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STEM education in mathematics education: focusing on students' argumentation in primary school

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Abstract

This study aimed to explore student argumentation in a mathematics classroom using lesson study and an open approach. The research methodology employed a qualitative approach that focused on the protocols of student problem solving and the results of the study are presented as an analytical description. The target group was 14 third grade students, divided into four groups in the 2016 academic year. This research collected data while teaching with a lesson study and open approach, analyzing student argumentation. The results revealed that the students who attended mathematics classes with a lesson study and open approach went through the four steps of the argumentation process, which occurred in the second step of the open approach, promoting student self-learning.

Keywords: Students' argumentation, Lesson study, Open approach

1. Introduction

The Basic Core Educational Curriculum, 2551 B.E., defined communication as an essential proficiency of students. Therefore, students have to be skilled in the use of language to illustrate ideas, cognitions and problems-solving abilities based on logical bases. Mathematics is essential for logical, systematic and analyzed development of ideas to support critical thinking [1] [2]. In terms of student-centered reform, teachers should offer an opportunity to their students that focuses on learning and self-learning processes. To manage the mathematical learning process, students should have opportunities to explain, argue, conclude and express their doubts (Usani Photisuk et al., 2543 B.E., cited in, [3]).

There are many problems that occur in Thailand's academic classes. Learning achievement is based examination and often does not assess the learning process. Most teachers focus on the instructor-center teaching for knowledge transfer such as, lecture, description, demonstration, and questioning methods, among others. [4] [5] also stated that most learning processes are focused on the teachers, i.e., narration, lecture, and content explanation and students engage in taking notes and recitation. This teaching approach focuses only on the content without real-life connections and process recognition. The PISA international test presents open-ended questions that lead students to reflect upon their reading and ideas to formulate answers. The acceptance of student answers is based on the logical explanations of the test-takers. The results illustrated that Thai education quality is in crisis due to inappropriate learning tools such fractious teaching processes [2]. In terms of the learner-centered reform, the teachers should offer self-learning opportunities to their students. Therefore, an open approach to teaching could be used to solve this problem. This teaching approach consists of emphasis on individual differences, ideas, and students' self-learning opportunities. There are four steps in this open approach. They are posing open-ended problems, self-learning by students, whole class discussions and comparisons and, summarization through connecting student' mathematics ideas emerged in the class [2]. According to [6], the advantages of an open approach are that such an approach embraces the students' individual differences both terms of ability and attention. The teaching culture is not simple, so it is difficult to change. In fact, the person who is at the center of this context is the "teacher". Therefore, any cultural transformation will need to be based on teacher development. Development will proceed gradually, continually, and be focused on reformation [4]. In Thailand, Assoc. Prof. Maitree Inprasitha first applied this innovation in 2545 B.E. (2002) with the guidance of the Japanese teaching profession. Their development guidelines include three steps [7], Plan, Do and See.

In order to develop learner-centered classes, teachers will have to be concerned with resolving issues, processing ideas, student arguments and mathematical justification. [8-10] stated that an argument can illustrate new ideas through the following four steps: 1) data, 2) warrants, 3) backing, and 4) claims.

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2. Research objective

The objective of the current study is to explore students' argumentation in a mathematics classroom using a lesson study and open approach.

3. Research framework

3.1 Students' argumentation

Students' argumentation (Figure 1) is a learning process with the four main components in Toulmin's argumentation model, as follows [10]:

1st step, Data: this is the students' opinion expression step, based on their ideas, that provides the foundation for a Claim.

2nd step, Warrants: the students' mathematical ideas that show the relevance of the Data to the Claim.

3rd step, Backing: the students' expression through speaking, writing and learning to support the Warrants.

4th step, Claim: this is the students' conclusion step. Here the Claim is supported by Data, Warrants and Backing.

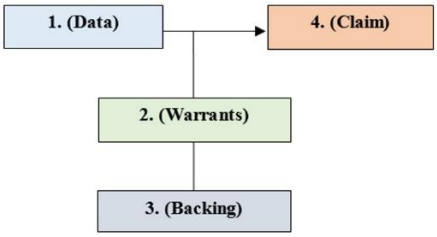

Figure 1 Argumentation process [10]

3.2 Lesson study

The lesson study (Figure 2) is a weekly cycle to improve an open approach as a teaching process according to [7]. This includes:

1st step, Plan- during this process, the researchers and co-researchers analyzed and designed opened-closed problematic situations referred to in volume 1 of a third year elementary mathematics textbook, Maitree Inprasitha (2553 B.E.), *Water Quantity Units*.

2nd step, Do- the lesson study team applied an open approach learning management plan with researchers and co-researchers as observers that focused on students' self-learning during the second phase of the open approach to explore students' argumentation.

3rd step, See- the researchers and co-researchers reflected upon the lesson in three ways: lesson achievement, students' ideas, as well as problems and solutions.

3.3 Open approach

An open approach (Figure 3) is one that is focused on opened-ended solutions. This approach gives self-learning opportunities to students to support their argument. There are four steps in this approach [7]. They include:

1st step: Posing open-ended problems. This process is the presentation of an open-ended problematic situation that the teachers provide to their students.

2nd step: Students' self-learning. Students solve the problems by themselves without any intervention from their teachers in terms of teaching or solution formulation.

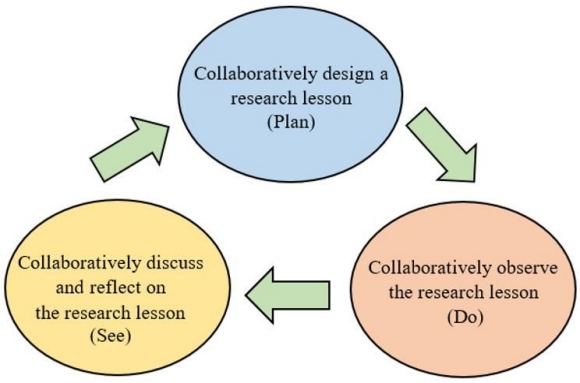

Figure 2 Lesson Study process [7]

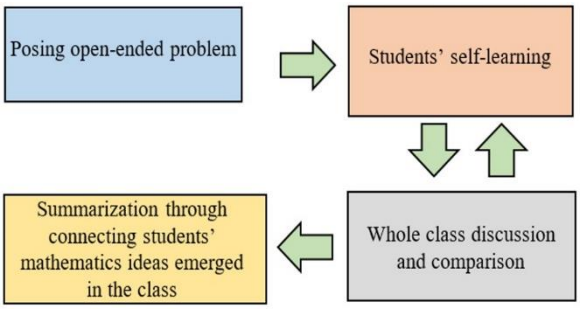

Figure 3 Open approach process [7]

3rd step: Whole class discussion and comparison. Students have to present or pose their ideas and engage in discussion with the whole class while the teachers attempt to draw the ideas from students.

4th step: Summarization is done by connecting students' mathematical ideas that emerged in the classroom. Students and teachers conclude by summarizing ideas and essential issues that emerged in classroom and connected the ideas to formulate a lesson conclusion.

4. Methodology

4.1 The target group

The target group was 14 third year elementary students, in the 2016 academic year. The target group was divided into four sub-groups (Figure 4). They learned using the lesson study and open approach for the previous two academic years.

Since 2014, the Banmaue School has participated in a project called "developing students' mathematics higher order thinking in the Northeast" at Khon Kaen University. It was supervised by the Center for Research in Mathematics Education (CRME). The teacher was a student intern in the Mathematics Education Program at Khon Kaen University.

After classroom observations it was found that the students were able to express their opinions, solve problems by themselves, consult with other students, and present their ideas to each other.

4.2 Research instruments

- Six lesson plans using a Water Quantity Unit
- Field notes
- Video recorder, camera and sound recorder
- Interviews

Figure 4 Observation before selecting the target group

4.3 Pre-Date collection process

Before data collection, the lesson study team observed the classroom, interviewed the teacher about the lesson study and open approach and inquire about the students' character.

Additionally, the lesson study team also attended a lesson study and prepared the learning environment to become acquainted with the students during the data collection process.

4.4 Date collection process

The lesson study team (Figure 5) attended the lesson study process to provide a learning management plan that consisted of three steps, i.e., plan, do, see. Furthermore, the researchers interviewed target students about emerging ideas as part of data analysis.

Figure 5 The lesson study team attended the lesson study process

5. Results

The second learning unit, period 1/6: Which one is more? is depicted in Figure 6.

Problematic situation: From the orange juice containers that students received from teacher, the students had to determine which container has more orange juice than others?

Figure 6 Which one is more? [11]

The students' argumentation process was as follows (Figure 7):

Students began with discussion and observed the qualities of the bottles in the data as first step of the argumentation process (D). They found that quantity of the water in plastic bottles was more than in glass (C). After that students tested several solutions. In the first test, they used a glass as a water level comparison tool (W_1). If they poured water from glass or plastic bottle into a water glass, the determined which one had a greater quantity (B_1). In the second test, students poured a quantity of water into two similar jugs (W_2) and then compare the water level (B_2) in each jug. In the third trial, they used a plastic bucket (W_3) as the water container and drew a line at each water level and compared the lines (B_3). In the last test, a direct comparison (W_4), the students poured water from the glass bottle into the plastic bottle, and vice versa. They observed the water levels (B_4). Other groups began with the discussion and observed the qualities of bottles in the first step, but the order of the warrants and backing were not the same. They did four warrants and four backings in this lesson.

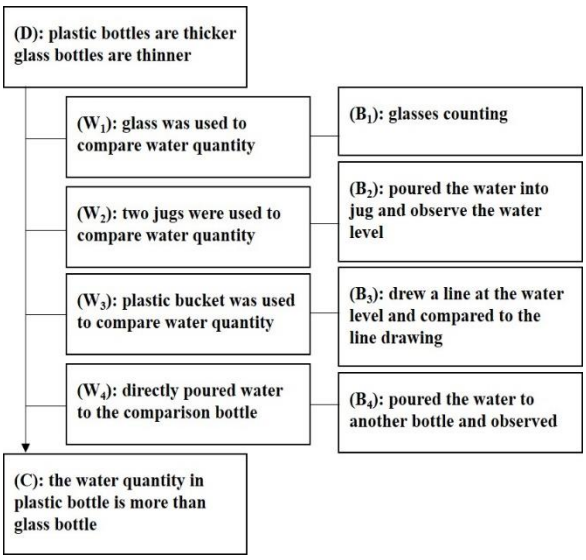

Figure 7 Students' argumentation process

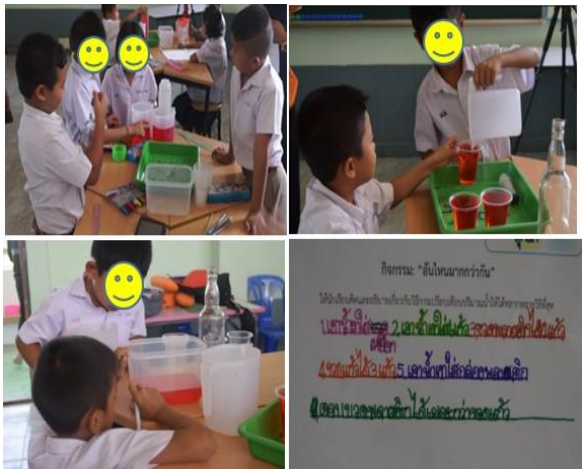

Figure 8 Students' self-learning in the second step of the open approach

6. Conclusions

The results reveal that the students who attended a mathematics classroom using a lesson study and open approach used the four steps of the argumentation process in the second step of the open approach for students' self-learning. Each step of the argumentation process consists of data, warrants, backing, and claims. Moreover, some students made warrants and backings more than once. Students who attended this mathematics classroom using a lesson study and open approach used a variety of ways to solve the problem. Warrants would be presented before the class during the third step of the open approach, whole class discussion and comparison. From this, students learned with each other and verified others' warrants. Claims were certified by all students during the fourth step of the open approach. Summarization was done through connecting students' mathematical ideas as they emerged in the classroom. Furthermore, all of students who studied in this mathematics classroom using the lesson study and open approach improved their reasoning as well as the self-confidence in argumentation because this approach give students an opportunity to solve problems by themselves result from this classroom teacher do not interfere with student thinking.

7. Acknowledgements

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