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Effect of Implementing Instruction Based on Flipped Classroom Approach on Critical Thinking and Attitudes toward Mathematics of Fourth-year Undergraduate Students in Mathematics Teacher Preparation Program, Faculty of Science and Technology, Suan Dusit University

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Abstract

This study aims to: (1) compare critical thinking ability in the course of Trends of Mathematics Teaching of fourth-year undergraduate students who attended the instruction based on flipped classroom approach with criteria of the course at 70 percent and (2) compare attitudes toward mathematics of fourth-year undergraduate students before and after attending the instruction based on flipped classroom approach. Sample of the study was 115 fourth-year undergraduate students who were studying in mathematics teacher preparation program at the Faculty of Science and Technology, Suan Dusit University and selected by purposive sampling. These undergraduate students were studying in “Trends of Mathematics Teaching” course in the first semester of 2017 academic year. Instructional activities in the course were based on lesson plans which were designed focusing on flipped classroom approach. At the end of the course, the undergraduate students had to complete a test focusing on critical thinking in trends of mathematics teaching by results of the IOC analysis that revealed every test item had IOC scores at 1.0 which were greater than the criteria at 0.5 and a questionnaire on attitudes towards mathematics by results of the IOC analysis that revealed every test items had IOC scores ranging from 0.67-1.00 which were greater than the criteria at 0.5. The collected data were analyzed for mean, standard deviation, one-sample t-test and pair-sample t-test.

The study revealed that: (1) the critical thinking ability of the undergraduate students who were in the instruction based on flipped classroom approach is statistically higher than 70% at the alpha level of 0.01 and (2) the attitudes toward mathematics of the undergraduate students after attending the instruction based on flipped classroom approach is statistically higher than those prior to attending the instruction based on flipped classroom approach at the alpha level of .01.

Introduction

Education in the 21st century focuses on supporting students to succeed in future work and real-life living. Mathematics is a discipline which is important for real-life living since it develops students' thinking and enhances students' creativity. Mathematics helps students to be able to properly predict, plan, make decision and solve problems. In addition, mathematics is an important tool for studying other disciplines such as science and technology. Thus, mathematics helps to improve the quality of life (Ministry of Education, 2008; Makanong, 2011; Panich, 2013).

Although mathematics is an important discipline, current teaching and learning mathematics is not successful. One reason is that the majority of teachers still teach by lecturing. Lecturing is usually employed in classroom teaching which places the teacher as an information provider and the student as an information receiver. With this instructional strategy, the student becomes used to listening to the teacher without giving opinion. Thus, the student learns from memorizing and limits the opportunity to develop skills in thinking, listening, and writing (Kanjarakpong, 2002; Panich, 2013). Another issue is instructional media is not included in mathematics instruction which limits the students to participate in classroom activities. This instructional approach creates boredom among students, afraid of studying mathematics, and have negative attitude toward mathematics. Students finally have low achievement in mathematics (Jaikwang, 2011). In addition, teachers may lack the technique to transfer knowledge to students. They do not prepare for instructional activities. Sometimes, the instructional activities do not motivate students. These situations create an environment where students lack the motivation to study so that they do not learn mathematics (Plangprasobchoke, 2006).

Critical thinking is one of the important skills. Individual with critical thinking are able to develop creative thinking, criticized thinking, and problem solving which are necessary skills in the 21st century. Mathematics is a discipline that helps students develop critical thinking. The teacher is an important person who promote students' thinking in classroom instruction by having appropriate instruction. The instruction should allow students to identify, reason, analyze, and criticize the given situation so that students are able to choose the best solution of the problem (Khammanee, 2014).

Flipped classroom approach is an instructional approach that is appropriate to promote students' thinking. This instructional approach allows students to self-learn from digital media and to apply what they have learned to do in-class activities. The use of digital media in flipped classroom approach allows students to flexibly learn based on their ability. Thus, students can learn as often as they need so that they clearly understand the content before doing in-class activities. As a result, teacher has more time to develop students' critical thinking ability in the classroom (Loomroy, 2003; Panyajirawut, 2013; Panich, 2013; Uttamung, 2015).

A course "Trends of Mathematics Education" at Suan Dusit University is a course with an emphasizes on innovation and in-trend research that are relevant to mathematics teaching. Activities in the course focus on studying from articles, journal papers, or research papers, including analyzing and discussing about trends or changes of mathematics teaching and learning. In this course, students have to study from various learning resources. Then, they apply what they have learned to do in-class activities. The teacher plays a role to facilitate activities, to support students to think, to lead discussion, and to guide students to make a conclusion about the content. These processes in the course "Trends of Mathematics Education" are related to student-centered approach which will enhance students' attitude toward mathematics.

From the aforementioned, this researcher believes that the implementation of flipped classroom approach would be effective to enhance students' critical thinking and attitude toward mathematics. Thus, the researcher studied how the implementation of flipped classroom approach in the course "Trends of Mathematics Education" would affect students' ability to critical think and enhance attitude toward mathematics. More details about the study will be described in the next sections.

Objectives

1. To compare critical thinking ability in trends of mathematics teaching of fourth-year undergraduate students who attended instruction based on flipped classroom approach with criteria of the course at 70 percent.
2. To compare attitudes toward mathematics of fourth-year undergraduate students before and after attending the instruction based on flipped classroom approach.

Conceptual Framework

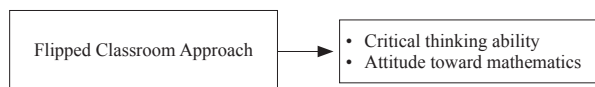


Figure 1 Conceptual Framework

Research methodology

1. Population and Samples

Population of the study was the fourth-year undergraduate students in Suan Dusit University. Sample of the study was 115 fourth-year undergraduate students who were studying in mathematics teacher preparation program at the Faculty of Science and Technology, Suan Dusit University. The selection was conducted by purposive sampling through students who were studying in “Trends of Mathematics Teaching” course in the first semester of 2017 academic year.

2. Research Design

This is a quasi-experimental research with one group of samples. Design of the research is shown in Table 1.

Table 1 Design of the Study

Sample	Pre-test	Intervention	Post-test
E*	• Attitude toward mathematics	X**	• Critical thinking ability • Attitude toward mathematics

* E is sample of the study.

** X is instruction based on flipped classroom approach which is was given to the samples.

3. Research Instrument

3.1 Research instrument is lesson plans focusing on instruction based on flipped classroom approach. Processes to develop the lesson plans are the following:

1) The researcher reviewed and studied theories and ideas about instruction based on flipped classroom from related documents, journal papers, and research papers.

2) The researcher reviewed and studied information about the course “Trends of Mathematics Education” from the curriculum of mathematics teacher preparation program, Suan Dusit University.

3) The researcher designed four lesson plans focusing on instruction based on flipped classroom approach. These lesson plans are for 12-hour teaching in Trends of Mathematics Education course. More details about each lesson plan are showed in Table 2

Table 2 Details about Lesson Plan Used in the Study

No. of lesson plan	Content
1	Exploring research and research articles related to mathematics instruction
2	Theory and teaching related to mathematics instruction
3	Examples of mathematics instruction in the 21st century
4	Students’ presentation of design and presentation of mathematics instruction in the 21 st century

4) Research advisor reviewed the lesson plans in order to check correctness and give suggestions.

5) The researcher rectified the lesson plans based on the advisor’s suggestion. As follows

- Improve the activities to be more appropriate for applying in class.

- Improve the language used in activities to focus on the development of critical thinking.

- Improve the format of worksheet to be more interesting.

6) The researcher applied the developed lesson plans to teach the research sample.

3.2 Collecting data instruments are: (1) a critical thinking test in trends in mathematics education and (2) an evaluation form for attitude towards mathematics.

1) A critical thinking test in Trends in Mathematics Education course was used to collect the data after finishing the course. Processes to develop the test are the following:

1.1) The researcher reviewed and studied documents, journal papers, and research papers that are related to educational measurements and evaluations.

1.2) The researcher reviewed and studied information about the course “Trends of Mathematics Education” from the curriculum of mathematics teacher preparation program, Suan Dusit University.

1.3) The researcher analyzed the content in the course in order to specify the numbers of test items in the test

1.4) The researcher developed five test items for critical thinking. Criteria used to score the test items are shown in Table 3.

Table 3 Description of the Score for Test Items in Critical Thinking Test

Score	Description
5	Students are able to criticize by applying knowledge related to mathematics instruction to describe clearly and make conclusion correctly.
4	Students are able to criticize by applying knowledge related to mathematics instruction to describe clearly but make conclusion partly.
3	Students are able to criticize by applying knowledge related to mathematics instruction to describe and make conclusion partly.
2	Students are able to criticize by applying knowledge related to mathematics instruction to describe partly but make conclusion incorrectly.
1	Students are able to criticize by applying knowledge related to mathematics instruction to describe illogically. However, there is evidence showing that students attempt to describe.
0	Students are not able to criticize or do not show evidence to answer.

1.5) Research advisor reviewed the test items in order to check correctness and give suggestions.

1.6) The researcher rectified the test items based on the advisor's suggestions.

1.7) Three specialists reviewed the revised test items in order to check content validity, appropriateness of language, and appropriateness of scoring criteria. After reviewing the test items, specialists assigned scores for checking Index of Item-Objective Congruence (IOC). Results of the IOC analysis revealed that every test item had IOC scores at 1.0 which were greater than the criteria at 0.5. In order to help undergraduate students clearly understand the questions and to better answer, the specialists suggested that more information should be included in the test items.

1.8) The researcher selected three test items which were IOC eligible to be included in the critical thinking test in Trends in Mathematics Education course.

1.9) The researcher used the critical thinking test to collect data from the research sample.

2) An evaluation form for attitude towards mathematics was used to collect the data after finishing the course. Processes to develop the test are as follows:

2.1) The researcher reviewed and studied documents, journal papers, and research papers that are related to the evaluation of attitudes towards mathematics.

2.2) The researcher developed 15 evaluation items for attitudes towards mathematics. The research sample had to rate their attitudes towards mathematics from one to five. Description of each rating score is shown in Table 4.

Table 4 Description of the Rating Score in the Evaluation Form for Attitude towards Mathematics

Rating score	Description
5	Extremely agreed
4	Agreed
3	Uncertain
2	Disagreed
1	Extremely disagreed

2.3) Research advisor reviewed the evaluation items in order to check correctness and give suggestions.

2.4) The researcher rectified the evaluation items based on the advisor's suggestion.

2.5) Three specialist reviewed the revised evaluation items in order to check the relevance between the evaluation items and behaviors that show attitude towards mathematics. After reviewing the evaluation items, specialists assigned scores for checking Index of Item-Objective Congruence (IOC). Results of the IOC analysis revealed that every test item had IOC scores ranging from 0.67 – 1.00 which were greater than the criteria at 0.5. In order to make the evaluation items easy to understand, the specialists suggested that language used in some items should be revised.

2.6) The researcher selected ten test items which were IOC eligible to be included in the evaluation form for attitude towards mathematics

2.7) The researcher used the evaluation form for attitude towards mathematics to collect data from the research sample.

In this study, the data collection consisted of two main processes: preparation process and data collection process.

4. Preparation process.

The preparation process started with the design of four lesson plans for 12 hours teaching for the course "Trends of Mathematics Teaching". These lesson plans focused on instruction based on flipped classroom approach, an instructional approach allowing students to learn new concepts with the use of technology. Instruction in the lesson plans consisted of four stages based on Schoolwires (2013) idea of flipped classroom approach.

4.1 Stage 1: Experiential Engagement. In experiential engagement stage, instructor describes teaching methodology used in the class to students and introduce content that will be taught in this course.

4.2 Stage 2: Concept Exploration. In concept exploration stage, instructor provides more details about instructional media to students. In this study, the

instructional media were digital media that the instructor developed and those from other sources.

4.3 Stage 3: Creating Meaning . In the creating meaning stage, students are allowed to learn new concepts from the instructional media that the instructor provides. Students have to understand the concepts presented in the instructional media since they have to apply their knowledge and understanding in the next stage.

4.4 Stage 4: Demonstration and Application. In demonstration and application stage, students have to apply knowledge and understanding that they gained in stage 3, creating meaning stage, to do in-class activity. In the activity, students have to discuss and exchange their knowledge and understanding to solve problems. During the activity, instructor plays a role as a facilitator who facilitates students to learn. Then, instructor and students collaboratively summarize the concepts gained at the end of the class.

After the researcher designed lesson plans, she prepared and developed instructional media, tools, and other documents related to the instruction specified in the lesson plans. An example of digital media used in this study is shown in Figure 2.

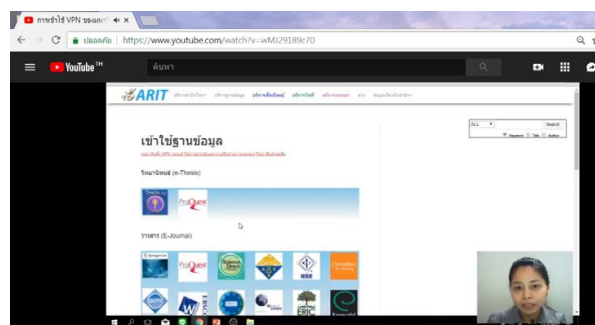


Figure 2 An example of digital media used in this study (Ruangnun, 2017a)

5. Collection of Data

Data collection process. The researcher collected the data in this study by herself. The data collection process started with evaluating students' attitude toward mathematics at the beginning of the course. The evaluation form was an online evaluation published in google form as shown in Figure 3.



Figure 3 An evaluation form on attitude toward mathematics used in this study (Ruangnun, 2017b)

Then, the researcher taught the fourth-year undergraduate students, who were samples of the study, by using the designed lessons. During the lessons, the researcher observed students' learning behavior. After completing four lessons (12 hours), students were evaluated based on their critical thinking ability by using the designed test and were re-evaluated on their attitude towards mathematics. Then, the critical thinking test and the evaluation form on attitudes toward mathematics were scored based on the criteria by the researcher.

6. Data Analysis

After the researcher scored the critical thinking test and the evaluation form on attitudes toward mathematics, the scores were analyzed by using SPSS for Windows software in order to:

6.1 Compare critical thinking ability of the fourth-year undergraduate students with criteria of the course at 70 percent by using one-sample t-test.

6.2 Compare attitudes toward mathematics of fourth-year undergraduate students before and after attending to instruction based on flipped classroom approach by using paired-sample t-test.

Results

This section shows two parts of the research results: (1) the comparison of critical thinking ability with criteria of the course and (2) the comparison of attitudes toward mathematics before and after attending to instruction based on flipped classroom approach.

The comparison of critical thinking ability with the criteria of the course. In the comparison of critical thinking ability of the fourth-year undergraduate students who attended to instruction based on flipped classroom approach with the criteria of the course at 70 percent, the researcher analyzed scores from critical thinking test for

arithmetic mean (\bar{x}), standard deviation (S.D.), and t score (one-sample t-test). The results are shown in Table 5.

Table 5 Mean (\bar{x}) Standard Deviation (S.D.) and T Score of Critical Thinking Score in the Comparison with Criteria of the Course at 70 Percent

	N	\bar{X}	S.D.	t	p-value
Samples	115	11.19	2.22	3.33	.001*

* p < .01

Table 5 shows that the arithmetic mean of the score in critical thinking is 11.19 out of 15 and the standard deviation is 2.22. In addition, table 5 shows that the fourth-year undergraduate students who attended to instruction based on flipped classroom approach have higher critical thinking ability in trends of mathematics teaching than 70% which is the criteria of the course at 99% confidence interval.

The comparison of attitudes toward mathematics before and after attending to instruction based on flipped classroom approach. In the comparison of attitudes toward mathematics of fourth-year undergraduate students before and after attending the instruction based on flipped classroom approach, the researcher analyzed scores from the evaluation form from arithmetic mean (\bar{x}), standard deviation (S.D.), and t score (paired-sample t-test). The result is shown in Table 6.

Table 6 Mean (\bar{x}) Standard Deviation (S.D.) and T Score of Attitudes toward Mathematics Score Before and After Attending the Instruction Based on Flipped Classroom Approach

	N	\bar{X}	S.D.	t	p-value
Pre-test	115	33.36	3.63	13.30	0.000*
Post-test	115	38.77	3.58		

* p < .01

Table 6 shows that the arithmetic mean and standard deviation of the score in attitudes toward mathematics before attending to instruction based on flipped classroom are 33.36 and 3.63, respectively. The score in attitudes toward mathematics after attending the instruction based on flipped classroom are 38.77 and 3.58, respectively. The score in attitudes toward mathematics after attending the instruction based on flipped classroom is statistically higher than those before attending the instruction based on flipped classroom at 99% confidence interval.

Discussion

This section discusses results of the study in two parts: (1) discussion of the result on the comparison of critical thinking ability with criteria of the course and (2) discussion of the comparison of attitudes toward mathematics before and after attending the instruction based on flipped classroom approach.

1. Discussion of the results on the comparison of critical thinking ability with criteria of the course.

The results reveal that the fourth-year undergraduate students who attended to instruction based on flipped classroom approach had higher critical thinking ability in trends of mathematics teaching than 70% which is the criteria of the course at 99% confidence interval. The discussion is as follows.

The result that the undergraduate students who attended to instruction based on flipped classroom approach have higher critical thinking ability reflects the importance of technology implementation in classroom instruction. The integration of technology makes content more interesting and enhances students' understanding. In addition, with the flipped classroom that students have to do activities after self-learning the content, the undergraduate students could apply knowledge in classroom activities. In the activities, they gained knowledge and developed critical thinking skills. They could give opinion, analyze content, present understanding, and evaluate peers' answer. These advantages are relevant with Na Mahachai (2013) who explains that supporting children to self-learn content prior to class and apply what they learn in class would enhance their learning. They could learn faster and better. Thus, there would be more time for developing their thinking skills. With the flipped classroom approach, students come to class with understanding since they self-learned the content prior to class. They would have time in class for discussing, joining classroom activities, and developing critical thinking skills. In addition, flipped classroom approach is an instructional approach that uses open-ended questions. The use of open-ended questions allows students to usually, continuously, and effectively use their critical thinking ability. This idea is relevant to what Papoi (2008) states that the abilities to think critically and creatively help individuals to develop their academic and profession. Individuals are able to develop new knowledge so that they understand the changes of society.

Flipped classroom approach is an instructional approach that promotes students' self-learning by using

electronic or online media, which are learning resources that the students are interested in. These learning resources provide students opportunities to easily access to content and review the content. This idea is related to what Panich (2013) describes as the flipped classroom approach as an up-to-date instructional approach that implements the use of ICT to motivate students. The implementation of flipped classroom approach helps students avoid non-advantaged activity. In addition, this approach supports students to explore and to learn content by themselves. This is relevant to the idea of Bergman & Sams (2007) who state that flipped classroom approach allows students to use technology to build learning environment in student-centered classroom. Students can learn from a short talk in electronic media as often as they want so that they better understand the content. These ideas are also related to what Ritkaew (2013) stated in her study. In the Ritkaew study, she implemented flipped classroom approach with the use of ClassStart. Her study reveals that undergraduate students had learning behaviors that differ from usual. The undergraduate students explored knowledge by themselves, persuaded peers to learn in the learning resources provided by instructor, and discussed in classroom activities.

2. Discussion of the results on the comparison of attitudes toward mathematics before and after attending to instruction based on flipped classroom approach. The results reveal that the score in attitudes toward mathematics after attending to instruction based on flipped classroom is statistically higher than those before attending the instruction based on flipped classroom at 99% confidence interval. The discussion is as follows.

The flipped classroom is an instructional approach that emphasizes students to self-learn from home. In case that students do not understand, they can study from the digital media as often as they need. After they understand the content, they apply knowledge to do in-class activities. The activities focus on students' participation, co-learning, giving opinion, and sharing knowledge. In addition, the activities promote student-to-student and student-to-teacher interactions. Thus, teacher knows more about individual students. Students are able to ask and discuss with teacher. This idea is related to Wonganuttararoj (2003) idea about individuals who affect to students' attitude toward learning. She describes that teacher, peer, and school environment are effective to students' attitude toward learning. The teacher plays an important role in developing students'

positive attitude toward learning, motivating students, and promoting students to realize the importance of learning. This idea is also relevant to what Mazur (2013) describes about result of implementing flipped classroom approach on students' achievement and perception in mathematics. Mazur describes that the implementation of flipped classroom approach can improve students' achievement, satisfaction in learning, and attitude toward learning.

Suggestions

1. Comments on Implementation of this Study

1. To implement flipped classroom approach, the teacher should realize the importance of instructional media prepared for students' self-learning. The instructional media has to be easy to understand and clearly communicated. Importantly, the teacher needs to realize that the instructional medias are not teachers. Thus, it is still necessary that the teacher has to additionally describe and summarize the content so that students clearly understand.

2. Within flipped classroom, students need to be responsible to study what the teacher assigns.

2. Comments on Future Study

2.1 There should be studies on results of implementing flipped classroom approach in other content or other educational levels.

2.2 Since flipped classroom approach is the instructional approach that allows students to apply knowledge to give opinion, there should be studies on results of implementing flipped classroom approach on the development of other abilities such as reasoning ability.

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