Learning differential calculus using self-regulated flipped classroom approach

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Abstract. Differential calculus becomes a primary pre-requisite material for every student to start learning calculus. It mainly discusses the concepts and theorems regarding derivative of functions. Many mathematics educators believe that learning differential calculus needs specific conditions and attitude as it cannot be set as rote and procedural learning. This research aims to find out the students' perception towards the implementation of self-regulated flipped classroom approach in their differential calculus class. Thirty-six students participated in the seven meetings of the class and gave their perceptions at the end of every meeting. They were engaged in a various type of learning activities outside the classroom such as setting their own goal, gaining information from many sources, and uploading a video of their presentation, while during the class, they were assessed with an interview confirming their understanding about the topics. The result suggests that the self-regulated flipped classroom approach is promising to maintain the students' right attitude towards differential calculus.

1. Introduction

It is common in the Indonesian mathematics education curriculum that differential calculus is the fundamental subject providing provision for the pre-service teachers to learn calculus and real analysis. The subject is usually taught in the early semester in the teacher training period. The differential calculus subject mainly discusses the concepts and theorems regarding the derivative of functions[1]. Prior to this, the knowledge of equations, functions, limit,and continuity are also important as the pre-requisite material.Further, the students discuss the definition of the derivative, the derivatives in trigonometric functions, the chain rule, the higher order derivatives and the application of derivatives. Since the material of differential calculus set the foundation of analytical thinking, this subject becomes the foundation of logical, critical and creative thinking for the students of mathematics education department[2–4].

The importance of the differential calculus material was not followed by the adequate performance of the students. In the latest two years of teaching differential calculus, mainly using the drill method, we found that the students still confused with the concepts. The students' differential calculus learning result in 2016/2017, for example, shows that only 30% of the students could achieve the score more than 70. We discussed this phenomenon with the other lecturers of the differential calculus and it was confirmed that the similar condition happened in all differential calculus classes. From this score, we

learn that the drill method has never been enough to leverage the conceptual understanding of the students[5,6].

Many mathematics educators believe that learning differential calculus needs specific conditions and attitude as it cannot be set as rote and procedural learning.One of the factors causing the low learning achievement is the low learning independence of students both in finding learning resources, practicing various problems solving,working with proof outside the classroom, and monitoring the learning outcomes[7–9].Independence in learning, in this paper it is called self-regulated learning, is one of the characters which the students have to possess in order to get a better achievement in the learning [10]. The self-regulated learning will make the students actively involved to organize their learning [11,12]. The students show a character of self-regulated learning when they take control of themselves and their learning activities. They motivate themselves during the learning, monitor their learning progress, and evaluate their learning achievement according to the target they have set at the beginning of every learning [13,14].Overall, the self-regulated learning can be presented in Figure 1.

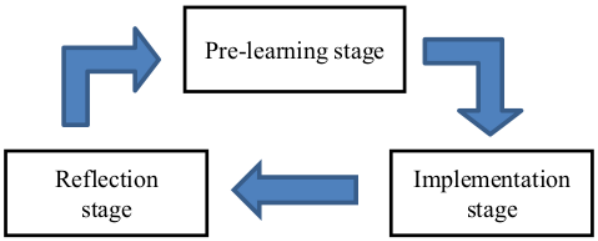

Figure 1. The stages of self-regulated learning.

In the pre-learning stage, the students have to analyze the learning task, the learning purpose/target, and the strategy to achieve the purpose by themselves. In the implementation stage, the students implement the strategy and work hard to achieve their target. In this stage, the students have to aware of their role and their learning progress. In the reflection stage, the students evaluate whether their learning result reflects their effort and analyze what needs to be improved during the learning process.

One of the efforts to make the students exercise their self-regulated learning is implementing flipped classroom approach. Flipped classroom approach is an instructional methodology which flipped the scheme of traditional learning[15]. The traditional learning, normally, delivers the instruction in the classroom, then the teacher addresses an assignment at home to follow up the material and to emphasize the students' understanding. The flipped classroom reverses this scenario by delivering the material outside the classroom (i.e. through e-learning, video presentation) and then the assignment is addressed at the meeting.

The main advantage in using the flipped classroom method is not in instructional videos used in learning, but in the remaining class time used to redesign and evaluate the learning. This time provides many opportunities for students to actively evaluate the experimental learning in order to measure higher order cognitive skills. Besides, the lecturer could guide the students to reach a higher level of thinking in Bloom's taxonomy rather than using a traditional approach that demands repetition and memorization. The flipped classroom can enable students to develop higher-order thinking skills such as at the stages of application, analysis, evaluation, and creation[16].

The flipped classroom is often known as inverted teaching where essentially flipped classroom has the concept of changing teacher-centered learning into student-centered learning. The flipped classroom has the goal that learning is perceived as belonging to students independently[17]. The students can take control of learning steps that are appropriate to themselves and are responsible for the learning process they do. There are four benefits that the flipped classroom offers, namely active learning, developing students' attitudes, appropriate use of class time, and giving attention to students in solving the problems they face[16,18]. One important element in FC learning is the existence of a

students' role, which is represented by self-regulated and self-efficacy of students. Thus the flipped classroom is often referred to as the self-regulated flipped classroom approach (SRFC).

To improve the students' self-regulated learning, the SRFC approach is implemented into a learning scheme that consists of learning outside the classroom. The monitoring system of the students' learning can use e-learning and database platform[8]. The outside class activities consist of e-books and quizzes given by lecturers. The students are required to read learning materials and work on quizzes before starting learning. The monitoring system using e-learning is done using a platform that has been developed during learning. Through e-learning, students can determine the expected learning goals and evaluate the strategies used before and after learning. Lecturers upload e-books and quizzes by giving comments and feedback,especially on lecture material. Lecturers monitor through learning-log and student profiles. The database provides an overview of the student's self-regulated learning diagnosis based on criteria set by the lecturer.

In the context of differential calculus, the SRFC has not been a trend to be used in the learning. Based on our experience, some practices to improve the calculus learning used the presentation method. It enables the students to explore the material they assigned to within a group. Unfortunately, the practice will only make the students expert in their own group topic, but not the entire material they have to learn. Furthermore, the SRFC is a promising method reported in some research [19,20]. Therefore, it is a good idea to experiment with the SRFC in the context of differential calculus subject. This research aims to find out the students' perception towards the implementation of self-regulated flipped classroom approach in their differential calculus class.

2. Methods

2.1. Design

This research is a descriptive qualitative research focused on the perception of the pre-service teachers in learning differential calculus using the SRFC. In the beginning, we designed the learning consists of two stage of activities, namely the e-learning stage and the meeting stage, as presented in Figure 2.

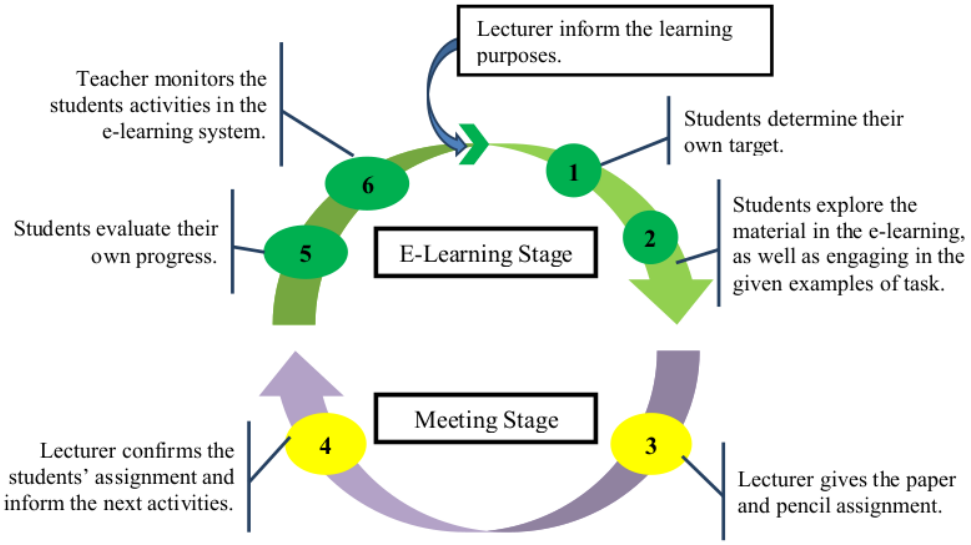

Figure 2. The learning scenario of the self-regulated learning in differential calculus subject.

2.2. Participants

There were 36 students of the mathematics department of Universitas Ahmad Dahlan joined the class in seven meetings of the SRFC learning. All the participants enrolled in a course of e-learning having their own usernames and passwords.

2.3. Treatment

We prepared five modules of the learning. The selection of the topics was considered based on the facts that some topics need visualization to ease the students' understanding of the concepts. Besides, we also prepared fivevideoed presentations of the material which were uploaded in the e-learning. The e-learning course of differential calculus can be accessed by log into the website https://elearning.uad.ac.id/course/index.php?categoryid=25.

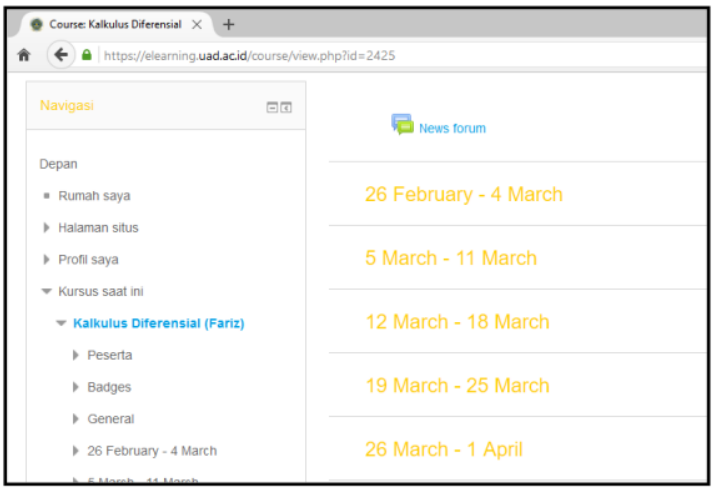

Figure 3. The e-learning website of the differential calculus.

The modules and the videoed presentation were uploaded to the system and the students could easily access the materials. There are two stages of the learning, namely the e-learning stages and the meeting stages. The students explored the material and tasks online first within their group, then, in the meeting stages, we explored the progress of their learning by confirming their understanding of the materials. We administered a written test and then confirmed by oral explanation.

At the end of the meetings, we asked the students to give their perception towards the learning. The aspects of the perception are (1) whether the engagement to the SRFC learning is easy or complicated, (2) whether the SRFC could motivate them to achieve their target, (3) whether they think that they were more skilled to deal with the differential calculus topics, and (4) whether they think that the SRFC should be implemented in the other subjects/topics.

3. Results and Discussion

3.1. The implementation of the self-regulated flipped classroom approach

To start the learning process, in the first meeting we informed the students about the rules of the learning. First, we informed the learning purposes that we asked the students to make theirown target to achieve all the learning purposes. There were 4 topics that the students have to master, namely: (1) the definition of derivatives as a limit of a function, (2) the procedures to find the derivatives, (3) the chain rule, (4) the higher order derivatives, and (5) the application of derivatives. During the seven meetings the students had, they had to plan their strategy and timeline on how and when they have to

learn each of the material.Further, the students accessed the modules and the videoed presentations. The examples of the videoed presentations are illustrated in Figure 4.

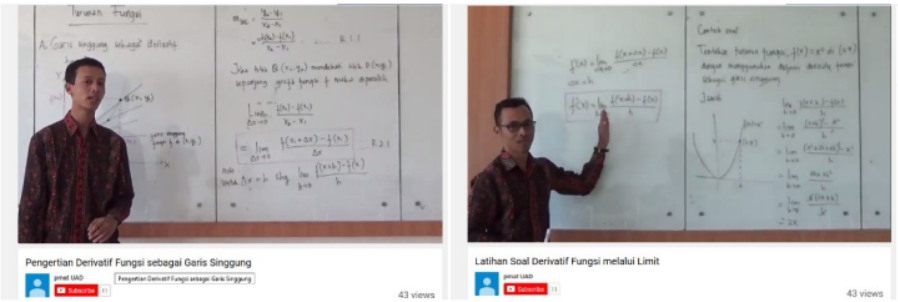

Figure 4. The videoed presentations of derivative definition as a limit of a function (left) and the example of finding the derivative of a function (right).

After the independent learning at home, the students joined the meeting with the agenda of confirmation about what they learned outside the classroom through the e-learning. It was a written quiz with an explanationof the topics learned. After submitting the quiz, the students explained orally about their work to enable us tofind out that the concepts they learned were the correct ones.

3.2. The pre-service mathematics teachers' perception of the SRFC approach

At the end of the learning, the students gave their responses to the aspects of perception to the SRFC. The perception is presented in Table 1.

Table 1. Pre-service mathematics teachers' perception of the SRFC approach

No	Aspects	Positive response (%)
1	The engagement to the SRFC learning is easy.	86.11
2	The SRFC could motivate the students to achieve their target.	77.78
3	The students think that they were more skilled to deal with the differential calculus topics.	69.44
4	The SRFC should be implemented in the other subjects/topics.	94.44

The positive responses in Table 1 show that the students accepted the approach. It confirms the previous studies that the SRFC was also good for the students in supporting the learning [8,15,17,19,20]. In the case of differential calculus, the SRFC is promising to be used in the learning.

4. Conclusion

Based on the results and discussion, we can conclude that (1) the students thought that the engagement to the SRFC learning is easy, (2) the SRFC could motivate the students to achieve their target, (3) the students thought that they were more skilled to deal with the differential calculus topics, and (4) the students thought that the SRFC should be implemented in the other subjects/topics. Future research is needed to see the effectiveness of the SRFC towards the conceptual understanding of the pre-service mathematics teachers in differential calculus subject.

Acknowledgement

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