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Self-regulated learning with massive open online course (MOOC) for the fundamentals of data structure course: A descriptive analysis

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ABSTRACT

Data structure is a foundation subject for computer science students in Malaysian universities. To fully grasp the subject, students are required to do a lot of exercises. Many students, however, are lacking the motivation to either carry out the exercises or to actively participate in the teaching and learning process. As a result, they find it difficult to internalize the concepts and master the programming skills. Consequently, students tend to perceive data structure as a difficult subject. The objective of this paper is to present the implementation of Massive Open Online Course (MOOC) in teaching the subject of Fundamentals of Data Structures. It was anticipated that the MOOC would facilitate the students in self-regulated learning (SRL), thus increasing their motivation and participation. The MOOC has been used by the Diploma of Computer Science students in Universiti Teknologi MARA, Perak Branch from September to December 2019. The students' perception on MOOC and its effect to six SRL attributes has been collected through an online survey at the end of academic semester. The result was very encouraging as it shows that the MOOC has contributed positively to the students' SRL notably in the area the self-defined goal setting, self-efficacy, self-interest and self-strategies.

1. Introduction

Recently, the implementation of a Massive Open Online Course (MOOC) has been increasingly discussed. Some practical research has been reported on the advantages of the MOOC to improve teaching and to learn in higher education (Foroughi, 2019; Wu et al., 2019). However, an important issue in the MOOC learning platform is a low completion rate, mainly for a difficult subject. There are a number of pieces of evidence that showed Self-regulated learning (SRL) can be an effective strategy to motivate students in MOOC (Zalli et al., 2019; Wong et al., 2019).

SRL is generally defined as an assortment of learning attributes that enable the learners to be active, constructive, and highly motivated. The learners with SRL attempt to effectively manage their cognition, intentions, and learning goal. Additionally, SRL has been recognized as one of the significant factors of students' success in online learning environments, including MOOC (Zalli et al., 2019; Wong et al., 2019).

Acknowledging the beneficial impact of SRL on MOOC platforms, it was anticipated that the approach could be very beneficial for students who learn difficult subjects such as programming and data structure. In the computer science field, the introductory data structures course provides students with topics related to the fundamental concepts and programming skills. The data structures theory and concepts are somehow difficult to be imagined as it requires an essential understanding on many processing aspects of computer hardware and software, including computer memory, compiler, data management, and programming. The programming techniques for implementing data structures are complex than the fundamental programming course. Due to the difficulties faced by students, motivating their interest in the learning of data structure is a challenging task for the lecturer, and it has been a common problem until recently (Budiman et al., 2017; Dicheva et al., 2019; Lawrence, 2004).

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In other words, learning about computer programming in the data structure course demands cognitive efforts, which should be self-stimulated by the students before, during, and after classes. Thus, SRL has been found to be very effective in learning computer programming. While some peoples believed that SRL is a gifted skill of talented students, many also research has given an empirical proof that the skill can be achieved through behavior changes in students' learning (Kizilcec et al., 2017). This can be achieved by creating the SRL environment and inculcate the self-efficacy scale. Fostering students' active learning, independent, and managing their individual learning problem have been the essential keys in self-regulated approach (Johnson and Davies, 2014; Nguyen and Ikeda, 2015). MOOC allows the lecturer to include some learning contents that can be expected to promote SRL attributes among students.

To the best of our knowledge, there exists a rapid progressing of research that highlighted the positive effect of SRL through MOOC and other kinds of online platforms. However, none of the works has been found in the literature related to the implementation of the MOOC and the effect on SRL of students on the Data Structure subject.

This article aims to present the preliminary insight of the MOOC learning platform and its effect on the SRL attributes. In this context, the objectives of this paper are as the following:

- to provide the fundamental design and implementation report on MOOC that has been developed for Fundamentals of Data Structure course. The result of completion rates from the MOOC data structure is also provided.
- to present the possible SRL attributes, which were expected to be achieved from the MOOC learning platform that was perceived by students who used the proposed MOOC.

The hypothesis of this study is students can develop their SRL even for difficult subject like data structure through the implementation of the MOOC.

This paper is organized as follows. Section two provides a literature of study related to self-regulated learning, MOOC, and the teaching strategies for the data structure course. Section three presents the methodology of the study followed by the result discussion in section four. The concluding remark is written in the last section.

2. Literature review

2.1. MOOC

Education stakeholders should take advantage of the existence of MOOCs. However, given the positive impact, there are still some challenges reported in many kinds of literature focused on trying to understand the low completion rates for courses in MOOC platforms (Liu et al., 2019). Analysis of learner behavior in MOOCs mentioned that students who have got the certificate were majority viewed without deep understanding the contents, and some of them were completely skipping (Zhang et al., 2019). This is a pressing issue until recently, mainly for a difficult subject.

An empirical study revealed that the majority of students perceived that multimedia elements, animation, video, and online forums are among the core features that attain their interest in MOOC (Gütl et al., 2014). A group of researchers suggested that students should be given the flexibility of learning at their own pace in MOOC as resolve the low completion rate problem (Jacqmin, 2019; Lee et al., 2019). In other words, the MOOC should be designed with elements that allow them to self-manage their skills, such as planning their learning time and goals, connecting with others, and finding their own resources (Wong et al., 2019). Self-regulated learning (SRL) has been proved to be very effective in supporting these skills. This sparks the interest that has investigated the learners' self-regulation strategies that support their satisfaction in learning environments like MOOCs (Zalli et al., 2019; Schunk and Zimmerman, 2012; Zimmerman and Kitsantas, 2005).

2.2. SRL

SRL consists of multiple attributes involved with planning, organizing, and self-evaluating to foster the student's motivation, active engagement in their learning process. According to Zimmerman and Schunk (2012) and Zimmerman and Kitsantas (2005), at least 18 attributes can be achieved from SRL, including goal setting, time management, self-efficacy, task interest/value, self-evaluation, self-satisfaction, and help-seeking. These attributes are among the common SRL determinants used in many studies related to active learning and students' motivation (Fontana et al., 2015; McPherson et al., 2019).

Online education settings have been determined to have positive correlations between self-regulated learning behaviors and achievement in academics (Hooshyar et al., 2019). Researchers have found that critical thinking, SRL, and active learning can be effectively achieved in online discussion or e-forum (Yen et al., 2019). It has been shown that SRL can also be developed among students from the setting of virtual online presentation (Abdullah et al., 2019). An online portfolio is also an interesting idea that gives a positive impact on the SRL (Nguyen and Ikeda, 2015).

Recent investigations have demonstrated that there is a positive relationship between SRL and MOOC (Lee et al., 2019). Acknowledging the benefits impact of SRL, some efforts that promote SRL for difficult subjects such as programming and data structure have also been conducted with many approaches. In computer science and engineering courses, data structure often is presumed by students as a difficult subject.

2.3. Data structure

A data structure is a subject that provides pieces of knowledge on defining the key concepts and skills to design, implement, and testing algorithms for solving real-world problems. The concepts require abstract reasoning that requires prerequisite knowledge on basic programming, computer hardware, and the processing methods. The programming for data structure entails advance techniques such as a pointer, array, and object-oriented programming. Usually, data structure subject is taken by at least 2nd-year students who have passed fundamental programming and computer subjects.

To increase students understanding in learning the difficult subject, many tools and technologies have been introduced for teaching data structure subjects. To be used freely by teachers and students, some animations and visualizations related to several algorithms of data structure can be accessed on the web, such as at the site developed by Galles (2011) from the Department of Computer Science, University of San Francisco. Mobile learning with visualization tools of data structure is another kind of tool that reported effective for learning the difficult theory (Budiman et al., 2017). Gamification is another interesting approach proved to be helpful for learning data structure (Dicheva et al., 2019; Lawrence, 2004).

Several MOOCs for learning data structure has also been developed by many universities that offer computer science and engineering courses (Chen and Zhang, 2017; Rutenbar, 2014). As to resolve the issue of completion rates, the majority of data structure and programming MOOCs have been designed with visualizations, animations, gamification, and forums elements (Chen and Zhang, 2017).

Given the progressing research that studied the impact of SRL on academic performance for data structure subject, there are currently very limited options in the literature that report related research on SRL effect through the implementation of MOOC data structure.

3. Methodology

3.1. Participants

A total of 51 Diploma of Computer Science students from the September 2019 semester in Universiti Teknologi MARA, Perak Branch Tapah Campus, participated in this study. These students registered the Fundamentals of Data Structure Course (CSC248) at their semester 4. The course consisted of six-chapter data structure theories and required programming skills. Five data structures that need to be developed are array list, linked list, stack, queue, and binary search tree. Students were given the flexibility to manage their learning modules and time in completing the MOOC. Students were informed that their participation and completion rates were not counted in the total assessment mark of the course.

3.2. The MOOC of fundamentals of data structure

The link to the MOOC can be reached at https://www.openlearning.com. The MOOC has been completed with six chapters. Each chapter consists of the chapter learning outcome, an animated video developed by lecturers, text notes, fun activities such as crossword puzzles, quizzes that cover the learning outcome, and links to Padlet to allow them to share their own ideas collaboratively and learning from YouTube as additional references.

One of the important issues in MOOC is to sustain students' interest in the online content. For this MOOC, every chapter is provided with at least one animated video.

Furthermore, to support interesting activities, the MOOC is added with gamification elements such as crossword puzzle in every modules of chapter as presented in the following Fig. 1.

E-Forum additionally proved to increased student interest in MOOC. Hence, the data structure MOOC has been designed to support different ways of E-Forum. Some chapters allow students to have E-Forum in the MOOC platform, and there are also a few links to Padlet web pages. The Padlet provides a more flexible approach to support E-Forum. Fig. 2 presents the example of E-Forum on the Padlet platform.

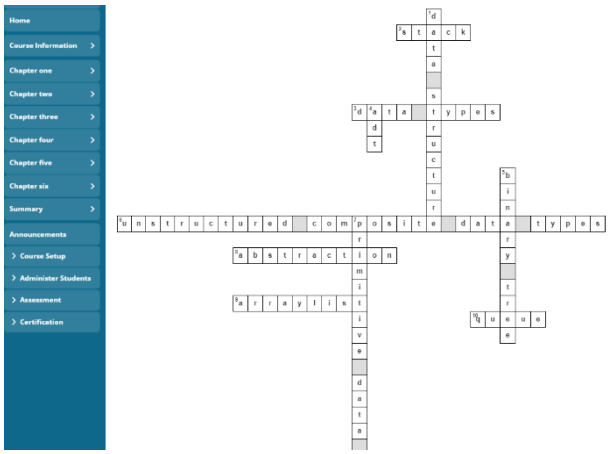

Fig. 1: Crossword puzzle in the MOOC

Therefore, the elements used in the proposed MOOC to encourage students' motivation to complete are animated videos, gamification, and E-Forum. The following Fig. 3 depicts the completion rates of students who registered the MOOC.

Majority of students who registered the MOOC able to complete the learning modules at more than 84% completion rates. This number can be considered as an indicator that shows the good motivation of students in completing the MOOC. Therefore, it is interesting to gain the students' perception of SRL attributes from the MOOC.

The standard value of low completion rates for MOOC has not been formally reported in any

literature. As mentioned by researchers, less than 10% has commonly happened to engineering and technology courses (Rai and Chunrao, 2016).

Fig. 2: Padlet E-forum

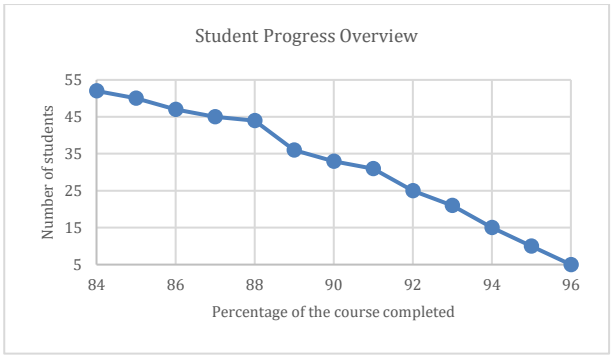

Fig. 3: Completion rates of the MOOC

Each question represents each element and all questions unless the open comment box consists of a Likert scale with five elements of the agreement: strongly agree, agree, moderately agree, disagree, and strongly disagree elements. The questionnaire was applied during the study week of the semester, which is week 15 before the examination week.

3.3. Data analysis

Only descriptive analysis was conducted to present the result. As each question presents one element of the SRL, the frequency of each item can be directly presented in a bar graph. The result is used to test the hypothesis of the study, which is students can develop their SRL even for difficult subject like data structure through the implementation of MOOC.

3.4. Instrument

A set of online questionnaires has been prepared to measure the students' perceptions and comments. Focused on SRL attributes, the survey contained a set of questions from a modified version of a published and validated instrument designed to measure SRL in a computer programming course (Echeverry et al., 2018) and also designed for Malaysia MOOC (Zalli et al., 2019). For this paper, only six elements are reported as listed in Table 1.

Table 1: Elements of self-regulated learning

Element	The question
Self-define Goal setting	I set short-term (daily or weekly) goals as well as long-term goals (for the whole course).
Self-efficacy	I feel that whatever I am asked to learn, I can handle it.
Self- strategies	When I am learning, I combine different sources of information (people, web sites, printed information).
Self-interest/value	The learning that I undertake is very important to me.
Self-satisfaction	I try to understand how what I have learned impacts my work/practice.
Self-evaluation	I know how well I have learned once I have finished a task.

4. Results and discussion

The following Fig. 4 presents the result of self-defined goal setting in the MOOC. Self-defined goal setting is the most important aspect of SRL (Echeverry et al., 2018; Kizilcec et al., 2017; Zalli et al., 2019).

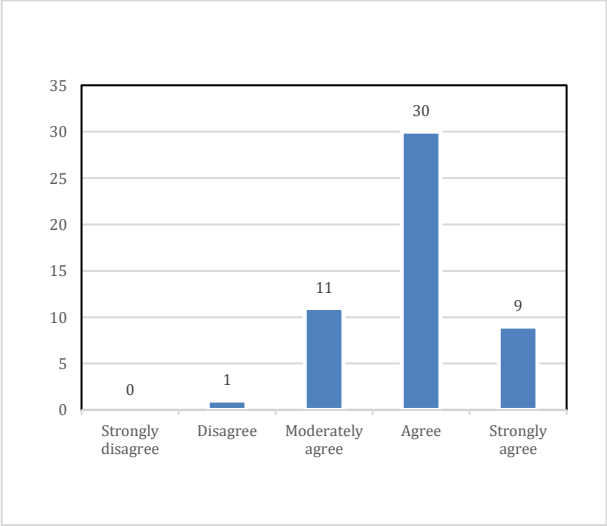

Fig. 4: Self-defined goal setting

Majority of students perceived that learning in the MOOC platform allows them to self-defined their own learning goals. According to researchers (Echeverry et al., 2018), the self-defined goal is one of the motivation aspects of learning. Another aspect of motivation is self-efficacy, as presented in Fig. 5.

The result from Fig. 5 presents a similar perception of students that feel motivated with their learning in the MOOC. The self-efficacy learning attribute has been experienced by the majority of them. Self-efficacy can be an important attribute to motivate students to resolve their challenges and achieving their goals (Wong et al., 2019). It has been proved in research that this attribute has a positive relationship with self-strategies in learning (Zalli et

al., 2019). Fig. 6 depicts the result of self-strategies in the MOOC.

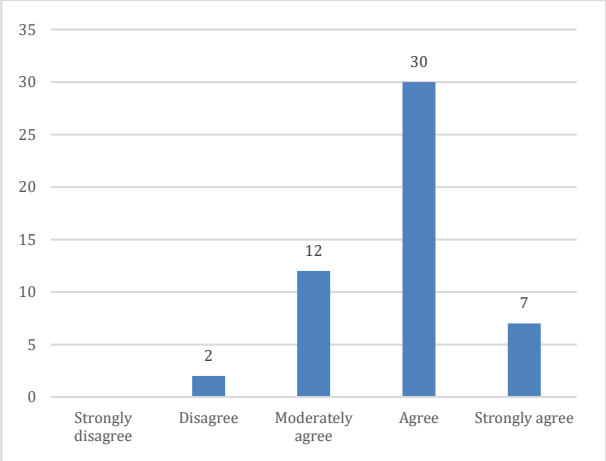

Fig. 5: Self-efficacy

The MOOC can force students to be more independent in finding the relevant resources of related knowledge, mainly from other online resources such as Google and YouTube. As presented in Fig. 6, all of them agreed that the self-strategies attribute was developed with the MOOC. Self-strategies attribute can be used to present students' effort, critical thinking, and time management aspects (Echeverry et al., 2018). Another important attribute of SRL is self-interest that can be related to their belief on the importance of topics that they learned (Zalli et al., 2019). The result is presented in Fig. 7.

Similarly, the majority of the students found that they have self-interest in the data structure topics even though it is a difficult subject. It is anticipated that the flexible learning provided by the MOOC with additional contents of animated videos and gamification has created an interesting learning environment for the students. This is in line with the positive impact of visualization (Budiman et al., 2017) and gamification (Dicheva et al., 2019) on learning data structure. Furthermore, the students perceived their self-satisfaction in learning is presented by Fig. 8.

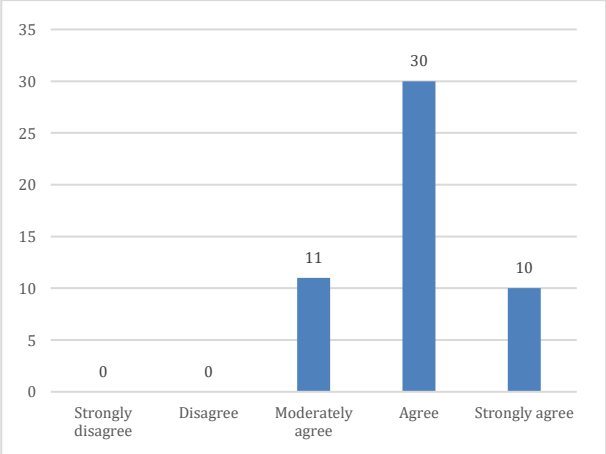

Fig. 6: Self-strategies

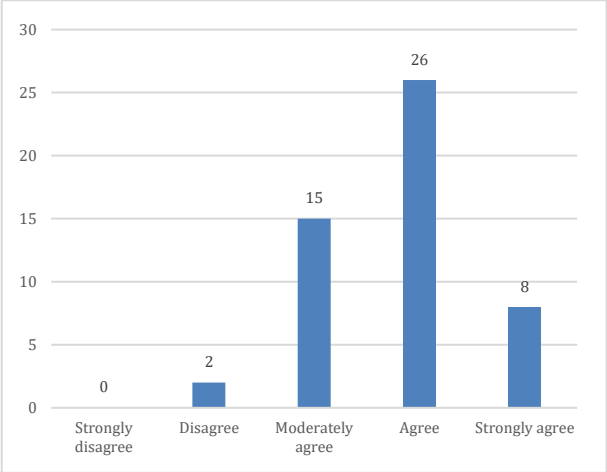

Fig. 7: Self-interest/value

In contrast with previous attributes, most students were not agreed with their self-satisfaction in the MOOC learning platform. Self-satisfaction referred to the students' happiness on their own works and practices for passing or completing the data structure subject (Echeverry et al., 2018). This result is consistent with the MOOC completion rate that the majority of students have not achieved higher than 90% of the completion rate. Lastly, Fig. 9 presents the self-evaluation attribute.

The student who able to measure their level of understanding and knowledge in particular learning is considered to have a clear direction to get higher success in learning (Kizilcec et al., 2017). Self-evaluation is one of the attributes of this aspect. Fig. 8 depicts that the number of students who really agree with the self-evaluation attribute in the MOOC is in the minority. Only 15 students moderately agree, and many of them were disagree. Therefore, it can be concluded that the majority of the students were unsure or lacking confidence with the knowledge that they have gained through the MOOC.

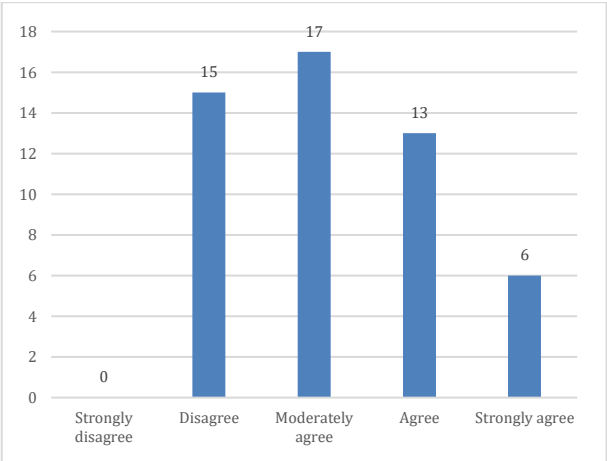

Fig. 8: Self-satisfaction

5. Conclusion

SRL is a promising learning strategy, which proved can enhance students' motivation to learning. With self-regulated learning, students can deeply comprehend complex topics during their learning. In

this study, the case study focused on the Fundamental of Data Structures subject, which always be presumed by the majority of students as a tough subject. The implementation of MOOC for the course is expected as an effective approach in the learning to help the students to be more interested, motivated, and active by means of SRL attributes. The results of this study present a positive effect on the four out of the six selected attributes to support the hypothesis of the study. However, as a preliminary study, this study needs further works in terms of many aspects, such as identifying the element of MOOC in relation to each SRL attributes. It is also important to find the relationship between academic achievement gained by the students with the MOOC and SRL attributes.

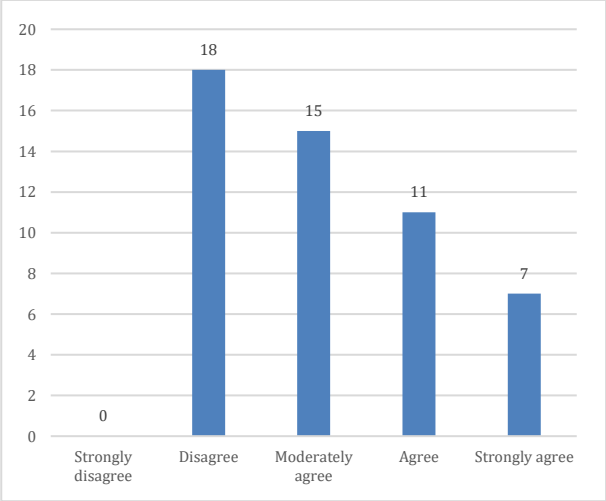

Fig. 9: Self-evaluation

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Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

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