ISSN: 2148-9955

International Journal of Research in Education and Science (IJRES)

www.ijres.net

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To cite this article:

Albalawi, A.S. (2018). The effect of using flipped classroom in teaching calculus on students' achievement at University of Tabuk. *International Journal of Research in Education and Science (IJRES), 4*(1), 198-207. DOI:10.21890/ijres.383137

IJRES International Journal of Research in Education and Science
Volume 4, Issue 1, Winter 2018 DOI:10.21890/ijres.383137

The Effect of Using Flipped Classroom in Teaching Calculus on Students' Achievements at University of Tabuk

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Article Info

Article History

Received:
18 April 2017

Accepted:
4 October 2017

Keywords

Flipped classroom
Teaching mathematics
Instruction
Technology reverse
Teaching

Abstract

This study aimed at investigating the effectiveness of using flipped classrooms in teaching the Math2 course for the preparatory year's students at the University of Tabuk, Saudi Arabia. The Math2 course was organized via an (ADDE) design model, with recorded videos of the topics included in the study; it was implemented by a Moodle platform and was available for the treatment group . Pre- and post-achievement tests were developed in calculus, being the topic of the Math2 course, and implemented for the two groups: the control group consisted of 45 students and the treatment group consisted of 47 students. The results revealed a significant difference in students' performance, favoring the treatment group which was taught using the flipped classroom instruction. However, no statistical significance was found in students' performance related to their majors (medicine, applied medical science, engineering, computer science, and science).

Introduction

In the past few decades, there have been drastic changes in education with the initiation of a new model of classroom teaching, called the 'flipped classroom.' It is related to any internet technology that may affect the process of learning in a classroom setting, so that teachers can provide students with more interaction and a flexible classroom environment (Bishop & Verleger, 2013). A flipped classroom model is commonly known for providing students with time to access technology, such as videos in curricular and non-curricular settings. Class and homework assignments are used variably, whereas it had been flipped in the past through the assistance of teacher-created videos. In other words, the pedagogy of the flipped classroom retains its notion of reversing what is meant to be done in the classroom, but is done instead as a homework assignment. (Bergmann & Sams, 2012). As a result, many educational institutions have become interested in the flipped classroom, particularly real and virtual communication as a basic composite of learning and classroom management (Bergmann, 2011). In the flipped classroom, teachers provide their students with online videos including classroom lectures, while encouraging them to prepare before coming to class. Based on this, students are able to accomplish them as inquiry-based assignments (conventionally known as homework assignments). This designs the flipped classroom to entirely change the teaching and learning paradigms. That is, with new internet technology, students have become impatient to rely on worksheets, becoming passive listeners during lectures (Freeman & Schiller, 2013).

Teaching becomes students centered-learning, so that students should be engaged effectively in the learning process and should take responsibility for their learning, and acquire the skills that make them life-long learners. Experience and self-regulation of the knowledge in one's brain are two important factors in constructivist approach. Jaworski (1993) stated that, "Coming to know is a process of adaptation based on and constantly modified by a learner's experience of the world" (p.2). Moreover, Vygotsky assured that individuals reach the higher form of thinking according to how their self-organization function works (Gredler,2005) . The most important concept of transferring learners to effective learner is through Self-regulated learning (SRL). Self-regulated learning is a concept that located under the constructivism theory's umbrella, and supports building knowledge through experience as Zimmerman (1990) guaranteed that the self-regulated learning hints to action and process aimed at the acquisition of information or skills that affect agency, purpose, and instrumentality perceptions by the learners. Bland (2006) assured that self-regulation is required for meaningful learning through students skills that control their learning in a problem-based learning environment. Self-regulation is defined as individual-contained emotions, ideas, and behaviors displayed to reach particular goals and that occur at different levels and features in each developmental period (Zimmerman, 2001). Accordingly, the self-regulated learners seek out information when needed and take the necessary steps to master it such as: planning

activities, organizing the content and following self-learning process (Artino & Stephens, 2009; Zimmerman, 1990).

Media and internet technology has given students and teachers actual educational restructuring that develops learning skills. Academic administrators and teachers must appreciate information technology in a students' education. Consequently, the learning and teaching process has become accessible and flexible enough with internet communication technology, whether by providing multimedia content or educational assessment for teachers and students. The availability of different multimedia services including Teacher-Tube, Google, Smart board, Magic board, Slides share, Smart phones, YouTube, and other significant media accessories indicate that the educational process will develop rapidly and become an automated field where students feel self-sufficiency (Collins & Halverson, 2009). Harris et al. (2016:331) conclude that "the flipped classroom model is one model educators are experimenting with to address the needs of learners and expand students' capabilities for learning more efficiently and effectively in a time when lifelong learning is crucial to individuals and society."

The flipped classroom has many benefits, as mentioned by Bergmann and Sams (2012), such as assisting struggling students to watch videos several times, enhancing the interaction between students and teachers, which provides a good environment through creating a learning atmosphere, so that students can learn at their own pace and empower the relationship among themselves, as well as information exchange. In the use of SRL by the students, Cognitive, metacognitive and self-regulative, and resource management are three widely used strategies classified by Pintrich et al. (1993). By using SRL, with motivation of using off- line and online videos, students can use many strategies that mentioned by Zimmerman and Martines-Pons (1990) including self-evaluation, organization and transformation, goal setting and planning, seeking information, keeping records, monitoring, environment structuring, self-consequences, rehearsing and memorizing, seeking social assistance and reviewing records.

Thus, this study conducted to investigating the effectiveness of using flipped classroom in teaching the math2 course to preparatory year students at University of Tabuk, raising the following question:

> What is the effectiveness of using the flipped classroom in teaching Math2 course on the student achievement at preparatory year of the University of Tabuk?

Problem Statement

Now technology is in everyone's home and life: this generation is enthusiastic about using it in each aspect of their lives. One of the new instructional methods is the flipped classroom, which refers students to recorded videos in the subject being taught; this allows students to access them at their convenience, using any kind of platforms, a "Moodle," the administrative program is used at the University of Tabuk for all students as part of the required activities. The researcher had been a dean for the preparatory year deanship at University of Tabuk, and thought of trying this method in a *Math2* course taught at scientific colleges during the first year including; medicine, applied medical science, science, engineering, and computer science. Thus, the idea and effectiveness of flipped classrooms is being examined in the teaching of the Math2 course at the University of Tabuk.

Hypotheses

The previous question which was generated on the introduction can be consisted of two hypotheses:
1) There is no statistically significant difference among students' performance in achievement tests, regarding the methods by which they are taught (traditional instruction vs. flipped classroom instruction).
2) There is no statistically significant difference among students' performance in achievement tests, regarding their majors.

Significance of the Study

The significance of the study stems from a set of considerations:
1) Implementing flipped classroom teaching instruction as a new methodology will give students more motivation to learn.
2) It will be a pedagogical strategy, assuming that it is effective, which can largely be used in teaching other subjects at the University of Tabuk.
3) An electronic material can be used as a reference for students at any time.

4) To add to the body of research that concern with depending on the effectiveness of students SRL and using technology on students' performance.

Limitations

This study will be limited:
1. It is a sample for male students, due to the segregation between males and females in educational institutions in Saudi Arabia.
2. For students who register for a math2 course according to their study plan.
3. Three topics required in the mathematics course: limits and continuity, differentiation, and applications of differentiation. The course was taught to the students during the fall semester of 2015-2016.
4. To measure only the students achievement after using the flipped classroom course, and not include measuring the type of SRL strategies used by the students.

Definitions

Flipped classroom

The flipped classroom as defined by Harris et al. (2016) is "a learning environment that provides students with a variety of means to study basic knowledge content as part of the pre-class-meeting homework, so that teachers can use class time more effectively for hands-on activities to practice, apply and demonstrate mastery of the content learned from the pre-class requirements (p. 326)."

Hughes (2012) defined the flipped classroom as a pedagogical method that replaces the standard lecture-in-class with opportunities for students to review and discuss the ideas before coming to class. The researcher in this study identifies the flipped classroom as a method that uses technology and related applications to let students review, discuss, comment, and have access at any time based on their own needs.

Math2: is a course taught to science majors only, concentrating on calculus.

The preparatory year student: is a term used at the University of Tabuk, and is equivalent to the freshmen students.

Literature Review

Recently, new developments in the field of multimedia education resulted in the flipped classroom technology, particularly in places such as the United States. Thus, much research has been conducted to investigate the flipped classroom and relevant areas. Researches reviewed here on flipped classrooms can be organized into two research areas categories according to the dependent variables including: students achievements, students skills, motivations, and thinking, and learning environment. The first area of research was investigating the effectiveness of flipping classroom on student achievement, attitude, learning skills, thinking, and engagement in learning. The second area of research was investigating the effect of flipping classrooms on learning environment and evaluating the flipped classrooms model.

Flipped Classrooms' Effect on Students Learning

Crouch and Mazur (2001) implemented the flipped classroom model with classes including over 100 students. The researcher collected data over 10 years. The research findings showed significant gains in learning based on standardized tests and conceptual understanding inventories. The results also indicated that the teaching model represents the background knowledge learning principle and reduces the cognitive load for learners by encouraging them to read before coming to class. In a recent study by Vaughan (2014), the use of the flipped classroom model in an introductory teaching course was assessed. The findings of the research showed that millennial learners possess ongoing access to knowledge. In addition, the study showed that students favor active learning in a collaborative educational setting. Talley and Scherer (2013) examined the effect of using the flipped classroom for undergraduate psychology students at a mid -Atlantic Historical Black College and

University (HBCU), using a STEM course for a flipped classroom with self-explanation; this requires students to review videos to explain the process using their own words. By comparing students' grades during this semester with the previous one, their performance was increased. The conclusion was that the use of effective learning techniques, embedded with a STEM course, plays a significant role in increasing retention in STEM disciplines among African Americans.

Jacqueline et al. (2013) conducted a study to examine the effective use of the flipped classroom technique in a traditional basic pharmaceutics course to assess student academic performance, engagement, and perception. The basic pharmaceutics course was flipped and delivered to 22 satellite students on 2 different campuses. Results revealed an increase of students' support for the flipped classroom, and how they positively perceived it. In addition, 89.5% of the students preferred the flipped classroom format after completing the course, vs. 34.6% before completing it. The findings suggested that the flipped classroom promoted student empowerment, development, and engagement; however, no significant differences were found in students' performance in comparison during previous terms. In a study of Ramaglia (2015), it was aimed at exploring the effectiveness of the flipped classroom in a high school math classroom on student performance and critical thinking. The researchers used experimental design with two groups: a control group with 30 students and a treatment group with 28 students. The results revealed no significant differences between the two groups in math test performance and performance on critical thinking, related to the teaching strategy used in this study. Also, Quint (2015) investigated the efficacy of the flipped classroom model in a university mathematics class. This research discussed the gap of the flipped classroom model in its relevance to control groups to evaluate the effectiveness of the flipped classroom model. The findings revealed that flipped classroom teaching developed learners' thinking. In addition, the findings showed that the consecutive use of the flipped classroom was efficient in creating growth in the measures of learners' output compared to classes treated conventionally. The study conducted by Saunders (2014) aimed at investigating the differences between a control group using typical instruction and using flipped classroom instruction within a treatment group of high school students' achievement and perception of mathematics learning. Common final assessment scores, active learning observation in the classroom, and teacher interviews were the tools for collecting data. No differences in comparison between performance of both groups in the two semesters (fall and spring) could be found. The results showed that the flipped classroom teaching method enhanced student learning during the second semester of the study. It was also found that successive implementation of the flipped classroom was more effective at producing gains in measures of student learning outcomes than a class taught more traditionally.

On the other hand, Barkley (2015) examined flipping the college classroom for enhanced student learning, which consisted of classroom teachers. The results indicated that the flipped classroom is a transformation in the mindset of teachers and students more than an alteration in techniques. Also, findings revealed that classroom teachers saw knowledge to accelerate learning and commitment output. In addition, this study shows that the main objective of the flipped classroom for fresh students is to exploit student output by using face–to-face instances with the learners. Sahin, Cavlazoglu, and Zeytuncu (2015) conducted a case study to examine flipping a college calculus course. The study consisted of 96 students, i.e., freshmen and sophomores. The researcher used descriptive statistics and the paired t-test for the data. The research findings showed that respondents were in favor of watching flipped classroom video recordings 44% more, compared to reading parts of a textbook, about 17% for the research. Also, 83% of the learners who flipped classes did better than those students who did not. Jerkin (2015) who studied the introductory American politics class based on student perceptions of the flipped classroom states that learners partly favored the flipped classroom, even though it was not explicit that they favored a completely flipped class, as some features of the flipped classroom were more effective than other ones. Neuberger (2010) who studied fostering effective mathematics teaching demonstrate that instructors found that some of their assumptions about math teaching shifted as a result of the effect of the teacher's performance. Also, her study showed that training assists teachers to better teach mathematics to their students.
A case study conducted by Muir and Geiger (2016) with one teacher and his grade 10 'mathematics extended' class from a large metropolitan secondary college in Tasmania, which consisted of 27 students. Interview, class observation, and survey were the instruments used to collect data. Findings indicated that the teacher and students were positive about their experiences with a flipped classroom approach, and that students were motivated to engage with the class. Sadik (2015) investigated the effectiveness of flipped lectures in improving student engagement and satisfaction. The study was conducted at Sultan Qaboos University in Oman, including 75 male and female students. The findings indicated that flipped classroom settings develop students' cognitive, behavioral, and emotional engagement in the lecture. They also develop general contentment with interactions and discussions, classroom time management, and overall settings and learning. Further, Jacobson (2015) points out in his study that the efficient classroom, team-based learning and lecture video acceleration affected learning efficiency of a first-year engineering course. His research showed that 45% of participants accelerate video lectures to 1.25X or 1.5X regular pace and another 45% of respondents observe them at standard speed. Less

than 10% of respondents accelerate videos faster than 1.5X regular pace. Overall, this research indicates that a TBL classroom can offer additional resources and successful learning settings. A study conducted by Nwosisi, Rosenberg, and Walsh (2016) aimed to analyze the effectiveness of flipping 30% of the course content in their institute. The study found that 94% of students liked this style of learning and 72% were convinced that it helped them learn the material better. It was found that flipped instruction facilitates interaction among students and instructors, leads to better learning, helps students effectively acquire skills and knowledge; and show good attitudes towards learning.

Flipped Classrooms' Effect on Learning Environment

Strayer (2007) conducted a study to examine effects of the flipped classroom on the learning environment: a comparison was conducted on learning activity in a traditional classroom and a flipped classroom with an intelligent tutoring system. He concluded that the flipped classroom is better suited for certain classrooms and courses than others. It provides students with appropriate academic settings and indicates that in the flipped classroom, students did not see it as convenient with the classroom orientation (in relation to teaching and learning tasks throughout the academic course). Kay and Kletskin (2012) evaluated problem-based video podcasts to teach mathematics in higher education. He points out that problem-based video podcasts are "short, web-based, audio-visual explanations of how to solve specific procedural problems in areas such as mathematics or science (p619)." Pierce and Fox (2012) investigated the impact of the flipped model on student performance and perceptions, conducted on a pharmacy-integrated therapeutics course and process-oriented directed inquiry learning. The findings of the research showed that students were effectively involved in critical thinking and developing the necessary problem-solving skills. Almohammadi, Barker, Lilley, and Veneziano (2015) examined the flipped classroom from a computer system's vantage point to diagnose errors in solving equation perspectives. A computer system has been developed in order to be able to separate out and classify errors relating to a lack of understanding of principals involved in solving such equations from errors relating to the lack of the basic mathematical skills necessary to solve them. The system was able to filter out these different classes of errors using a simple interactive dialogue box for students with a set of random equations The findings of the study propose methods where the system may be expanded and used for the advancement of scientific research. Likewise, Scott and Tanner (2015) investigated action experiments and an industry partnership influenced a flipped classroom approach. The study examined the use of the flipped classroom in two successive second-year information systems courses since 2013. The findings showed that reflections and lessons for every individual assisted in conceptualizing interventions and adjusting to alternative and accessible ones. The temperament of the partner developed, as anticipated.

In addition, King and Piotrowski (2015) conducted research to investigate E-learning and flipped instruction integration in business education. The findings showed that i) past research on the flipped model of instruction with a focus on application in business school coursework; ii) outlines were available for major E-learning resources based on experiences of the first author in designing and executing flipped classes for a business school curriculum; and iii) reports on experience-based success and failure with this pedagogical model of integrating E-learning and flipped instruction in face-to-face instruction. Moreover, students with motivation and positive attitude toward learning, besides working in a good design learning environment will succeed in achieving good performance. Jerkins (2015) flipped an "Introduction to US Politics" course, which consisted of 140 students in order to examine the students' perception of taking the class; students perceived it positively and most liked it. However, the study concludes that students were not inclined to engage in group work in a flipped classroom, which arises at critical points in which instructor must think about how to deliver content outside the class, but not just upload lectures to YouTube and still call it flipped.

Baran (2014) reviewed research on mobile learning in teacher education as well. The study was comprised of research on mobile learning techniques worldwide; its findings indicated that (a) there is an increasing trend integrating mobile learning in teacher education contexts; (b) theoretical and conceptual perspectives are scarcely reported; (c) variations exist in perceptions, attitudes, and usage patterns; (d) engagement with mobile learning and devices is primarily reported as beneficial; (e) challenges were rarely reported; and (f) several pedagogical approaches support mobile learning integration for teacher education settings. Such results were discussed to delineate their suggestions on the advancement of mobile learning in teacher education for integrative research.

Based on previous studies, it can be summarized that a flipped classroom model provides a method for teachers to assist students and reinforces representation outside of the educational setting, thereby decreasing the cognitive load needed for deeper learning in the academic environment. If students are guided toward these

goals to reflect about background knowledge outside of class, the cognitive load will be reduced and learning will be more convenient while students are in class.

Methodology

The quasi-experimental design was adopted in this study with two groups: the control group and treatment group. For the treatment group, they were taught with flipped class instruction as a pedagogical method, in which students have access to the recorded videos at any time by their own via Moodle platform, whereas the control group was taught without using the flipped classroom and had no access to the videos.

Participants

The participants of this study consisted of all preparatory year's students who registered in a math2 course from five different colleges: medicine, engineering, computer science, applied medical science, and college of science. The total number of students who complete the course and represent the population was 320. Sample of the study consisting of 92 students were divided into two groups: a control group with 45 students, and a treatment group with 47 students. Table 1 illustrates the number of students in the study sample who completed the course during Fall semester 2015/2016.

Table 1. Study sample classified by majors

College	N = Students	Control	Treatment
Medicine	17	9	8
Engineering	21	11	10
Computer Science	21	12	9
Applied Medical Science	17	8	9
Science	16	7	9
Total	92	45	47

Instruments

To accomplish this study's goals, the researcher used an examination as an instrument to measure students' achievement in Math2. It passes through many procedures to be the final version and valid for the purpose of this research.

The first step was identifying the purpose of the test, which was to measure student achievement in the Math2 course. The second step was analyzing the content of the math2 and building the table of specifications to weigh each subject, of math2 content, and its percentage was compared to the topic in order to prepare the first draft of test questions. The third step was test validation of the instrument, which was sent to experts to review content and check face validity, as their notes were taken into account. Moreover, correlation among test questions was calculated to assess consistency and validity. The correlation coefficient ranged from 0.67-0.92. The fifth step, a pilot study consisting of 30 students to take the test for reliability, with adequate time to take it, and calculate its item difficulty, which was reported between 0.35-0.75. The reliable Alpha-Cronbach coefficient was 0.902. The adjusted time for the test was 50 minutes, while the final version was used as a measurement of students' achievement in calculus topics, representing the Math2 course.

Finally, in order to flip the course, Math2 was analyzed and content was designed online with the analysis, design, development, implementation, and evaluation (ADDIE model) given its launch in the Moodle platform. To achieve the purpose of the study, recorded videos of Math2 content were uploaded and available for the treatment group at any time. Following ADDIE's model, the steps were followed to get the final design of the math2 course.

To ensure the equity and equality of both groups, a pre-test of calculus was performed and graded. A T-test was calculated (Table 2) to measure whether there was a significant difference among students in both groups in performance. Results revealed there was no statistically significant difference in performance, which indicates equality among participants in this study.

Table 2. T-test results for control and treatment groups

Mean Control group	Mean Treatment group	F	Sig.	t	df	Sig
4.21	4.62	2.114	0.149	-1.028	90	0.307

Results

Test the First Hypothesis

The first hypothesis was: there is no statistically significant difference among students' performance in achievement tests, regarding the methods by which they are taught (traditional instruction vs. flipped classroom instruction). To test the study hypothesis, a one-way ANCOVA was conducted. It can be found that there was no statistically significant difference among student performance in this achievement test (regarding the way by which they were taught (traditional instruction vs. flipped classroom pedagogy). Table 3 illustrates the study sample means in the two groups: the control group and treatment group. It appears that the treatment group mean (19.87) was higher than the control group (14.96). Table 4 illustrates the sample by majors:

Table 3. The test mean and standard deviation of control and treatment group:

Group	Mean	Std. Deviation	N
Control	14.96	2.881	47
treatment	19.87	1.973	45
Total	17.36	3.488	92

Table 4. The test mean and standard deviation for control and treatment groups by major

Major	Mean	Std. Deviation	N	Mean	Std. Deviation	N
	Control group			Treatment group		
Medicine	16.11	2.57	9	19.88	1.126	8
Engineering	14	3	11	20.9	2.03	10
Science	15.33	3.65	12	19.22	2.11	9
Applied Medicine	15.13	2.42	8	18.89	2.15	9
Computer Science	14.14	1.95	7	20.33	1.87	9
Total	17.36	2.88	47	19.87	1.973	45

Test the Second Hypothesis

The second hypothesis was: there is no statistically significant difference among students' performance in achievement tests regarding their majors**.** To determine if this difference is significant, one-way ANCOVA was conducted. Table 5 demonstrates that no differences among students' performance means are related to their majors. However, there were significant differences among students' means in favor of the treatment group which was taught by using flipped classroom. The effect size was 0.522, meaning that the effect of the independent variable (teaching with a flipped classroom) has an effect of 52% in student performance and the reaming 48% accounted for other variables.

Table 5. The one way ANCOVA results

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	610.583[a]	10	61.058	9.960	0.000	0.551
Intercept	4256.569	1	4256.569	694.313	0.000	0.896
Pretest	2.927	1	2.927	.477	.492	0.006
Group	542.702	1	542.702	88.523	.000	0.522
Major	9.550	4	2.388	0.389	0.816	0.019
Group * Major	39.565	4	9.891	1.613	0.179	0.074
Error	496.580	81	6.131			
Total	28829.000	92				
Corrected Total	1107.163	91				

The second hypothesis was: there is no statistically significant difference among students' performance in achievement tests regarding their majors. By calculating the one-way ANCOVA for the independent variable, students' majors, Table 5 shows that no significant difference among their performance was related to their majors. Moreover, only 2% of the effect was accounted for by the major.

These findings are inconsistent with many studies: Rosenberg, and Walsh (2016); Almohammadi, Barker, Lilley and Veneziano (2105); Quint (2015); Saunders (2015); King (2015); Barkley (2015); Sahin, Cavlazoglu, and Zeytuncu (2015); Muir and Geiger (2015); Sadik (2015); Jacobson (2015); Vaughan (2014); Scott and Tanner (2013); Talley and Scherer (2013); Jacqueline, et al. (2013); Pierce and Fox (2012); Crouch and Mazur (2001). Nwosisi,. However, these findings are opposite to what Strayer (2007)found, as well as that in Jerkin (2015). That may be due to the way by which the two studies were conducted where Strayer (2007) concern with the environment of flipped classrooms and students' setting which students did not prefer, also Jerkin (2015) applied the flipped in the politics subject which may be not attractive for the students. Moreover, no study took the major of participants as a variable except in this one, where no differences were recorded.

Conclusion and Recommendations

This study aimed at investigating the effectiveness of utilizing the flipped classroom in teaching math2 at the University of Tabuk. Experimental design showed two groups: a control and a treatment group in this study. Treatment group used flipped classroom of calculus for the whole semester. Students at the treatment group had the chance to access the recorded video at their ease. The study tested two hypothesizes:(1) there is no statistically significant difference among students' performance in achievement tests, regarding the methods by which they are taught (traditional instruction vs. flipped classroom instruction), (2)there is no statistically significant difference among students' performance in achievement tests, regarding their majors. Results revealed that using the flipped classroom in teaching math2 was effective, since there was a significant difference between the two groups, favoring the treatment group in their achievement test in calculus. However, there was no difference among students in their performance in a calculus test in relation to the students' majors.

In terms of recommendations, it would be suggested using the flipped classroom for instructors to enhance student learning. Teachers should consider using the flipped classroom as a strategy especially for at-risk students in need of learning help. The University must pay more attention to the infrastructure required for flipped classrooms in all courses, given the assistant tools for faculty teaching members. Concentrating on technology must be a theme for conferences and research sponsored by the University. There is a need for more research in the use of flipped classrooms in pedagogy and teacher education, utilizing new technology in classrooms, managing obstacles of such technology, concentrating on training sessions for in-service teachers for utilizing and designing videos to help students, and assisting students at risk through using a flipped classroom. More research is needed in testing type of SRL used by the students and its effects on student performances and attitude besides another variable that can be tested as number of entrance in online class for watching videos. Finally, a study of building a theoretical framework and paradigm for using new technology is needed.

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