will learn to understand that metals wrapped around and how with one piece of wire can turned into a magnet whenever current is flowed through the wire. But for mentors, the electromagnetism content (of BEEI 1323) extends to the understanding of the Faraday's Law and applying the law to solve problems related to it as well as a portion on numerical calculations. For mentors, they will learn on engineering concepts and numerical problems that are s appropriate at university level. For example [7] highlighted that students' difficulties were on applying the concepts of electromagnetism in an introductory course at university level. They found out that the students' form of reasoning at secondary school was important to make their form of reason at university level better. Recommended teaching order for electricity and magnetism were also reported in [8].

2.3 How will the subject content be taught?

As for mentors, the main objective is to achieve the desired course learning outcomes through the mentoring activities. Basically, they are taught the course contents through online lectures and conduct experiments physically in laboratory sessions at the faculty. Upon course level content completion, they are be given time to communicate with their mentees and prepare materials for the five mentoring sessions. During the community service, the communications between mentors and mentees are be carried out through online applications e.g. Telegram or WhatsApp. As for the mentoring sessions, Google Meet application is used. These mediums are the common applications used by school teachers in order to deliver their home based teaching and learning, PdPR [9].

2.4 How to evaluate whether learners achieve the goals?

Mentees' achievement is evaluated by their respective mentor after each mentoring session. Mentors have prepared online quizzes to observe their teaching method effectiveness. For mentors, they are assessed via course assessment rubrics set by the lecturer. They are assessed on their ability to observe and understand their mentees learning achievement, specifically for each topic. Apart from this, the mentors' ability to prepare informative and helpful learning materials are also be assessed. To obtain mentees' feedback on the online mentoring program, a short survey was conducted. This will be further explained in Section 3.

3. IMPLEMENTATION OF STEM ONLINE MENTORING PROGRAM

The design of the program are explained in Section 2. This Section 3 elaborates the results of the online STEM mentoring program.

3.1 The lecturer's observation

The following explains the observations made by the main author as the course lecturer. These observations were made by studying on how the mentors react and respond to every challenges that they faced throughout this mentoring program.

Initially, the most challenging task was for mentors to communicate with the mentees. As reported by the local news, many teachers were struggling to keep in contact with their students. The purpose was to monitor closely their participation in the school online classes or PdPR. It was even more difficult for mentors to make the first contact and persuade mentees to join the online classes outside of school hours. Some of the mentors reported that they were blocked by mentees because they were thought to be scammers and so on. However, by the help of school teachers and the endurance shown by the mentors, they finally managed to invite the mentees to their first session with their mentor.

In the mentoring, a mentor was assigned to facilitate three to five mentees. It was observed that each mentor took the responsibility and made proper preparations before the online learning sessions took place. The pressure to teach has made them try to retrieve what they had previously studied or taught before. The lecturer found out that the students tend to ask more critical questions and with more depth when they were preparing their teaching materials compared to Q&A sessions after course lecture.

For an example, in Chapter 1 of the course, students learnt about electric current. They will learn that movement of electrons create current flow in the reverse direction. Due to pressure to teach their mentees through this program, for the first time, the lecturer had been asked by mentors on atom's properties and valence electrons. Interestingly this question was rarely discussed in any conventional classes before. It was found out that mentors were making an extensive preparations before teaching their mentees.

Through the program, it was also observed that mentors had gained experience in using available applications to create effective online classes. In conventional online classes, many students tended to be only participants of online sessions. However, by being a mentor, the students had to organize their own online sessions. They learned how to use various virtual webinar platforms and had the opportunity to explore additional applications to conduct online quizzes (such as Mentimeter, Google Form and Kahoot!) other extra features of social messaging application in Telegram and WhatsApp such as polling and others. The mentors had shown proactive efforts in exploring and leveraging the online applications on their own.

3.2 A short survey questionnaire and results

To understand how mentees respond to this mentoring program, a short survey has been conducted by the mentors. The survey was conducted after the second session week, and was opened for two days only. A total of 58 mentees (41.42%) answered in this short and quick survey. The reason for the short opening was because the survey data was needed to be used in a pitching session for this program at the national level.

There were three statements given and the respondents were required to state their level of agreement to it. The respondents or mentees have to choose either to "Highly Agree", "Agree" or "Do Not Agree". The questions are as shown below: -

> ***Q1:*** *My mentor answered the questions given to them and their answer helped me to understand better.*
> ***Q2:*** *My mentor prepared good teaching materials and these materials helped me to understand electricity and magnetism better.*
> ***Q3:*** *With the help of my mentor, I was able to enhance my understanding in electricity and magnetism topic.*

As a result, none of the mentees answered "Do Not Agree" to any of the statements. For Q1, a total of 97.10% was totally agree with the statement. This item was the highest agreement percentage compared to the other two questions. Both Q2 and Q3 gained 85.70% and 91.40% respectively.

Apart of this short survey, some of the mentors even request personally from mentees on their opinion about the mentoring program. Most of the feedback also agreed that they gained benefits from the mentoring program because the mentors had really helped them in understanding the E&M subject. The explanations and numerical examples shown by mentors have really changed mentees' perception towards Science, particularly on E&M topics.

4. DISCUSSION

As mentioned earlier, the main objective of the mentoring program is for the undergraduate students to achieve their learning objectives in BEEI 1323 course. This program proves that by diffusing and adopting community service learning innovation into the faculty course enables the students to gain valuable and priceless experiential education.

This learning-by-teaching approach makes the students become very critical in understanding the topic correctly and clearly before handling the webinar sessions with mentees. They are really worried that they might have taught something that is wrong or misunderstood the mentees. To avoid this from happening, students are making extra efforts on preparing without any hesitation. They are happy and satisfy when their mentees thank them for their effective learning sessions.

Based on authors experience from conducting this program, they believe that, to make any mentoring program successful, there are some steps required to be

fulfilled. Firstly, do short meetings frequently. This applies to all, i.e., instructor-to-mentor and mentor-to-mentee meetings. For example, the STEM Mentor Mentee project has outlined at least five number of meetings within a 12 week period. The schedule set is at 40 to 60 minutes for each meeting. This is better than conducting one day program in one shot.

Secondly, take advantage of the online mode. In online environment, there are opportunities to create a unique and meaningful experience by leveraging the available online applications. One may design creative teaching materials, create conducive student-centered online sessions and design online quizzes and forms for immediate feedback autonomously.

Thirdly, for online classes, the instructor has to provide synchronous and asynchronous sessions for their students. Both methods have great significance in making the online learning class effective. Live mentoring is vital. In this program, the small ratio of mentor to mentee (1:3 or 5) enable the live mentoring session to be fruitful.

This mentoring program has proved that both mentors and mentees gain benefits. Through SULAM, authors have innovated the course implementation enabling students to gain deeper understanding of course content, a broader appreciation of the discipline, enhanced sense of personal values and civic responsibility.

However, despite of all the advantages and benefits, community service learning still is not popular and there are a lot of room for improvement on its implementation. Perceptions such as “service learning implementation means huge amount of work”, “it is impossible to suit my course to service learning”, “embedding service learning requires high budget” and so on could be solved. One of them is by creating culture change and beliefs at the faculty level. Key to this viewpoint is the identification of collective attitudes, beliefs, and values about teaching, learning, and community, and an understanding that shared principles can effect cultural change [10].

5. CONCLUSION

Service learning has helped students to develop social responsibility and an ethic of service to the community. This online mentoring program has been successfully completed. The permission to implement of BEEI 1323 using SULAM pedagogy has made the realization of STEM Mentor Mentee 2021 voluntarily program more structured and systematic.

It is important to highlight that, not all lecturers are prepared and willing to adopt community service learning in their courses due to lack of knowledge and skill. However, with a proper guidance and continuous support from the faculty and university management, service learning could become the main program to train and educate students to become a well-rounder and this gives them motivation to work harder in the future as well as placing the university to be solution providers for the community.

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