Improving Student Achievement in Mathematics through the Flipped Classroom Model

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ABSTRACT
This classroom action research aims to develop student achievement in mathematics based on the flipped classroom model. Efficiency of the proposed model, student learning effectiveness, and student satisfaction had been measured. The participants were 35 grade-11 students studying in the second semester, academic year 2014, Mahaprutaram Girls’ School under the Royal Patronage of Her Majesty the Queen, Bangkok, Thailand. Instruments used in this study are consisted of 9 lesson plans based on the flipped classroom model, achievement tests for examine student learning effectiveness, and a questionnaire used to evaluate student satisfaction. The selected topic used in this research is “Vector in 3 Dimensions”. The data was statistically analyzed using descriptive statistics. The $E_1/E_2$ criteria was used to evaluate learning process efficiency, an effectiveness index was used to examine student learning effectiveness, and a questionnaire with five-point Likert-scale was used to analyze student satisfaction. The research findings show that the learning process has efficiency at 90.60/88 attaining above the 80/80 standard. Student learning effectiveness after being instructed had an effectiveness index score of 0.7868 which means student knowledge had increased by 78.68% comparing with their basis. Student satisfaction towards the instruction is at high level (4.00 out of 5.00).

Keywords: Flipped Classroom, Achievement in Mathematics, Student Satisfaction Vector in Three Dimensions

1. Introduction

According to the National Education Act of B.E. 2542 (1999) (revised: 2002) section 22, education should be based on the principle that all learners are capable of learning and self-development. Learners should all be regarded as the most important people. Educational management should encourage students to develop themselves with the best of their potentiality. Learning management base on Core Curriculum for Basic Education in Thailand B.E.2551 provides learning standards/indicators as targets for the development of learners and leads them to be capable of learning and desirable characteristics. Teachers must also consider that all learners are different with unequal learning capabilities. Quality of learning and instructing has to be evaluated for every school in Thailand. Schools must also be able to apply the evaluation results for improving the quality of learning and instructing (Office of the National Education Commission).

Mathematics has an important role in the core curriculum of basic education as it deploys creativity, logic, systematic, methodology, and being used to analyze problems or situations. It helps people predict, plan, make decisions, solve problems, and being used in daily life. Mathematics is a universal language that can be used for communication and making connection between various subjects (The institute for the Promotion of Teaching Science and Technology, 2012). Mathematics is an important tool for the study of science, technology and other applied sciences. It is useful for implementation of the assisted living and improves the quality of life (Ministry of Education, 2008).

Mathematical concepts were concerned abstract by many Thai students since they contain many definitions, axioms, and theorems. With Thai traditional classroom instruction it was difficult to enhance student understanding of some topics in mathematics. Isnian (2009) states that achievement is the result, the successfulness, the extent or ability, the progress in learning educational experiences that the individual indicate in relation with his/her educational learning. According to scores from Ordinary National Education
Test (O-net) in Thailand show that student’s achievement in Mathematics is low level (The National Institute of Educational Testing Service, 2010).

The analysis of instructional management of mathematics for grade 11 in Mahaprutaram Girls' School under the Royal Patronage of her Majesty the Queen, Bangkok, Thailand revealed several important issues. There were a significant number of topics but the designated time for classroom instruction was inadequate. Almost students spent all the class time to learn, understand, and analyze problems. The time restriction limited student improvement and obstructed fast learners. To enhance their understanding and to support students with different learning capabilities, an alternative method is required.

1.1. The Flipped Classroom Model

A flipped classroom is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter (Aaron Sams, 2014).

Using flipped classroom instruction, class time is mainly used to present contents, discuss in complex topics, and work with other students. An interactive media is used for answering basic and repetitive questions (Center for Digital Education, 2014). Center for Digital Education’s VP of Strategic Programs said that “flipping the classroom is helping students consume contents at their convenience while using valuable class time to discuss, experiment and collaborate with peers and instructors for fuller knowledge” (Dulles, 2012).

Flipped classroom instruction increases student–teacher and student–student interaction which results in students have the knowledge and achievement. The flipped classroom makes optimal use of instructor and students time (Bergmann & Sams, 2012).

Coach (2013) found that the feedback of flipped classroom from students has been very positive and suggested that this really helped some students to grasp the key concepts better. Math teachers Ed Ventry and Amy Kilmer at Niagara Falls High School (NY) flipped their classes in 2013 in hopes of using class time for more applied activities and individualized instruction. After implementing the flipped approach, student’s achievement had increased compared with the prior measurement (Yarbo, Arfstrom, Mcknight, & Mcknight, 2014). The flipped classroom produces better outcomes conclude that students in the flipped classroom achieved better results than the control group (Ferrer & A.Garcia-Barrera, 2014). Osman (2014) found that changing from a traditional classroom to a flipped classroom had given the positive impact on student perception and achievement (Osman, Jamaludin, & Mokhtar, 2014).

Distance learning is an important tool to enhance quality of learning and instructing to achieve the goals of the Core Curriculum for Basic Education in Thailand B.E.2551. Flipped classroom instruction is a process which ideally supports distance learning with the high availability of the internet. Teachers can upload contents such as videos and assignments to the designated website or blog. Learners can choose to work ahead if they learn fast or spend more time in reviewing course materials to enhance their understandings.

From the above reasons, researcher was interested in using the flipped classroom model to develop effective teaching for increasing student achievement and to improve learning efficiency. Concepts of the proposed method are to provide contents in a video format for students to learn and review at any available place and time. The researcher also provided interactive communication between students and the teacher via online media. Class time was used to check student understanding and extend knowledge learned from out-of-class activities. Classroom activities included problem-solving and group discussion. Finally, feedback was collected from students for future revision.

In this research, a flipped classroom model was applied to the “Vector in 3 Dimensions” topic which is one of the content being taught in this grade-11 class. This knowledge is useful in describing movement, speed and acceleration. It is important for studying other related topics such as Geometry, Algebra, and Physics (The institute for the Promotion of Teaching Science and Technology, 2011).

1.2 Research Objectives

This research aimed to enhance student achievement in mathematics. The following statements were assigned as research objectives:

1) To develop lesson plans based on the flipped classroom model and to measure their efficiency.
2) To evaluate learning effectiveness of students who are instructed using the proposed model.
3) To investigate student satisfaction in being instructed by the proposed method.

2. Methodology

2.1 Participants
Participants in this research were 35 grade-11 students studying in the second semester, academic year 2014, Mahaprutaram Girls’ School under the Royal Patronage of Her Majesty the Queen, Bangkok, Thailand.

2.2 Instruments
The following instruments were used in this research:
1) Lesson plans of the “Vector in 3 Dimensions” topic, based on a Flipped Classroom Model. A total number of 9 lesson plans were used.
2) Achievement tests corresponding to the selected topic.
3) A questionnaire about students’ satisfaction in the instruction using a Flipped Classroom Model with five-point Likert scale.

2.3 Data Collection
This research was performed as follows:
1) Studied related works and course description.
2) Prepared lesson plans based on the flipped classroom model following the course description in the selected topic (Vector in 3 Dimensions). Prepared course contents and other research instruments including measurement tools and a questionnaire.
3) Introduced students to the learning process based on the flipped classroom model. Students were asked to complete the achievement test (pre-test).
4) Instructed students following the prepared lesson plans. The estimate time is 12 hours in the second semester of 2014.
5) Tested the students using the achievement tests (post-test). Students were also asked to fill in the questionnaire at the end of the instruction.
6) Analyzed the data and made conclusion.

2.4 Data Analysis
The analysis of collected data was done statistically using several models described as follows:
1) The efficiency of the proposed lesson plan was calculated using the $E_{1}/E_{2}$ criteria (Promwong, 1977), where $E_{1}$ is a percentage of the average score students obtained during the instruction (exercises) and $E_{2}$ is calculated the final result (post-test). Calculation of the $E_{1}/E_{2}$ efficiency is described in (1) and (2).

$$E_{1} = \frac{x_{1}}{N_{1}} \times 100,$$  \hspace{1cm} (1)$$

where

- $E_{1}$ is the efficiency of the learning process,
- $x_{1}$ is the average score of all students obtained from the exercises,
- $N_{1}$ is a total score of the exercises in the lesson,

$$E_{2} = \frac{x_{2}}{N_{2}} \times 100,$$  \hspace{1cm} (2)$$

where

- $E_{2}$ is the efficiency of the learning outcomes,
- $x_{2}$ is the average score of all students obtained from the post-test,
- $N_{2}$ is a total score of the post-test in the lesson.
A standard level of the $E_1/E_2$ criteria was assigned at 80/80 (Promwong, 1977). It is remarked that this criteria was used in this research because it is well compatible with Thai educational context where pre-test, exercises, and post-test are normally used as parts of the instruction.

2) The learning effectiveness was analyzed from pre-test and post-test scores using an effectiveness index (E.I.) (Kidrakan, 2002, July) which is described in (3).

$$E.I. = \frac{P_2 - P_1}{Total - P_1}, \quad (3)$$

where

- $E.I.$ is an effectiveness index,
- $P_1$ is the sum of all student’s score from pre-test,
- $P_2$ is the sum of all student’s score from post-test,
- $Total$ is the product of the number of students and the full score of the test.

3) Evaluation of the student satisfaction was done using mean and standard deviation through the satisfaction questionnaire with five-point Likert scale.

3. Results

The designed lesson plans have 9 exercises, a pre-test and a post-test. Student scores had been collected throughout the instruction. Following formulas in Formula 1 and Formula 2, the results are presented in Table 1.

<table>
<thead>
<tr>
<th>$E = E_1/E_2$</th>
<th>$x_1 = 32.61$</th>
<th>$N_1 = 36$</th>
<th>$E_1 = 90.60$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_2 = 17.60$</td>
<td>$N_2 = 20$</td>
<td>$E_2 = 88.00$</td>
<td></td>
</tr>
</tbody>
</table>

Student learning effectiveness was analyzed by comparing pre-test and post-test scores with the application of the Effectiveness Index (E.I.), as shown in Table 2.

<table>
<thead>
<tr>
<th>Product of the number of students and the full score of the test $(Total)$</th>
<th>Sum of all student’s score from pre-test $(P_1)$</th>
<th>Sum of all student’s score from post-test $(P_2)$</th>
<th>Effectiveness index $(E.I.)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$35 \times 20$</td>
<td>306</td>
<td>616</td>
<td>0.7868</td>
</tr>
</tbody>
</table>

The evaluation of student satisfaction was done by calculating percentages of students who rated the score in each category. The results are presented in Table 3. The average satisfaction score is 4.00 which is at the “High” level.
Table 3
Student satisfaction

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The flipped classroom gives student greater opportunities to communicate with other students.</td>
<td>28.57%</td>
<td>38.86%</td>
<td>13.71%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>2. Student communicated with the teacher more often.</td>
<td>45.71%</td>
<td>20.57%</td>
<td>17.14%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>3. Student applied out-of-class experiences with the lesson and learned from practical applications.</td>
<td>22.86%</td>
<td>43.43%</td>
<td>13.71%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>4. Student is motivated to learn more in the flipped classroom.</td>
<td>17.14%</td>
<td>43.43%</td>
<td>17.14%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>5. Student worked hard to learn the content.</td>
<td>28.57%</td>
<td>34.29%</td>
<td>15.43%</td>
<td>1.14%</td>
<td>0.00%</td>
</tr>
<tr>
<td>6. Student had learned a lot in this course.</td>
<td>34.29%</td>
<td>29.71%</td>
<td>12.00%</td>
<td>3.43%</td>
<td>0.00%</td>
</tr>
<tr>
<td>7. Student actively participated in all aspects of the course.</td>
<td>20.00%</td>
<td>43.43%</td>
<td>13.71%</td>
<td>1.14%</td>
<td>0.00%</td>
</tr>
<tr>
<td>8. Student likes watching the lesson videos.</td>
<td>14.29%</td>
<td>20.57%</td>
<td>17.14%</td>
<td>11.43%</td>
<td>0.57%</td>
</tr>
</tbody>
</table>

4. Conclusion and Discussion

In this research teaching mathematics using the flipped classroom model was performed under the selected topic (Vector in 3 Dimensions). The proposed methodology was applied to 35 grade-11 students. The proposed lesson plans have efficiency at 90.60/88.00 attaining above the standard level at $E_1/E_2 = 80/80$. Student learning effectiveness after being instructed showed an effectiveness index score of 0.7868 that means students increase their knowledge of 78.68%. Student satisfaction towards the instruction is at high level (4.00 out of 5.00).

According to the experimental results it can be concluded that the flipped classroom model developed student achievement in mathematics. This study supports the contention of Yarbro (2014) that the flipped classroom model is associated with the increasing of student achievement.

Students most agree that they communicated with the teacher more often with the flipped classroom. They also agree that they have greater opportunities to communicate with other students and they could apply out-of-class experiences with the lesson and they could learn from practical applications.

5. Suggestion for Future Studies

The researchers had collected some useful comments and experiences which can be used to improve future studies, as mentioned below:
1) Contents given in a video format for self-study should not be too long and they should contain only contents in which students can study by themselves.
2) Video data should be prepared in a variety of formats and platforms such as YouTube, Facebook video, video files, and DVD.

3) It was found from this research that the most important part of the flipped classroom is not out-of-class activities but the in-class activities such as group discussion and presentation.

References


Bergmann, J., & Sams, A. (2012). Flip Your Classroom: Reach Every Student in Every Class Every Day. International Society for Technology in Education.


