Innovative Flipped Learning Engagement Model for Technical and Engineering Students in TVET Context

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ABSTRACT

The present case study investigated the effects of a Massive Open Online Course (MOOC) based Flipped Learning Engagement (FLE) model approach on students' overall achievement and problem-solving ability in an undergraduate computer programming course at Universiti Teknikal Malaysia Melaka (UTeM). The existence of MOOCs and various new educational technologies offer a new way in designing flipped learning (FL) for Technical and Vocational Education and Training (TVET). However, guidelines and analysis of the feasibility of MOOC-based flipped learning are still lacking. Other researchers lacked understanding regarding the effectiveness of using MOOCs and flipped learning especially for teaching technology and engineering-based TVET students. Participants are 72 undergraduates' students taking Programming Techniques courses from technology and engineering faculties. In this study, a quasi-experimental design was used to evaluate the effectiveness of the proposed MOOC-based FLE model approach. The results of the independent t-Test showed that TVET based students who followed the MOOC-based FLE model approach demonstrated better achievement as compared to those in the conventional learning group. In addition, the study revealed that TVET students who learned using the MOOC-based FLE model approach had stronger problemsolving abilities than those who learned with the conventional classroom learning approach.

Keywords—Flipped learning, Massive Open Online Course (MOOC), Flipped learning engagement model, Computer programming, TVET education

INTRODUCTION

A. Online Learning

The use of educational tools has increased, and the spread of networking technology has largely changed elearning practice. The term 'e-learning' can be defined as facilitated learning that is supported using Information and Communication Technology (ICT). Therefore, the concept of 'e-learning' covers the use of computers and technology as major tools for the exchange of knowledge within teaching and learning, especially for Technical and Vocational Education and Training (TVET). These include several activities using technology to promote the learning process in an online mode [1].

Online learning is a major step forward in teaching TVET students, which means that students will be exposed not just to face-to-face (F2F) interactions, but with other mediums such as video, forum, activities, animated slides and online discussion [2][3]. E-learning also promotes the use of technology to support a wide range of educational activities [4]. Is this strategy appropriate for students studying technology and engineering in TVET higher education institutions?

B. Massive Open Online Courses

E-content is also essential for the development of the local learning system. One method is to use Massive Open

Online Courses (MOOCs) with flipped learning (FL) approach. The advent of MOOC has offered a new option for designing FL. Typical FL assumes a common designer of both face-to-face and online learning [5]. Teachers can flip their courses using MOOCs developed using in-house content or from other institutions. MOOCs have not been "normalized" in teaching and learning practice especially for engineering and technical TVET based students [2].

In previous research, MOOCs have been implemented as blended learning modes [2][6][7] for wearable technology to enhance technical MOOCs [8], and gamification in MOOCs [9]. Other researchers have investigated the effectiveness of reverse classes in teaching an introductory programming course to college students [10]. However, analysis of its feasibility and advantages both from pedagogical and psychological perspectives is still lacking although there are few studies conducted on students' perceptions and behaviors, and comparisons between traditional learning and MOOC-based flipped learning [11].

One of the concerns and key elements to make online study and flipped learning approach successful is student engagement. The low completion rate of MOOC is a result of a lack of enthusiasm for the course engagement to motivate TVET students toward participation [12]. For non-technical subjects, engaging students in MOOCs environment suit very well. However, for technical TVET students, especially computer programming courses involved significant challenges because such MOOCs must be able to offer practiceoriented learning and problem-solving skills for the MOOCs to be effective and engaging [13].

C. Flipped Learning Engagement Model

This present study discusses a new MOOC-based Flipped Learning Engagement (FLE) model and evaluates the effects of the proposed model implemented in a computer programming MOOC called Programming Technique by conducting a quasi-experimental investigation. The main objective of this study was to investigate what effects the proposed MOOC-based Flipped Learning Engagement (FLE) design model would have on students' achievement in an undergraduate computer programming course.

The research questions investigated in this research are as follows: (RQ1) Would the proposed MOOC-based FLE model approach improve students' achievement in learning computer programming courses? and (RQ2) What differences in students' achievement on problem-solving skills can be observed between classes adopting MOOC-based FLE model approach and the traditional F2F learning after the course.

METHODOLOGY

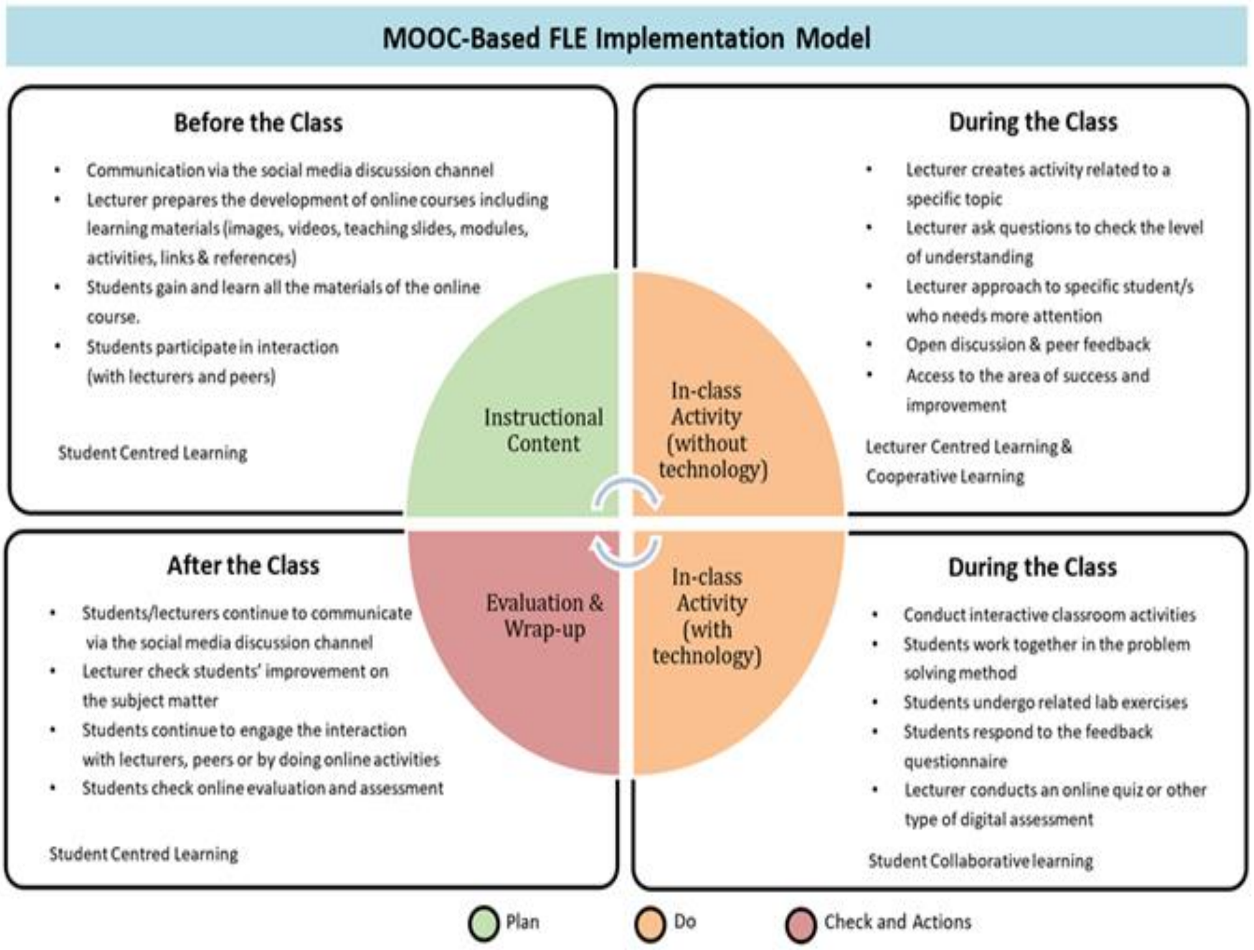
In this study, a quasi-experimental design was used to test and evaluate the effectiveness of the proposed MOOC-based FLE. Quantitative and qualitative data collection methods were conducted to allow participants to get a more comprehensive understanding of students' experiences in the MOOC-based flipped-learning environment. There were two types of data collected: (i) overall students' achievement data collected via pretests and post-tests taken by the control and experiment groups, and (ii) students' achievements in problemsolving skills via pre-tests and post-tests.

A. The Development of a MOOC-based FLE Model

The conceptual model of the MOOC-based FLE approach for the study is propose based on secondary data collected from literature reviews and expert panel discussions conducted involving experienced lecturers in computer programming courses and other participants. The conceptual model consists of three main components (i) a MOOC-based flipped learning design, (ii) a model of student engagement, and (iii) an architecture of collaborative learning platform.

The implementation of a MOOC-based flipped learning engagement design consists of four phases which are (i) instructional content, (ii) in-class non-technology activities, (iii) in-class using technology activities, and (iv) evaluation and wrapping-up activities. The proposed implementation model is as shown in Figure 1.

Fig. 1. The new MOOC-based FLE implementation model



All the suggested activities to be carried out are listed in the proposed implementation model within each phase. The implementation model provides an opportunity for in-class activities so that instructors can use a digital approach if classrooms are equipped with technology and students can access the internet, or otherwise the instructors can use the traditional flipped approach by conducting F2F activities with the students without internet connections or digital tools.

B. Participants and Setting

The samples are technology and engineering undergraduate TVET students from two classes that took Programming Techniques courses at the Universiti Teknikal Malaysia Melaka (UTeM). A total of 72 students participated in this study. There were 35 students in the control group and 37 students in the experiment group. The Programming Techniques course was a three-credit course offered in both fields. Each class for the course was scheduled to have 2 hours lecture per week and 2 hours practical session per week. This course runs for a total of 14 weeks. The MOOC e-content, and e-activities set up on Pointer topics for the quasi-experiment include slides, six videos, seven e-activities, one quiz, and one tutorial from external resources.

C. Learning Process and Activities

The following was the stages involved during the quasi-experiment: (i) Stage I (week 11): Before conducting any treatment, all students took a pre-test using a set of questions to test their existing knowledge patterns for the control and experiment groups, (ii) Stage II (week 12 & week 13): Experiment groups went through selfdirected learning process using Programming Techniques MOOC with the guide of instructors using social media channels. During this stage, students were required to communicate with instructors and peers. On the other hand, the control groups were taught using F2F conventional teaching and learning methods for two weeks, and (iii) Stage III (week 14): After completion of each treatment process, all students undergo class activities with the same instructors to enhance their understanding.

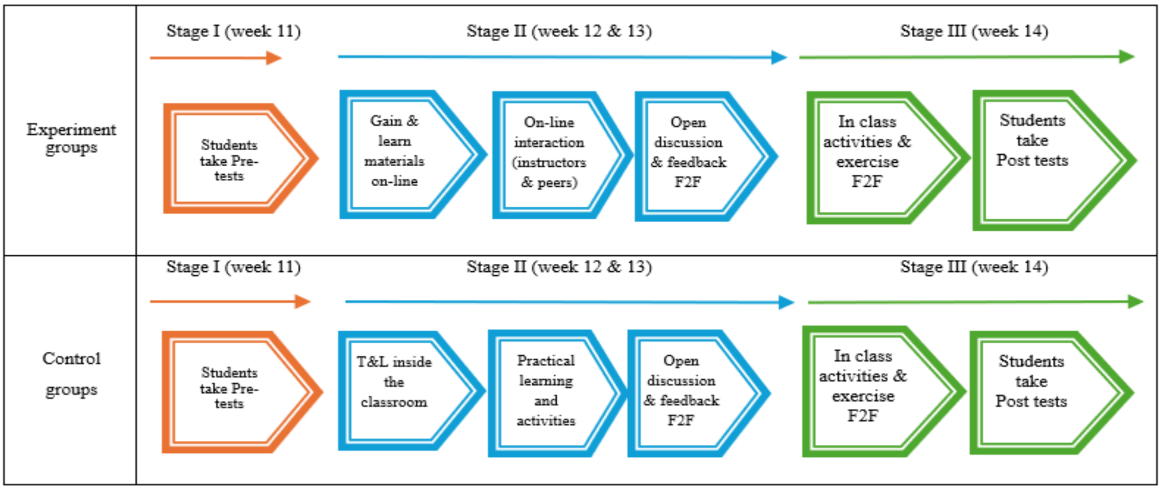


Fig. 2. Quasi-experiment stages for experiment and control groups

The class activities were done using the F2F approach. At the end of week 14, all students were asked to do post-test questions on the same topic. Figure 2 shows a summary of the three quasi-experiment stages showing the pedagogical approaches used during each stage for the quasi-experiment.

D. Instruments

In this study, the research instruments were distributed at the start and end of the quasi-experiment to find answers to the research questions. The instruments for RQ1 and RQ2 are questions on Pointers for pre-tests and post-tests. Both tests consist of three parts: (i) Part A consists of 10 True/False questions worth 20 marks, (ii) Part B consists of 10 multiple choice questions worth 20 marks, and (iii) Part C consists of two structured questions worth 60 marks. To measure students' achievement on problem-solving skills, questions that consist of full programming codes were used. These involve two questions on Part B worth 2 marks each, and two questions on Part C worth 30 marks each.

E. Students' Achievements

To examine the level of change due to the variables measured in the quasi-experimental conditions, students' achievement was measured by using the total marks in pre-tests and post-tests. Total mark is standardized on a 0–100 points scale that totals up the scores from all part A, B and C. Results of these were used to answer RQ1 of the study. To answer RQ2, analysis of students' achievement on the two programming questions in Part B (Q1PB and Q2PB), and the two structured (programming) questions in Part C (Q1PC and Q2PC) of the pre-tests and post-tests were used to measure problem-solving skills of the students before and after the experiment.

F. Data Analysis

SSPS 19.0 were used in analysing the quantitative data collected from the pre-tests and post-tests. Initially, descriptive statistics were produced to explore the frequency, mean, and standard deviation. Later, independent t-tests were applied to analyse the differences in the two groups for overall students' achievement. The F2F classes were recorded on video for observation of students' experience.

RESULT

Two types of data collected: (i) students' achievement data collected via pre-tests and post-tests taken by the control and experiment groups, (ii) students' achievements in problem-solving skills via pre-tests and post-tests.

A. Students' Overall Achievement

RQ1 is to find out whether the proposed MOOC-based FLE model approach improves students' achievement in learning computer programming courses. To answer this question, the overall mark for pre-tests and post-tests for both control and experiment groups were analysed using independent t-Tests. Results of the pre-tests are shown in Table 1. The research results are not significant ($t=-.145$, $df=70$, $p>0.05=0.885$). The control group had a mean score of 31.31 while the mean score for the experimental group was 30.92. An independent t-Test shows that students in the two groups had no significant difference in their pre-test scores (t=-.145, df=70, p>0.05=0.885). This result suggests that the students' prior knowledge of the Pointer topic was quite similar before the experiment. In other words, there is no significant difference between the experimental group (M=30.91; SD=11.66) and the control group (M=31.31; SD=12.00) for the pre-test.

TABLE 1. Independent T-Test Results of Pre-Tests for Control and Experiment Groups

Group Statistics

	Test Group	N	Mean	Std. Deviation	Std. Error Mean
PRE-TEST	experiment	37	30.9189	11.06139	1.81848
	control	35	31.3143	12.00924	2.02993

Independent Samples Test

		Levene's Test for Equality of Variances		t-Test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
PRE-TEST	Equal variances assumed	.121	.728	-.145	70	.885
	Equal variances not assumed			-.145	68.658	.885

After going through the experiment, the results of the independent t-Test are significant (t=3.117, df=70, p<0.05=0.003). Table 2 shows the post-test results. This result suggests that the students' overall achievement on the Pointer topic after the experiment using the MOOC-based FLE model approach. In other words, there is a significant difference between the experimental group (M=51.08; SD=12.13) and the control group (M=42.22; SD=11.94) for the post-test. The experimental group that used the MOOCbased FLE model and followed the process of flipped learning using the Programming Technique MOOC achieved a better result compared to the control group that followed the conventional teaching and learning process. Therefore. H01 was rejected. There is a significant difference in students' achievement between students using the MOOC-based FLE model approach as compared to students who learn using conventional F2F teaching method.

TABLE 2. Independent T-Test Results of Post-Tests for Control and Experiment Groups

Group Statistics

	Test Group	N	Mean	Std. Deviation	Std. Error Mean
POST-TEST	experiment	37	50.0811	12.13438	1.99488
	control	35	42.2286	11.94617	2.01927

Independent Samples Test

		Levene's Test for Equality of Variances		t-Test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
POST-TEST	Equal variances assumed	.041	.841	3.117	70	.003
	Equal variances not assumed			3.119	69.884	.003

B. Students' Achievements in Problem-Solving Skills

To investigate whether there were significant differences on student achievements in problem-solving questions for the Pointer topic between pre-tests and post-tests of the control and experiment groups, the test scores were compared using descriptive analysis. The results in Figure 3 show the mean for students' scores of pre-tests (Q1PB=0.57; Q2PB=0.91; Q1PC=6; Q2PC=5.03) on problem-solving questions for control groups while the mean scores of pre-tests (Q1PB=0.7; Q2PB=0.54; Q1PC=5.73; Q2PC=6.22) for experiment group. This result suggests that the level of prior knowledge on problem-solving skills of both control and experiment groups were about the same. This can be observed also in the line graph shown.

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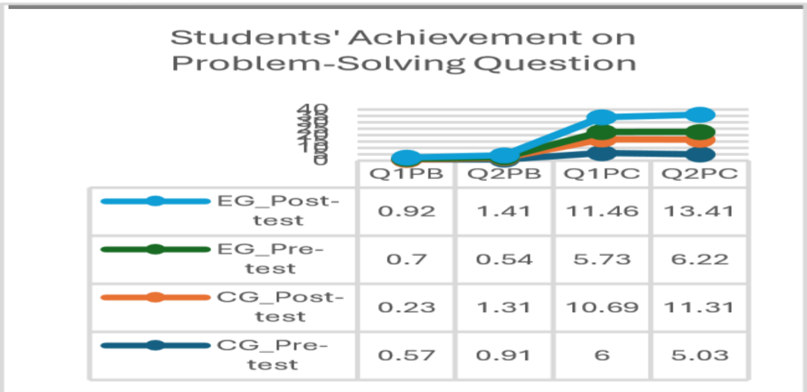

	Q1PB	Q2PB	Q1PC	Q2PC
EG_Post-test	0.92	1.41	11.46	13.41
EG_Pre-test	0.7	0.54	5.73	6.22
CG_Post-test	0.23	1.31	10.69	11.31
CG_Pre-test	0.57	0.91	6	5.03

Fig. 3. Students' achievement on problem-solving questions for control (CG) and experiment (EG) groups

After students had carried out the flipped learning activities, the results show the mean for students' scores of post-tests (Q1PB=0.23; Q2PB=1.31; Q1PC=10.69; Q2PC=11.31) on problem-solving questions for control groups while the mean scores of post-tests (Q1PB=0.92; Q2PB=1.41; Q1PC=11.46; Q2PC=13.41) for experiment group. This result suggests that both groups' achievements had increased after the experiment. However, overall achievement of the experimental group was higher than the control group. In other words, there is a significant difference between the experimental group (Overall mean score = 42.50) and the control group (Overall mean score = 36.78) for the post-test.

The experimental group that used the MOOC-based FLE model and followed the process of flipped learning using the Programming Techniques MOOC achieved a better result in problem-solving questions as compared to the control group that followed the conventional teaching and learning process. Therefore, H02 was rejected. There is a significant difference in students' achievement in problem-solving skills between students using the MOOC-based FLE model approach as compared to students who learn using conventional F2F teaching method.

IV. DISCUSSION

With regards to RQ1 (Would the proposed MOOC-based FLE model approach improve students' achievement in learning computer programming courses?), the results indicated that TVET students studying in a MOOCbased FLE model approach demonstrated better achievement as compared to those in the conventional learning group.

This finding is consistent with another research [14][15]. This is probably related to the engagement in the MOOC e-content and e-activities before the F2F classroom, and higher order thinking skills activities conducted during the F2F classroom. The course design enables students to do self-paced learning outside of class to process the information introduced in the MOOC. Students benefited from the lecture videos they watched before the F2F class which supports that micro-lecture videos are valid means for achieving desired learning goals [16]. In addition, e-activities provided in the MOOC allow students to consolidate their knowledge after watching the lecture videos in a timely manner.

Moreover, this research has an added advantage since the MOOC was built in-house and the F2F FL activities were personalized and adapted to the students' needs. The finding is consistent with other research that claimed students perform better and have a better understanding of the concepts when classes are personalized and adapted to individual needs [17].

Observation from the F2F classroom videos revealed that the flipped learning method led to increased students' preparedness for the classes. This finding is consistent to claims by other researchers [18][19][20]. To ensure that a flipped classroom to be effective, this study follow guidelines and recommend for instructors and MOOC designers also to incorporate: (i) very organized pre-class assignments, (ii) tools for responsibility to guarantee that students will complete the pre-and post-class assignments, (iii) well planned and attractive activities for students to engage during lecture time, and (iv) all correspondence lines should be open for students to communicate with their instructors.

In RQ2, the research investigated whether there are differences in students' achievement in problem-solving skills that can be observed between classes adopting the MOOC-based FLE model approach and the traditional learning after the computer programming course ended. The results demonstrated that there is a significant difference in students' achievement on computer programming problem-solving skills for classes adopting the MOOC-based FLE model approach as compared to the traditional classes.

This reveals that TVET students who learned using the MOOC-based FLE model approach had stronger problem-solving abilities than those who learned with the conventional classroom learning approach. This result is consistent with other research result [21][22] which investigated the impacts of a flipped learning approach on students' learning achievement, learning motivation, learning attitude, and problem-solving ability on a software engineering course.

Overall, in comparison with the traditional learning approach, the MOOC-based FLE model approach significantly improved TVET students' achievement and problem-solving ability in computer programming courses. The findings provide evidence that the MOOC-based FLE model approach can benefit students in learning computer programming courses. In this study, the effectiveness of the MOOC-based FLE model was confirmed by conducting quasi-experiment research. The results show that the flipped learning design based on the MOOC-based FLE model may improve TVET student achievement. Another significant finding of the research is that the students have a positive achievement in applying problem-solving for computer programming courses.

This study can be used as a reference by instructors and MOOC designers in implementing MOOC-based flipped learning. One limitation of this study is that the sample size of the experiment was not large, therefore it may be not generalizable to other cases. For future, continuous studies using the MOOC-based FLE model need to be conducted for more computer programming topics and to cover various samples to get additional evidence.

Although flipped learning approach is a student-centred teaching method, teacher accompaniment [23] is another area that needs to be investigated further for other researchers to be able to achieve an effective flipped learning implementation.

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