

Calculus Flipped Classroom: Pre-class & In-class Learning Outcomes and Students' Perception

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Abstract

This study applied the flipped classroom into calculus subject to determine students' learning outcomes and their perceptions toward calculus flipped classroom. Learning outcomes were investigated in pre-class sessions, in-class sessions, and then be compared to the traditional class. All materials in this calculus flipped classroom were presented in screencast via Google Classroom. The sample of this study was taken from calculus class students at Prisma University. The data were collected through a questionnaire, written tests, and Kahoot online test, then be analyzed descriptively and statistically using the 2-sample t-test and paired t-test. The results showed no significant differences in the average score of learning outcomes between the pre-class of calculus flipped classroom and traditional class. However, the average score after in-class sessions was higher than the average score in the traditional class. Furthermore, positive responses were shown by students who were treated with the flipped classroom.

Keywords: Flipped classroom, Pre-class, In-class, Perception, Learning outcomes

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INTRODUCTION

Education and technology cannot be separated. Advanced education leads to advanced technology, and in return, advanced technology contributes in developing education. The era of technology industry 4.0 demands advanced education in its implementation, specifically in universities. Answering the needs in technology industry 4.0, Indonesia has begun to focus on the application of technologies in the field of education, in line with the paradigm shift that emphasizes on Student-Centered Learning (SCL), not only in basic education, but also in higher education. The SCL system and the use of e-learning are encouraged by lecturers as a demand to professionalism. The lecturers are even required to attend the Applied Approach (AA) and improvement of instructional technique skills program, known as PEKERTI, as courses that may equip lecturers in implementing SCL and e-learning.

In relation to clarification activities, giving explanations and interpretations, e-learning can be less effective than traditional learning methods. The learning process is much easier in face-to-face meetings with lecturers than e-learning, because it can integrate various approaches within its process (Arkorf & Abaidoo, 2015). The implementation of SCL and e-learning together is more effective when they are implemented in blended learning (BL) class. The term "blended" means that traditional instructor is equipped with an electronic format (Ghirardini, 2011). In BL, students are given access into learning resources in the form of online course materials and they are also attend face-to-face class sessions (Hahessy et al., 2014).

Flipped Classroom (FC) is a type of blended learning (Abeysekera & Dawson, 2015) that utilizes the use of online media while still relying on face-to-face sessions in class. Bergmann and Sams in 2007 had begun to implement FC in high school in Colorado. The FC concept simply substitutes what is traditionally done in the classroom, be done at home, and what is traditionally called homework, is done in the classroom (Bergmann & Sams, 2014). One of the goals of FC is to provide more interaction to teachers and students (Wolff & Chan, 2016).

According to Muzyka & Luker (2016), FC is a state where students are exposed to learning materials before class (pre-class) and face-to-face sessions (in-class). In pre-class sessions, students acquire basic subject knowledge by viewing learning materials from the lecturer in various media format, such as online videos, podcasts, or text-format materials, prior to class (Crawford & Senecal, 2017). In the in-class session, the teacher can do SCL activities by adapting think-pair-share (TPS), discussions, jigsaw reading models, problem-solving, laboratory activities, interactive lectures, role play, collaborative design & creation, or rubric feedback (Hsieh, 2017; Strayer, 2012; Gerstein, 2011). Bergmann (2014) suggested that educators must ask one directive question, "what is best for students in the classroom?" Based on the the question, it can be concluded regarding to lifelong education, that there is no such thing as "excessive" in education.

Calculus has become a scourge for many students, especially students who take a concentration in science and technology. A lot of students were found to have difficulties and failed in this course, and even had to repeat several times before they can be declared graduated. Calculus is a basic course in various study programs at universities. Calculus is a branch of mathematics that deals with calculating the instantaneous rate of change, known as differential calculus, and the sum of many small factors to determine the whole, known as integral calculus (Berggren, 2016). In short, calculus is the study of change.

The evaluation process in calculus subject needs to be done to improve students' understanding, and it starts from the lecturer as an instructor. An understanding to the content in calculus material as well as applicative knowledge must be built so that the subject can be useful for students, especially in the fields occupied by students. The climax is that students are able to produce products in their respective fields supported by adequate calculus knowledge.

Albalawi (2018) was applying FC in his calculus lecture at Tabuk University, trying to investigate student learning outcomes. The research sample was taken from study programs outside mathematics namely medicine, engineering, computer science, applied medical science, and science. The results showed that the implementation of FC in teaching calculus is effective. Sun & Xie (2017) did FC in Calculus 1 subject and concluded that the majority of students liked the lecturing model and had improved exam results. A different result was obtained by Ziegelmeier & Topaz (2015) in regarding to learning outcomes. They were comparing two sections of the entry-level course applied multivariable calculus and found similar score on graded components of the course, and the majority of students were comfortable with the format of each section.

According to the previous studies mentioned above, it can be concluded that FC has a positive impact on calculus subject. The implementation of FC is done in two sessions, namely pre-class sessions and in-class sessions. The evidence of FC's success (or not) is determined by students' grades, utilization of technology, efficiencies in teaching, cultural shifts or changes, applicable to other teaching areas, academic

satisfaction, and students satisfaction (Kavanagh et al., 2017). In addition to investigate the influence of FC on students' learning outcomes and their perceptions toward calculus flipped classroom, this study is also carried out a deeper investigation to students' learning outcomes in each session on FC and then compared to learning outcomes in traditional classes. Special influence FC has made (or not) on students' learning outcomes using its' two study sessions will be revealed as their perception. This main idea is an innovation in this research. None of the studies above have investigated this. If FC has a positive impact on lectures, the factors that support the occurrence of that can be further investigated, in this case, the influence of FC lecture sessions.

RESEARCH METHOD

This research is a quantitative experiment. The sample of this study was taken from the students of the Faculty of Science and Technology at Prisma University, who were studying calculus subject in the academic year 2019-2020. The participants were selected through simple random sampling method. There were 42 students divided into 2 groups, namely the control group and the experimental group. The control group was a group that is treated in a traditional classroom in calculus courses (C-TC), while the experimental group is treated in a flipped classroom in calculus (C-FC). Both groups have been tested for normality and homogeneity for data analysis. The variables measured in this study are learning outcomes in pre-class sessions, learning outcomes after face-to-face sessions (in-class), and also student perceptions toward calculus flipped classroom.

The implementation of the course was conducted as follows; the control group conducted lectures traditionally and the experimental group conducted the FC Lecture materials in the form of screencast that has been prepared by the lecturer, and then are distributed through Google Classroom, where they may hold discussions there. Subject materials were given in the classroom in direct learning and structured assignments to be done as homework. Pre-class learning outcomes in these two groups were then measured at the beginning before the in-class session via online quizzes using the Kahoot learning application. Learning outcomes from in-class sessions on calculus lectures were measured in the form of written exams. Learning outcomes in pre-class sessions and in-class sessions from the experimental group were also compared through the results of those two tests.

Data analysis was performed on students learning outcomes covered; (1) the experimental group pre-class learning outcomes compared to the control group, (2) the learning outcomes after the in-class session in the experimental group compared to the control group, (3) the experimental group learning outcomes in the pre-class session compared after the in-class session. The in-class test was considered as a post-test. The 2-sample t-test was used to measure (1) and (2). The paired t-test was used to measure (3). The significance level of 0.05 was used in this research. Regarding student perceptions, Likert's scale on the questionnaire was used for data analysis. Items on the questionnaire were scoring (5) strongly agree, (4) agree, (3) neutral, (2) disagree, (1) strongly disagree. This was done only in the experimental group. Minitab 18 and Excel 365 were used to analyze the data. The hypotheses in this research are as follows;

Table 1. Research Hypothesis

Hypothesis		The meaning of H_a
(1) and (2)	$H_0: \mu_1 = \mu_2$ $H_a: \mu_1 > \mu_2$	The average score of students' learning outcomes in the experimental group is higher than the control group
(3)	$H_0: \mu_d = \mu_0$ $H_a: \mu_d > \mu_0$	The average score of students' learning outcomes after in-class sessions is higher than before
Decision		Reject H_0 if $t_{count} > t_{table}$

RESULTS AND DISCUSSION

As a condition for the 2-sample t-test, the normality and homogeneity tests were conducted to the experimental group (C-FC) and the control group (C-TC). The Anderson-Darling (AD) test was used for the normality test, Bonett and Levene method were used for the homogeneity test. Significance level $\alpha = 0.05$.

Table 2. The Normality and Homogeneity Tests

Method	The experimental group	The control group	Decision
AD	0,413	0,373	Pass the normality test
Bonett	0.632		Both classes were homogenous
Levene	0.746		

All values in Table 2 are greater than $\alpha = 0.05$, so the experimental group and the control group were normal and homogenous.

Table 3. T-test on Pre-Class Learning Outcomes of C-FC and C-TC

Group	N	mean	sd	df	t_{count}	p-value	t_{table}
Exp	21	34.29	14.07	40	-1.10	0.862	1.68
Con	21	38.90	13.00				

T-test results of pre-class learning outcomes of C-FC and C-TC are presented in Table 3, as it shows the average score of the experimental group is not higher than the control group. The t-test shows $t_{count} = -1.10 < t_{table} = 1.68$, means it receive the H_0 . It can be concluded that the average score of students' learning outcomes in calculus flipped classroom shows no different from students' learning outcomes in the traditional class.

Table 4. T-Test on Learning Outcomes of C-TC and After In-Class Sessions in C-FC

Group	N	mean	sd	df	t_{count}	p-value	t_{table}
Exp	21	64.67	16.03	40	3.28	0.001	1.68
Con	21	48.89	15.10				

Table 4 represents the post-test results in the experimental group and the control group. As shown in Table 4, the mean of the experimental group is higher than the control group with $t_{count} = 3.28 > t_{table} = 1.68$, which means the H_0 is rejected. It can be concluded that the average of students' learning outcomes after in-class sessions in calculus flipped classroom is higher than the students' learning outcomes in the traditional class.

Investigation on the effect of in-class sessions in the flipped classroom on the experimental group was tested by paired t-test. Pre-class sessions' result was compared to the post-test as in-class sessions result. It is shown in Table 5 below.

Table 5. T-Test on Pre-Class and In-Class Learning Outcomes of C-FC

Sessions	N	mean	sd	df	t_{count}	p-value	t_{table}
Pre-class	21	34.29	14.07	20	7.28	0.00	1.72
In-class		64.67	16.03				

As Table 5 shows the $t_{count} = 7.28 > t_{table} = 1.72$, it means that the H_0 is rejected. The average score of student learning outcomes after in-class sessions is higher than before.

Table 6. Students' Perception of C-FC in The Experimental Group

Statements	Percentages**		
	Strongly agree	Agree	Neutral
I have a positive attitude towards FC* after the course	46.4	37.8	12.2
I appreciate learning with video	32.1	64.3	3.60
I am more flexible and mobile as a learner	3.60	85.7	10.7
I must take more responsibility for learning	17.9	57.1	25.0
I can study at my own pace	10.7	67.9	21.4
My learning processes are more supported	10.7	57.1	32.1
The non-traditional classroom activities were meaningful	14.3	42.9	42.9
It is easier and more effective to learn	17.9	67.9	14.3
I do more learning on my own spare time	7.10	75.0	17.9
I am more motivated as a learner	14.3	71.4	14.3
I am more active as a learner	7.10	78.6	14.3
I experience stronger peer-collaboration	3.60	53.6	21.4
It feels like a distance course	7.10	60.7	14.3
Video* made learning more effective	28.6	71.4	0
Video quality was satisfactory	35.7	57.1	3.6
Video made me learn more	25.0	57.1	14.3
Video motivated me to learn	21.4	57.1	21.4
Video can replace traditional lectures completely	17.9	67.9	10.7
I rather have videos than traditional lectures	35.7	39.3	35.7
Video made calculus easier	21.4	71.4	7.10
It was useful to see other students' questions and teacher answers in GC*	14.3	82.1	3.60
GC supported my learning	21.4	71.4	7.10
It was useful to communicate with teachers through GC	7.10	71.4	21.4
GC motivated me to learn	14.3	57.1	25.0

*FC = Flipped classroom, GC = Google classroom, video = screencast
 **Some students answered disagree or strongly disagree for the rest percent.

The implementation of the flipped classroom in delivering calculus lectures in this study was using screencast and Google classroom. The measurement of students' perception in C-FC (the experimental group) was using a questionnaire (Table 6) that was adapted from Nouri (2016) regard to the flipped classroom, the screencast, and Google classroom utilization.

As shown in table 6 above, more than 75% answers are “agree” and “strongly agree” on almost all items of the questionnaire. However, there are three items lower than 75%; “My learning processes are more supported” (67.8%), “The non-traditional classroom activities were meaningful” (57.2%), I experience stronger peer-collaboration (71.4%). This means that the students responded positively to the implementation of FC using screencast and GC in calculus lectures.

From the results of previous statistical tests, the information obtained by pre-class sessions at FC did not produce higher learning outcomes than the traditional class. The provision of materials in this pre-class session were done by sending videos in the form of pre-prepared screencast, then supported by discussion activities in GC. The materials sent were the same as the material lectured to students in traditional classes. Meanwhile, according to the results of the questionnaire distributed to students, it showed the existence of positive perceptions from students in the FC class, but did not affect much in their learning outcomes.



Figure 1. Pre-class session (left) and In-class session (right)

The advantage of FC is that there are in-class sessions, in addition to pre-class sessions that focus on providing core course material there. The pre-class sessions can be classified as the e-learning session because it prioritizes the use of digital media. The existence of FC in-class sessions is to support pre-class activities. The in-class sessions can be classified as the SCL sessions because they are highly emphasize on student-centered learning activities. After a session in the classroom, a higher learning outcome was obtained in the flipped classroom, compared to the traditional class. This result is quite possible because in this session, there was a process of clarification, review, and training. Moreover, FC does not charge students to do homework, but the homework is discussed together in in-class sessions, as shown in Figure 1. Effective FC implementation is based on clarity, consistency, and constant communication (Hsieh, 2017).

Cognitive load is a learning issue that is considered in implementing FC. In this case, it is highly related to the use of technology. Mutaqin, Marethi, & Syamsuri (2016) found out that the knowledge of students was better when prospective mathematics teachers using blended learning than the traditional classes. Also, blended learning students were more active in working on assignments than ordinary classes. Banas and Velez-Solic (2013) in concerning multimedia and online learning, revealed that the habits of students in the presence of an intermediary or media delivery instructions (materials) can often affect their cognitive load. Digital technologies can play an integral role in the success of the flipped classroom; from the capacity to support and engage students to the understanding of how students learn through learning and assessment analytics (Kavanagh et al., 2017). Students access material outside the classroom (pre-class), therefore, lecturers must design and format

material that is suitable and appropriate for students, which enable them to be accustomed to the technology used in study before in-class sessions.

Video is the best way to deliver learning material even though it is more complex. Calculus materials on FC were given using screencasts. Crawford & Senecal (2017) stated screencasting as one way to present presentations online, done by recording visuals that appear on a laptop screen. Ideally, the length of audio and video recording is no more than 10-15 minutes and clearly must be connected to learning objectives and assessment (Raths, 2014). Research on the use of video was found to support improved learning outcomes in mathematics learning according to (Weeraratne & Chin, 2018).

Google Classroom is a Google Apps for Education software which was popularized on August 2014. This is a learning porch that enables teachers to create, share, and classify paperless assignments. Google classroom also facilitates students and lecturers to connect on and off-campus. This virtual class strongly supports the implementation of FC, especially pre-class sessions. Although FC pre-class learning outcomes using Google classroom in this study gave insignificant results regarding to learning outcomes compared to the traditional class, several studies have shown positive results as in Bondarenko, Mantulenko, & Pikilnyak (2018) and Widodo (2017).

The evaluation process in this research was carried out by providing qualitative and quantitative tests. Qualitative tests measured students' perceptions in learning the content of materials provided outside the classroom. The next test was online quizzes that can be accessed by students from outside the classroom and in the classroom. Zappe & Litzinger (2017) suggested the use of midterm and final semester tests in the FC should be carried out, and also asked students about their access to lecture content that is the amount of watching, how much time they have studied, and which parts of the material were considered very helpful.

Regarding students' perceptions, the results of this study support previous studies. McLaughlin et al. (2014) conducted a study on Pharmacy students at the University of North Carolina and found a 5% increase in achievement and 90% of students preferred FC lectures. The results of Bennedsen's study of FC in mathematical concepts, logic, modeling, and proofing techniques found that students enjoy the lecture process and appreciate the lecture (Bennedsen, 2017).

The strengths of applying FC for students are; (1) able to watch lecture material wherever and whenever, (2) the learning process is done according to their own pace, (3) better understanding because videos are presented sequentially and concisely, (4) comfort and self-confidence since the material has been studied before face-to-face in class, (5) the level of frustration of learning in the low class, (6) the opportunity to discuss may unite the concept with friends while in class, (7) increased motivation due to watching videos is more interesting than reading books. As for lecturer; (1) active and close communication is established with students in the classroom, (2) improving student attitudes in learning, (3) grouping students for active discussion, (4) increasing students' ability to solve open-ended problems, (5) effective and time-saving because videos can be watched over and over again (Ramirez, Hinojosa, & Rodriguez, 2014; Rivera, 2016; Shi-Chun, Ze-Tian, & Yi, 2014).

Technological innovation is expected to improve the quality of lectures and advance education. Through the previous discussion, in the context of lectures, the application of FC has a great potential to improve student learning outcomes

specifically and also to enrich their learning activities. The use of FC shows its relevance to increase student enthusiasm for learning.

The following are some considerations in planning pre-class preparation for FC. In preparation for pre-class, prepare available materials, for example, Onenote and mousepen software. The recording process may use Camtasia software with a maximum duration of 15 minutes video. The recorded video is uploaded in a virtual class application (e.g. Google Classroom). Students in virtual classes are required to watch videos and fill out personal evaluation sheets and complete homework assignments to watch videos, which have been uploaded together with video tutorials. Furthermore, following Hsieh (2017), in-class activities are used for development or feedback, using well-known learning models such as think-pair-share.

Things that were found in this study must be considered in FC lectures; 1) consistency in teaching preparation by lecturers and students learning, (2) availability of supporting digital media, (3) availability of internet networks, (4) activeness of lecturers and students in communication especially for pre-class sessions.

Advances in technology and e-learning at the highest standards allow for distance learning. This is considered not good for lecturers and students, especially the students of mathematics education because it eliminates the element of face-to-face, the absence of lecturers and students directly, which is needed to shape the personality of prospective teachers. In other professional lectures, face-to-face lectures are still needed. Flipped classroom lectures are allowed for actual face-to-face development of lecture content that can be used for project assignments, and also the use of virtual classes to monitor activities outside the classroom, and also for interactions. Thus, the FC lectures make it possible to revive lectures, especially calculus.

CONCLUSION

This study is investigated pre-class sessions and in-class sessions on FC calculus lectures regarding to learning outcomes and perceptions. Lectures were supported by the use of screencast and Google Classroom which are proven to have a positive impact. The results showed no difference in learning outcomes between pre-class lectures using calculus flipped classroom compared to the traditional classes. However, the implementation of in-class sessions provides an improvement toward the learning outcomes compared to learning outcomes in the traditional classes. Positive responses were also shown by students with the application of flipped classroom in calculus classes. Based on this research, several topics need to be studied further, including; (1) evaluation methods in pre-class sessions, (2) applications that pay attention to students' learning styles and basic mathematical abilities, and (3) instructional indicators for instructors to identify when flipped classroom is appropriate to be applied to lectures or not.

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