ENHANCING STUDENTS' ACHIEVEMENT AND INVESTIGATING STUDENTS' SATISFACTION IN LEARNING MATHEMATICS BY USING FLIPPED CLASSROOM

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The objectives of this classroom action research were to enhance students' mathematical achievement and to survey students' satisfaction in learning by using flipped classroom. The participants were 32 grade 11 students who enrolled in the second semester of the academic year 2019 at a high school. The topic used in this study was Vectors in Three Dimensions. The instruments were 7 lesson plans, achievement test and satisfaction survey. Learning management by using flipped classroom comprised 3 steps: 1) before class, students studied online learning through video clips, handouts and quizzes, 2) during class, teacher reviewed key concepts and students discussed the contents that they had studied from home, solved harder problems, and got individual help from teacher and 3) additional skills or extended knowledge. Data were collected from pretest, posttest, and satisfaction survey. Data were analyzed by using Effectiveness Index, mean, percentage, mode, and standard deviation. The results showed that: 1) the Effectiveness Index of the flipped classroom was 0.8 which revealed that students' achievement was increased 0.8 from the beginning and 2) students' satisfactions in three categories: students' understanding category, learning activities category, and learning atmosphere category by using flipped classroom were at satisfied, satisfied, and very satisfied, respectively.

Keywords: flipped classroom; students' achievement; students' satisfaction

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Introduction

Mathematics is a school subject that stimulates student's thinking. It enhances reasoning, creative thinking, planning, deciding and solving problems. Mathematics is a tool for studying science and technology. Therefore, mathematics is useful for living and developing the quality of life.

The Basic Education Core Curriculum implemented in 2008 aimed to enable all children and youths to continuously learn mathematics with their potentiality. This aim was applied from Grade 1 to Grade 12 while the contents extended wider as students move up to higher levels.

The contents comprised six strands:

Strand 1 - Number and Operation,

Strand 2 - Measurement,

Strand 3 - Geometry,

Strand 4 - Algebra,

Strand 5 - Data analysis and Probability, and

Strand 6 - Mathematical skills and processes.

Today, The Basic Education Core Curriculum implemented in 2008 (Revision 2009) was developed by IPST delegated authority from the Ministry of Education which prescribed the contents in three strands:

Strand 1 - Number and Algebra,

Strand 2 - Measurement and Geometry, and

Strand 3 - Statistics and Probability.

Schools can make their own decision from the national curriculum to produce a school-based curriculum in which schools can choose contents and sequence to teach on their own.

For Thailand, the educational reform has introduced decentralization and delegated authority to schools as a school-based management system. Schools are supposed to develop a school-based curriculum based on learning outcomes and indicators illustrated in the Basic Education Core Curriculum in Mathematics Area. The Institute for the Promotion of Teaching Science and Technology (IPST) has promoted a new method of teaching science, technology, engineering, and mathematics to foster students for standards of learning outcomes, indicators, and 21st-century skills by emphasizing knowledge and skills which are suitable to real life and careers.

Moreover, the Institute for the Promotion of Teaching Science and Technology (IPST) developed an additional mathematics curriculum for high school mathematics to provide mathematical knowledge and skills to students studying science programs such as complex numbers, matrices, vectors in three dimensions, analytic geometry, trigonometric functions and basic calculus.

By the reform and by the government setting of specialized institution for teaching science, technology and mathematics (IPST), it should be expected that student's achievement in science and mathematics was at satisfactory level. However, the average mathematics O-NET (Ordinary National Education Test) scores on grade 12 were 24.88%, 24.53%, and 37.50% in 2016, 2017, and 2018 respectively (The National Institute of Educational Testing Service, 2018).

The low average scores clearly indicated that high school students in Thailand need improvement and higher quality of mathematics instruction. Students should have an

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opportunity to increase their mathematics scores at both national and international level. In order to achieve this, mathematics instruction needs reform by changing from the traditional approach to a new approach.

The same situation of unsatisfactory student's achievement happened in school that the researcher had worked with. From discussion with teachers in math department, it could be concluded that the causes were: 1) limited class time, 2) school activities and events decreased class time and 3) short time in discussion about important concepts and problem solving.

Nowadays, technology has made great advance. Online activities such as online conference, online marketing, google classroom and online learning are rapidly growing. Two American secondary school teachers, Bergmann J. and Sams A. (2012) used the advantages of online learning to help their students who had to leave the classes during sport competition events. This practice gradually develops to be a new teaching and learning method called flipped classroom. The method was adapted by many practitioners and institutions in various fields such as mathematics, science, engineering, and languages (Reidsema C. et al., 2017; Margulieux L. et al., 2013). The result from applying flipped classroom were positive to students' achievement (Cronhjort M. et al., 2016; Kanjanapan T., 2016).

The flipped classroom can extend class time. In online learning, students can replay video clips many times as they want and work on some parts of the lessons in advance. So, it allows more time in class discussion which can lead to deeper understandings of contents and encourage students to engage in learning. Therefore, many teachers, in recent years, have adopted flipped classroom and expanded class time to develop students' understanding. Students have more time to think critically about mathematical concepts and ideas through collaboration, justifying, and explaining their processes while the teacher facilitates and guides them (Brunsell & Horejsi, 2013).

In teaching mathematics, the researcher has been assigned to teach vectors in three dimensions for grade 11. The idea of vectors is important in applied mathematics because many quantities used in physics such as force, motion, flow of fluid and electric current, light and sound are concerned with vectors. The researcher studied various textbooks to be used as a basis for the instruction of vectors in three dimensions.

Those textbooks were Vectors and Related Topics in Schaum's Outline Series in vector analysis second edition (Spiegel, 2009; Lipschutz & Lipson, 2009), Cambridge Additional Mathematics (Haese et al., 2014), New Additional Mathematics (Ho & Khor, 2006), Calculus textbook (Stewart, 2018) and IPST mathematics textbook in grade 11. Moreover, the researcher has studied textbooks about teaching of vectors such as teaching of vectors (Lee & Lee, 2009) and Handbook for Grade 11 Mathematics Teacher developed by IPST.

In addition, the flipped classroom was a new approach in learning and teaching method for students. By this method, the participants had to adjust themselves to the new method. Before class time, they must control themselves in watching online video clips, reading math handouts, doing work sheets and quizzes.

During class time, keys concept would be reveal and students studied and discussed more contents, examples, problem solving and knowledge extension. These activities needed time and concentration. It might cause tension to them. So, the researcher wanted to know whether they were satisfied with this method.

From the above problems and the benefits of flipped classroom as mentioned, this study aimed to use flipped classroom to enhance mathematics achievement and to survey students' satisfaction in learning mathematics.

Conceptual Framework

Action research is conducted by the researcher to solve specific problem(s) in a specified area or by practitioners for improving their practices. Classroom action research is also conducted by teachers as researchers to solve problem(s) in classroom or to improve their own teaching. It sometimes creates ideas for grounded theory which are bases for main theory. Actually, in action research, the researcher neither identifies sample nor population because the researcher aims to solve problems in a specific area nor also does not aim to generalize the research results.

In teaching mathematics, the problems fixed with students' low achievement which is related to understanding, reasoning, proving, and problem solving. Now, teacher can extend class time for more discussion and problem solving by using internet which gradually develop to be a new method of teaching and learning called flipped classroom.

Flipped classroom composed of three steps: 1) before class, 2) during class, and 3) extending skills or knowledge. Before class teacher assigns student to study basic concepts online through video clips, study handouts and quizzes in advance. During class time, teacher review important concepts, discuss more examples and problem solving. From various studies and ideas from flipped classroom, this classroom action research aimed to enhance students' achievement by using flipped classroom and to investigate students' satisfaction in learning mathematics by using flipped classroom. The researcher adopted the action research model presented by Kemmis and McTaggart (1988) which involves spiral and recursive steps of: 1) planning a change, 2) acting and observing the processes, 3) reflecting on these processes, and 4) revised the plan.

Research Methodology

This research took model of classroom action research with three cycles to enhance students' mathematical achievement and to investigate students' satisfaction in learning mathematics by using flipped classrooms. Participants in this research were 32 grade 11 students studying in the second semester, academic year 2019 at a secondary school in Bangkok, Thailand

Research Instruments

The instruments used in this study were consisted of lesson plans, achievement test, satisfaction survey, and teacher's reflections.

1. Lesson plans: There were 7 lesson plans on vectors in two dimensions and three dimensions integrated with flipped classroom. The contents were 1) introduction of geometric vectors, 2) Coordinate systems in two dimensions and three dimensions, 3) Vectors in two dimensions and three dimensions, 4) Addition, subtraction, scalar multiplication of vectors, and their properties, 5) Unit vectors and direction cosines, 6) Dot products, cross products and their properties, 7) Application and problem solving. At the end of periods 3, 5, and 7, the researcher reflected teaching results for improving in the following

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periods. All lesson plans were commented by an expert. Then, they were revised according to the comment.

2. Achievement test: Mathematical achievement test was developed by the researcher. It was composed of 10 multiple-choice items for 10 points, and 3 written tests for 10 points. This test covered all the topics used in this study. The Index of Item Objective Congruence (IOC) was used to measure the congruence between learning objectives and the test items. The IOC of this test was measured by 3 experts. For this achievement test, the value of IOC in multiple-choice items was 0.97, but IOC in written tests was 0.89.

From 6 cognitive domains presented by Anderson and Krathwohl who presented the revised Bloom's taxonomy, the researcher considered testing students only 4 cognitive domains (remember, understand, application, and analysis) as presented by Anderson and Krathwohl (Anderson & Krathwohl, 2001).

3. Satisfaction survey: This rating-scale survey was a 5-point Likert scale was developed by Kanjanapan (2015) to survey student satisfaction in learning by using flipped classroom. There were 20 items that can be categorized into 3 groups: students' understanding, learning activities, and learning atmosphere. This survey had Cronbach's internal confidence 0.89. The questions used in this research were shown as follows:

Category 1: Students' understanding

Item 1. I understand the content more because I do it by myself, not only listening to teachers.

Item 2. I can remember the content longer.

Item 3. I can understand the content by myself.

Item 4. I can apply this learning process to other subjects.

Item 5. I'm proud of myself when I can understand the hard content.

Item 6. I can decide by using reasoning.

Item 7. I can understand my friends more.

Item 8. I can work with others.

Item 9. I think this learning process makes me learn more than only listening to teachers in the classroom.

Category 2: Learning activities

Item 10. Learning management suits the content.

Item 11. Learning management helps me to exchange knowledge with others in the classroom.

Item 12. Learning management helps my thinking and decision.

Item 13. Learning management makes me brave when questioning or answering.

Item 14. Learning management helps me to comment in the classroom.

Item 15. Learning management makes me understand the content more.

Item 16. Learning management helps me and friends learn together.

Category 3: Learning atmosphere

Item 17. Learning atmosphere makes me participate in learning management.

Item 18. Learning atmosphere makes me responsible for myself and others.

Item 19. Learning atmosphere makes me studious.

Item 20. Learning atmosphere makes it easier to talk and to ask questions with the teacher.

The data were collected from following sources: pretest, posttest and satisfaction survey and analyzed by using effectiveness index, mean, mode, and standard deviations.

Research Results

Results on enhancement of achievement

Table 1 - Students' scores from pretest, posttest and Effectiveness index
(made by co-authors)

Total	student's score from pretest			student's score from posttest			Effectiveness index
	Mean	S.D.	Sum	Mean	S.D.	Sum	
768	8.88	2.47	284	21	1.48	672	0.8

From Tab. 1, there was a large gap between mean of pretest and that of the posttest. It showed the enhancement of students' achievement. On the other hand, standard deviation of posttest scores was smaller than that of the pretest. It showed the narrowed distribution of the posttest scores.

The effectiveness index was 0.8 which is higher than the accepted effectiveness index (0.5). The effectiveness index 0.8 meant that the students' achievement was improved 0.8 compared to that at the beginning. It could be concluded that using flipped classroom could be able to enhance students' achievement.

Results from satisfaction survey

From Tab. 2, the results showed that students were satisfied with understanding category and learning activity category while they were at least satisfied in learning atmosphere category. In summary, students were satisfied with all categories in learning by using flipped classroom.

Additional results from students' internet access

The number of online devices and the time used by students for internet access

Before the experiment, the researcher investigated online devices used by students and the time used for internet access. The results were shown in Tab. 1 and Fig. 1.

Tab. 3 revealed that the number of students who had a cell phone, a computer, and a tablet were 31, 29, and 15 respectively. One student didn't have a cell phone but he had a computer at home, so every student could access to the online learning

Time used by students in internet access per day were shown in Fig. 1 below.

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Table 2 - Results from students' satisfaction survey
(made by co-authors)

Item No.	Result	Summary of the category
Category 1: Students' understanding		Satisfied
1	Satisfied	
2	Satisfied	
3	Satisfied	
4	Satisfied	
5	Satisfied	
6	Satisfied	
7	Satisfied	
8	Satisfied	
9	Very Satisfied	
Category 2: Learning activities		Satisfied
10	Satisfied	
11	Satisfied	
12	Satisfied	
13	Satisfied	
14	Very Satisfied	
15	Satisfied	
16	Satisfied	
Category 3: Learning atmosphere		Satisfied or Very Satisfied
17	Very Satisfied	
18	Satisfied	
19	Very Satisfied	
20	Satisfied	

Table 3 The number of students who had online devices
(made by co-authors)

Online devices	Number of students	
	Have	Don't have
Cell phone	31	1
Computer	29	3
Tablet	15	17

Figure 1 – The number of students' internet using per day
(made by co-authors)

Fig. 1 showed that students spent at least 1-3 hours in internet access. Most students (21 students) accessed 3-6 hours a day. So, each student was accustomed to internet accessing.

Conclusion

1) For students' achievement, the effectiveness index from this study was 0.80 which was higher than that of the accepted index, 0.50 (Kidrakan, 2002). This indicated that students' achievement was enhanced after using flipped classroom. The index 0.80 meant that students' achievement was enhanced 0.80 compared to that from the beginning or the pretest.

2) For students' satisfaction, the results revealed that by using flipped classroom, students were satisfied with math learning in all three categories: 1) students' understanding, 2) learning activities and 3) learning atmosphere.

Discussions

Students' achievement was enhanced because of using flipped classroom. This enhancement was the results from the following:

- 1) class time was extended from before-class study such as watching video clips online, studying handouts, doing homework and quizzes,
- 2) more class time for discussion and problem solving from worksheet, and
- 3) extending new skill/knowledge such as practice more harder problems and more application.

Reflection in each cycle helped the researcher to improve teaching process, to talk to students who didn't do quizzes or didn't understand the contents. In addition, line group supported students' learning. Participants could discuss problems, solution processes and communicate through it. All of those activities inducted students to learn and to spend more time in learning.

The enhancement was consistent with many studies. Karadag and Keskin (2017) studied the effects of flipped learning approach which revealed that it positively affected students' academic achievement and attitudes toward mathematics. Furthermore, for some components of flipped classroom in mathematics, many studies showed that they could enhance students' mathematical achievement.

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Khairiree (2018) found that students studied by using flipped classroom were more engaged than that of traditional classroom. The flipped classroom helped students manage time in doing classroom activities more efficiently and improved their achievement. Unakorn and Klongkratoke (2015) stated that flipped classroom engaged students for self-learning and increased opportunities for students to achieve learning objectives of learning statistics topics in grade 11.

Poomorn, A. (2015) also stated that for students' satisfaction towards flipped classroom instruction, most of the students strongly agreed that they communicated with the teacher more often. They also agreed that they had greater opportunities to communicate with other students. They could apply out-of-class experiences with the lesson and could learn more from practical applications.

One crucial point to consider was about preparing teaching and learning materials such as handouts and quizzes. The researcher applied the practices and recommendations from experts and professional organization for the benefits of students' understanding, computational skills, reasoning and problem solving.

The recommendations were about: 1) content selection and sequencing it (Spiegel, 2009; Lipschutz & Lipson, 2009; Haese M. et al., 2014; Ho & Khor, 2006), and 2) teaching vector concepts, important points to be careful, and some pitfalls to be avoided (Lee, P. Y. & Lee, N. H., 2009). The followings were some points integrated in teaching:

1) visualization of vectors, vector operations, negative and unit vectors by drawing directed line segments to represent them,

2) reasoning such as why $\frac{\vec{u}}{|\vec{u}|}$ is a unit vector in direction of $\vec{u}$ or why $(\vec{u} \cdot \vec{v}) \cdot \vec{w}$ is meaningless,

3) computation in vector operations,

4) prove some theorems left for students,

5) prove harder problems,

6) applications in physics for dot product (the work done) and cross product (the torque), and

7) extended knowledge such as equations of spheres and lines in space.

For students' satisfaction towards flipped classroom, the results showed that most students were satisfied with learning.

These results were consistent with the studies of Baber (2020), Aziz et al. (2018), Alami (2019), and Abeysekera & Dawson (2015).

Recommendations

Recommendations for teachers

Until now, teachers and students experienced online learning. It was a good time to use flipped classroom by extending from online learning. There were two parts to be considered, teachers' part and students' part. In part of teachers, using flipped classroom needed much time and effort in preparing lesson plans, video clips, handouts, homework, quizzes, learning activities, and problems. In part of students, they needed before class time, concentration and self-study ability in watching video clips, studying handouts, doing homework and quizzes. Considering from both parts, teachers at the beginning of using flipped classroom, might try

just only one-fourth or one-half of a course and looked back to evaluate both teachers' and students' parts and improve them. Then, teachers could develop and expand to the whole course.

Recommendations for future research

Further repetitive research about using flipped classroom were still in need to fulfill various points which were not answered from this study. Some of them were the following:

1) effectiveness of flipped classroom to high school student at normal or average ability.

Sample in this study were in leading high school and were in high economical area. They showed above-average learning abilities. What was the effectiveness to the average students?

2) Effectiveness of flipped classroom to lower-secondary school students (grade 7 – grade 9 students)

Many research and practices were performed with high-school or undergraduate students but rarely with lower-secondary students.

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