Advances in Engineering Research, volume 209
International Joint Conference on Science and Engineering 2021 (IJCSE 2021)

Students' Engagement Through Flipped Classroom Using Geogebra Task in Multivariable Calculus Class

Dayat Hidayat[1,*] Siti Khabibah[2] Rudianto Artiono[3]

[1,2,3]*Department of Mathematics, Universitas Negeri Surabaya, Surabaya, Indonesia*
[*]*Corresponding author. Email: dayathidayat@unesa.ac.id*

ABSTRACT
Flipped Classroom is widely used as an alternative learning strategy in both secondary school level and tertiary level. This article investigated students' experience and students' engagement through flipped classroom using geogebra task in multivariable calculus class. Participants of this study were 30 multivariable calculus students from a university in Surabaya. Data were collected through classroom observation, video recordings, and questionnaires. The results indicated that Flipped Classroom had a positive impact on the learning process in the classroom. In addition, it supports student engagement in the classroom, with more than 70% cognitive and behavioral student engagement and more than 60% student affective engagement. Overall, the result highlighted educators could enhance quality of learning process and students' engagement by flipped classroom.

Keywords: *Flipped Classroom, Geogebra task, Students' engagement.*

1. INTRODUCTION

In the current era, the use of technology has become a necessity for every human being. In the education sector, the use of technology to support learning has become a trend in the 21st century. Technology allows a person to learn anywhere and anytime with the many learning resources available. So that one of the concepts "Bring Your Own Device" is becoming popular in the current learning era [1]. One of the learning strategies that uses technology to improve learning outcomes is flipped learning. Flipped learning is a student-centered learning strategy and reverses the traditional lesson. By providing content like lecturers or teacher explanations by videos to students outside of the classroom that would usually be taught by the teacher at school. Through students studying and reviewing material at home, class time is used for active learning, collaborative activities and increased time with the teacher [2].

Besides technologies used, another important thing that must be guaranteed by a teacher is student engagement in learning. The engagement of students is important so that they are able to construct their own knowledge and then can develop the ideas that are in their minds flexibly. Student engagement is defined as:

The energy and effort that students employ within their learning community, observable via any number of behavioural, cognitive or affective indicators across a continuum. It is shaped by a range of structural and internal influences, including the complex interplay of relationships, learning activities and the learning environment. The more students are engaged and empowered within their learning community, the more likely they are to channel that energy back into their learning, leading to a range of short and long terms outcomes, that can likewise further fuel engagement [3].

Based on definition there are three dimensions of engagement; cognitive, affective, and behavioral. The three dimensions of engagement have a major influence on student learning outcomes so that in carrying out learning the teacher should be able to pay attention to these three things.

There have been many studies that conclude that the use of technology can increase student engagement in learning. Various interactive content in technology can make students interested in carrying out learning and keep their focus. In the Flipped classroom, video outside the classroom can be considered as the initial phase in guided retrieval, which forms the basis for student engagement with assignments in their situational and referential activities. The innovative processes needed to engage students as they work with classroom

assignments should increase students' ownership of discovering concept of mathematics [4].

Discovering mathematical concepts is not easy for some topics, especially at the tertiary level of mathematics courses. One of the most difficult subjects for students to understand is multivariable calculus. The concepts are many and dense as well as require good analysis and visualization therefore students cannot easily understand them. There are several conflicts in learning multivariable calculus which makes this course one of the most difficult courses to learn [5]. Therefore, it is necessary to promote approaches to overcome their difficulties and increase their engagement.

Several studies about flipped classroom or flipped learning have been conducted. Most studies support that flipped classroom provides benefits for successful learning. In his research, Cevikbas concluded that the flipped classroom offered a great opportunity to promote students' mathematical thinking and understanding [6]. Moreover, Serpil Yorganci examine the effect of E-learning, Blended-Learning, and Flipped Learning and showed that mathematics achievement of students Flipped Learning were significantly higher than others [7]. Besides that, numerous studies working on literature review of highly cited studies on flipped learning ([1],[8]). In addition, Melissa Bond delivered systematic review about student engagement through flipped learning within STEM subject [2]. This study aims to investigate student experience and student engagement through flipped classroom using geogebra task within multivariable Calculus subject.

2. METHODS

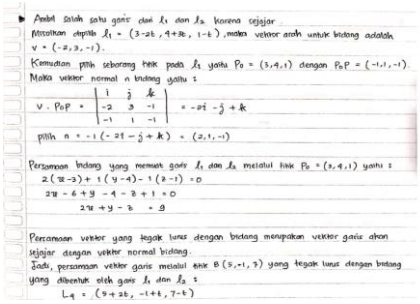
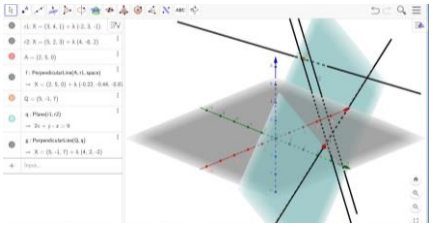
This is a descriptive-explorative research which aims to investigate how flipped classroom conducted by utilizing geogebra task in multivariable calculus class. Participants were 30 college students who were taking a multivariable Calculus course at a university in Surabaya. Data of this research study were classroom observation, video recordings, and questionnaires. Classroom observation was used to make sure the learning process was done according to the plan that has been made. Video recordings were needed to be able to monitor student engagement in the learning process and a questionnaire as data used to see students' perceptions and engagement in class. The data was presented descriptively about the learning process in the flipped classroom using geogebra task and the students' engagement in the learning process in class.

3. RESULTS AND DISCUSSION

The flipped classroom carried out in this study adheres to the principles of flipped learning. Phase 1, learning materials including learning videos, powerpoint slides and project assignments are made available to students before face-to-face meeting. Students can access material about one week. Phase 2, All interactions are carried out through the university's learning management system (LMS) that can be accessed via tablets, mobile phones, or each student's computer. Discussion forum, exercise, and quiz are shared with class and documented as a learning process. Phase 3, in the face-to-face phase, deep interaction occurs to understand the assigned tasks and deepen the material. This phase following by integrated question and answer (QnA) session. Based on phase 1 and phase 2, students completed materials and quizzes before attending class. Assessing quiz instantly and generating timely feedback were key ingredients in the face-to-face phase and likely prepared students for the larger, tougher and less frequent exams [9].

Phase 4, independent practice and lab activity. In this phase individual geogebra project was started. Students were given a problem to be solved analytically and using geogebra. The use of geogebra as a tool in constructing student understanding is very good, especially for abstract topics. Moreover, student engagement in the learning process related to the material will increase. This is due to flipped classroom students spent substantially less time (42%) on listening and more on different types of individual and group work [9]. Moreover, a study reveals that students in Flipped Learning state that by working in mathematics education and doing mathematics, they engage more intensively with the topics being dealt with and learn more through this intensive engagement [10]. In this phase, students perform their ability to solve problems through the previous knowledge they have constructed and explore it using geogebra (Table 1).

Table 1. Students' independent practice

Geogebra Task	***Students' work***
• *Solve the problem below using geogebra complete with the steps* • *Show that the results on geogebra are the same as the results you get using analytical calculations* *Let l_1 and l_2 are two lines that have vector equations $r = \langle 3-2t, 4+3t, 1-t\rangle$ and $r = \langle 5+4t, 2-6t, 3+2t\rangle$ respectively.* *(a) Show that there is a line l_3 that passes through (2,5,0) that intersects l_1 and l_2 orthogonally and then find the vector equation of l_3* (b) *Find the equation of the vector l_4 which passes through the point $(5,-1,7)$ which is perpendicular to the plane formed by l_1 and l_2*	*Analytical*  *Using Geogebra* 

In this study, we explain student engagement in the flipped classroom based on the dimensions of engagement proposed by Fredricks et al (2016). There are three dimensions of engagement namely cognitive, affective, and behavioral. Cognitive engagement is about understanding, self-regulation and deep learning strategies, affective engagement related to students' interest and sense of belonging and positive reactions to the learning environment, and behavioral engagement related to persistence, participation, and positive behavior [2]. We analyzed this student engagement based on the results of the questionnaire and the existing class observation data.

Based on cognitive engagement, flipped classroom has a positive impact. As the results of the questionnaire that describe 86% of students argue that the learning videos in the class help in understanding the lecture material. Furthermore, 72% of students agree that the use of geogebra in project assignments helps them understand more thoroughly about the material.

In affective dimension, flipped classroom provides enough enjoyment for students during learning. The results of the questionnaire explained that 65% of students thought this lecture was interesting to attend. Furthermore, 60% of students think that the quizzes on the LMS are easy to access and to do. This moderate result of the affective dimension may be due to some technical problems. Such as learning videos that are less interesting and quizzes that are not too innovative could be the cause. This is in line with the results of the study that technical problems such as video quality that is not as good as other learning videos can cause participants to consider the flipped classroom to be unattractive [11].

For the last behavioral dimension, flipped classroom also facilitates students to actively participate and be confident. The questionnaire shows that 78% of students are confident that they will be able to absorb the material and 88% of students are ready to face lectures after studying the material in the learning video that has been given. This is in line with the results of the study which stated that the flipped classroom had a positive contribution to class participation and self-regulation skills [11]. Moreover, the high degree of freedom and self-determination of students in Flipped Learning environments could lead to active and self-responsible learning in classrooms [10].

4. CONCLUSION

Flipped Classroom can be as an alternative learning to promote students' engagement and understanding. Not only flexibility in learning but also good learning interactions between teachers and students as well as materials. This learning strategy make a valuable contribution to foster learning through inquiry [12] and work independently in mathematics education. The next suggestion is that affective student involvement needs to be developed when implementing the flipped classroom.

One way that is able to develop this is using various interactive media and learning management system platforms.

AUTHORS' CONTRIBUTIONS

Dayat: data curation, method drafting manuscript, finishing article, Siti Khabibah: conceptualization, reviewing article and Rudianto: data visualization and editing.

ACKNOWLEDGMENTS

The authors wish to acknowledge to the Dean of Faculty of Mathematics and Natural Science and Head of Mathematics Department of Universitas Negeri Surabaya

REFERENCES

[1] S.C Cheng, G.J. Hwang, C.L Lai, Critical research advancements of flipped learning: a review of the top 100 highly cited papers, Interactive Learning Environments (2020) 1-17. DOI: https://doi.org/10.1080/10494820.2020.1765395

[2] M. Bond, Facilitating student engagement through the flipped learning approach in K-12: A systematic review, Computers & Education 151 (2020) 103819. DOI: https://doi.org/10.1007/3-540-11494-7_22

[3] M. Bond, K. Buntins, S. Bedenlier, O. Zawacki-Richter, M. Kerres, Mapping research in student engagement and educational technology in higher education: A systematic evidence map, International journal of educational technology in higher education (2020) 1-30. DOI: https://doi.org/10.1186/s41239-019-0176-8

[4] H. Fredriksen, Correction to: Exploring Realistic Mathematics Education in a Flipped Classroom Context at the Tertiary Level, International Journal of Science and Mathematics Education 19 (2) (2020) 377-396. DOI: https://doi.org/10.1007/s10763-020-10065-x

[5] H. Kashefia, Z. Ismail, Y.M. Yusof, Using Blended Learning to Support Students Thinking Powers in Multivariable Culculus, Sains Humanika 57 (1) (2012) 1-14. DOI: https://doi.org/10.11113/sh.v57n1.214

[6] M. Cevikbas, G. Kaiser, Flipped classroom as a reform-oriented approach to teaching mathematics, Zdm 52 (2020) 1291-1305. DOI: https://doi.org/10.1007/s11858-020-01191-5

[7] S. Yorganci, Implementing flipped learning approach based on 'first principles of instruction'in mathematics courses, Journal of Computer Assisted Learning 36(5) (2020) 763-779. DOI: https://doi.org/10.1111/jcal.12448

[8] C.H. Fung, M. Besser, K.K. Poon, Systematic Literature Review of Flipped Classroom in Mathematics, Eurasia Journal of Mathematics, Science and Technology Education 17(6) (2021) 1-17. DOI: https://doi.org/10.29333/ejmste/10900

[9] W. Maciejewski, Flipping the calculus classroom: an evaluative study, in: Teaching Mathematics and its Applications: An International Journal of the IMA 35 (2016) 187-201. DOI: https://doi.org/10.1093/teamat/hrv019

[10] R. Weinhandl, Z. Lavicza, S. Schallert, Towards Flipped Learning in Upper Secondary Mathematics Education, JME (Journal of Mathematics Education) 5(1) (2020) 1-15. DOI: http://doi.org/10.31327/jme.v5i1.1114

[11] E.O. Şen, K. Hava, Prospective middle school mathematics teachers' points of view on the flipped classroom: The case of Turkey, in: Education and Information Technologies 25 (5) (2020) 3465-3480. DOI: https://doi.org/10.1007/s10639-020-10143-1

[12] S. Schallert, Z. Lavicza, E. Vandervieren, E., Towards Inquiry-Based Flipped Classroom Scenarios: a Design Heuristic and Principles for Lesson Planning. International Journal of Science and Mathematics Education (2021) 1-21. DOI: https://doi.org/10.1007/s10763-021-10167-0