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## High school students' mathematical modelling in classroom using open approach

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### Abstract

This research aimed to study students' mathematical modelling in classroom using Open Approach. The target groups were 9 students of 11<sup>th</sup>-grade student in 2016 academic year, Kalasinpittayasan School, Kalasin Province. The research had collected the data in classroom by using open approach with 4 steps: 1) Posing open-ended problem, 2) Students' self-learning, 3) Whole class discussion and comparison and 4) Summing-up by connecting students' emergent mathematical ideas. Researcher analyzed students' mathematical modelling based on Galbraith and Stillman's framework. The result found that, classroom using open approach provided mathematical modelling in the second step of open approach, students' self-learning and the third step supports students to fulfill their own modelling process from comparing ideas.

**Keywords:** *Mathematical Modelling, Open Approach.*

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### 1. Introduction

Mathematics plays a key role of human thinking development; creative, logical, systematic, traditional thinking. As well as be the factor of problems or situations analysis with careful, expectation, planning, decision, solution and appropriate daily basis. In addition, mathematics is one of the science learning tools includes be the factor of life development [1]. Therefore, the goal of learning mathematics in primary, secondary and tertiary education is that the students become able to use mathematics in a variety of situations [2].

After considered school learning in Thailand which focused on the achievement from examination without mathematical processes [3] found that, most teachers have taught with old methods that focused on: students' memorizing and recitation without consideration, creativity, and solution. In consequence, the learning processes should be improved from teacher focusing into students' self-learning [4].

Mathematics teaching approach in Japan called Open Approach as the factor of mathematical education development and study achievement development which focused on solution process in forms of knowledge and thinking ability. The purpose of open approach is: the students should learn mathematics with their own might and ability to develop or conduct any mathematical works [5]. Open approach also makes students solve the problems in classroom in form of the problem situation as the initial step, open approach according to Inprasitha's framework includes 4: 1) Posing open-ended problem, 2) Students' self-learning, 3) Whole class discussion and comparison and 4) Summing-up by connecting students' emergent mathematical ideas [6]. The problem situation of open approach was defined based on the real world and students could transit from real world situation into mathematics through self-learning. From mentioned above, students could carry out mathematical model in forms of equation, mathematical rules or mathematical formula [7].

Mathematical model is the real-world representation through mathematical knowledge [8] and links mathematics classroom to students' everyday life: working and decision thus, the daily situation could be modeled through situation analysis, understanding and using appropriate mathematics [9]. The study of mathematical modelling focuses on mental activities of students which move around modelling process from one modelling stage to the next [10].

From the mentioned above, the study students' mathematical modelling in classroom using open approach illustrates not only the students' competencies in situation explanation or interested phenomenon through mathematics and mathematical model but also assures that, students are able to transit from the real-world situation into mathematics through self-learning.

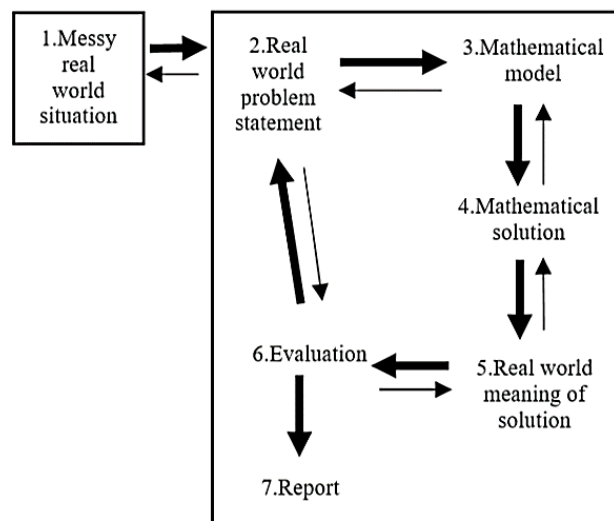
## 2. Research Objective

This research aimed to study students' mathematical modelling in classroom using Open Approach.

## 3. Research Framework

### 3.1 Mathematical Modelling

Mathematical modelling is the process of using mathematical approaches to understand and make decisions about real world phenomena according to Galbraith and Stillman [10] as follows.



**Figure 1** Modelling process. (The heavy arrows denote the direction of the modelling cycle. These light arrows are included to emphasize that the modelling process is far from linear) [10]

- 1) Messy real-world situation to real world problem statement: students clarify context of problem through acting out, simulating, representing or discussing problem situation. Moreover, they simplify assumptions and specify strategic entities.
- 2) Real world problem statement to mathematical model: students identify dependent and independent variables for mathematising through making relevant variables and assumption.
- 3) Mathematical model to mathematical solution: students work mathematically and use mathematical knowledge to get answers.
- 4) Mathematical solution to real world meaning of solution: students interpret mathematical results by identifying mathematical results with their real world.
- 5) Real world meaning of solution to evaluation (revise model or accept solution): students consider real world and mathematical results. Then, they would accept the answer and summarize after satisfied with the model or revise if the model does not meet the requirement.

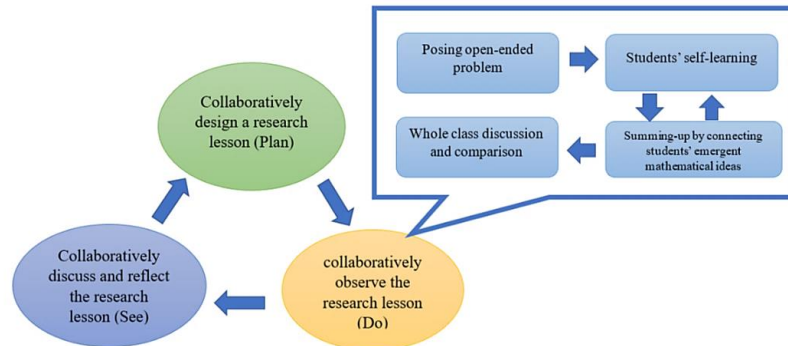
## 4. Research Methodology

### 4.1 Lesson study

Lesson study is the cooperation from researcher, teachers and assistant researcher in terms of lesson planning, lesson plan adaptation in open approach classroom. The researcher and assistant researcher observe the classroom situation. After the class ending, reflect the results with teachers and teaching observers. There are 3 processes of lesson study according to Inprasitha [6].; collaboratively design a research lesson (Plan), collaboratively observe the research lesson (Do) and collaboratively discuss and reflect the research lesson (See).

## 4.2 Open Approach

Open approach is the teaching approach that supports students' self-learning thus, the mathematical model is the outcome of students' solution in forms of equation, rules, and formula. open approach according to Inprasitha [6] which includes 4 steps as follows: 1) Posing open-ended problem, 2) Students' self-learning, 3) Whole class discussion and comparison and 4) Summing-up by connecting students' emergent mathematical ideas.



**Figure 2** Four phases of the Open Approach incorporated into Lesson Study. [6]

## 4.3 Target group

The target groups were 9 students of 11th-grade in 2016 academic year, Kalasinpittayasan School, Kalasin Province. The students were divided into 3 groups for collaborative learning because learning is adapted stimulus surrounding and create a new one by learners' knowledge keep in mind. Learning process needs to use communication process [11].

The students have studied with open approach when they were 10th-grade student. These students were in traditional classroom for 9 years before studying by open approach. Researcher collaborated with co-researcher on designed lesson plan and took open approach to the classroom twice a month for a year.

Early period of using open approach, students not familiar with this approach, they waited for how to solve the problem from teacher when they could not solve it. After about 3 months, students more familiar with open approach, they dared to share ideas with friends, more confident when they had to present their work in the front of classroom.

## 4.4 Research instruments

- 1) 5 lesson plans (The lesson plan in this research was designed in steis a detailed guide for teaching. It was designed by integration real world problem with open approach)
- 2) Fieldnote
- 3) Video recorder, camera, and sound recorder
- 4) Interview

## 4.5 Data collection

Researcher and co-researchers use process of lesson study for collecting data. Start at designing lesson plans and predicting students' ideas. After that, the plan was applied in classroom. The next step is reflection the students' leaning outcomes. These processes carried out until complete 5 lesson plans. The classroom data was recorded in forms of fieldnote, pictures, classroom videos, students' work and interview.

## 5. Results

**First step:** Posing open-ended problem (Problem situation in this paper is the sample from 1 of 5 lesson plans)

**Problem Situation:** Alin and Alan are studying in the same school. Alin's house was located far from school 17 kilometers while Alan's house was located far from school 8 kilometers.

**Question 1:** What do you know about problem situation?

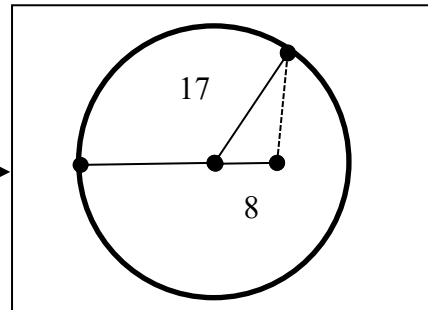
**Question 2:** How far from Alin's house to Alan's house?

**Figure 3** How far from Alin's house to Alan's house? Task.

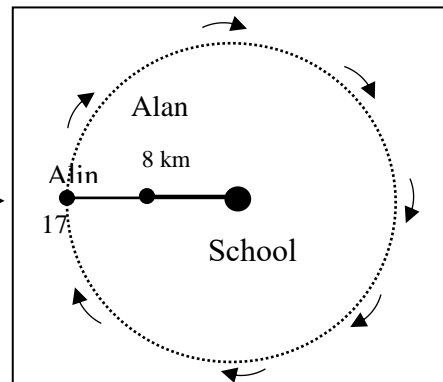
**Second step: Students' self-learning**

After applied open approach as a teaching approach in classroom, mathematical modelling emerged during open approach self-learning from students that considered in mental activities in each transition step of mathematical modelling process, from initial to further step as follows:

1) From messy real world situation to real world problem statement: Students discussed the goal of problem situation then simulated problem situation by drawing.

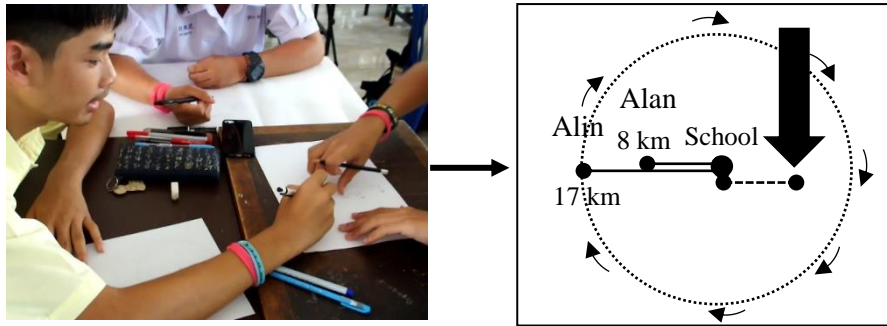


**Figure 4** Student simulated problem situation by drawing the circle represented possible position of Alin's house, center of circle represented school position, and dash line represented distance from Alin's to Alan's house.

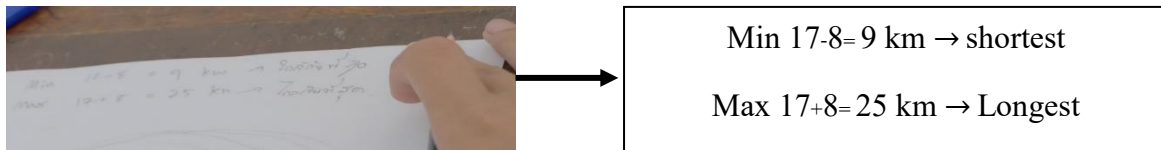


**Figure 5** Student used the fingers to show how distance change when they moved Alin's house on the circle.

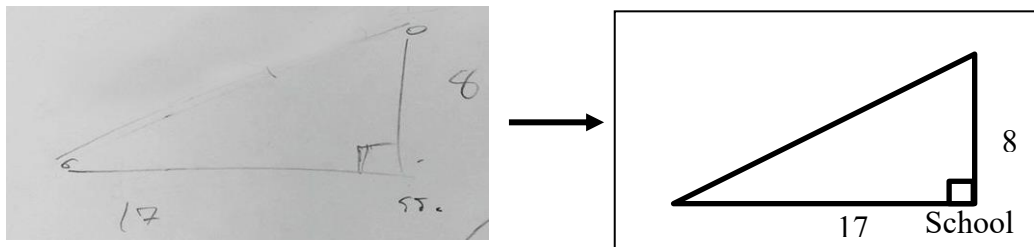
2) From real world problem statement to mathematical model: Students defined the variables from problem situation data then use mathematical knowledge to formulate mathematical model in equation form or mathematical theory.



**Figure 6** Student found that when put each point on the same direction (straight line), it provided the shortest and longest distance.

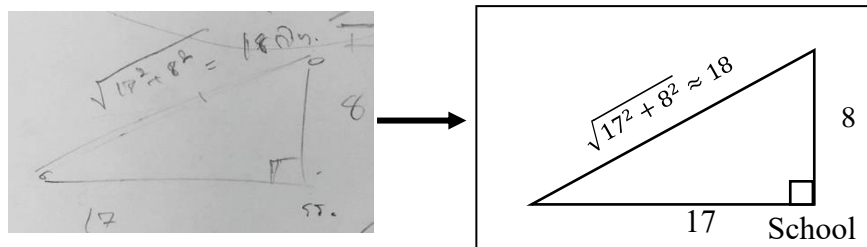


**Figure 7** Student wrote the shortest and longest distance.



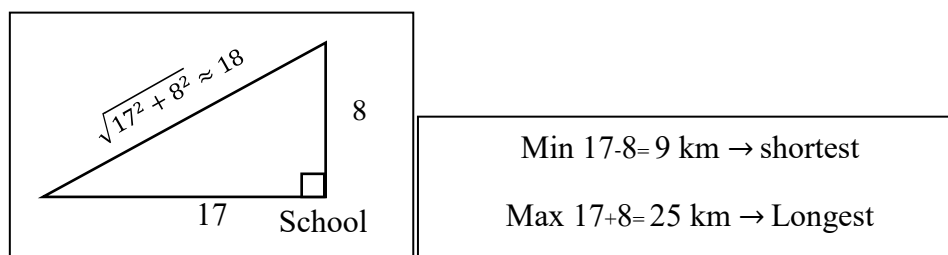
**Figure 8** Student used right triangle to find distance, from this model could link to Pythagoras theory.

3) From mathematical model to mathematical solution: Students used mathematical knowledge to calculate or find solution from mathematical model they made.



**Figure 9** Student got the answer from Pythagoras theory.

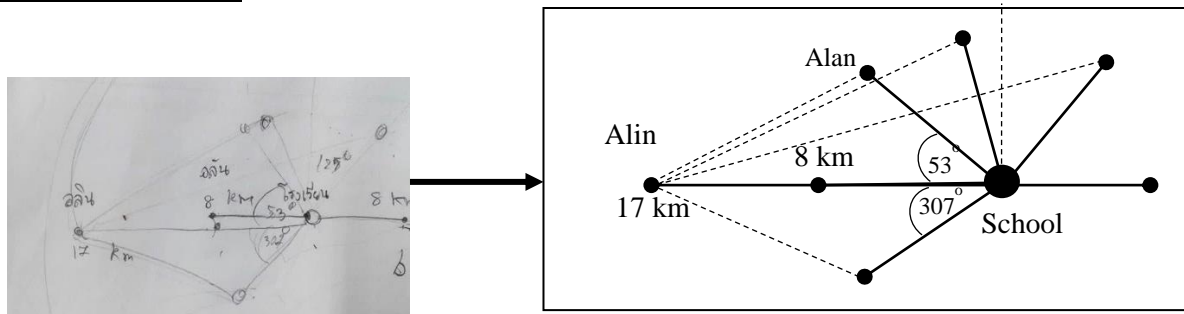
4) From mathematical solution to real world meaning of solution: Students considered about the results appropriate to the real world or not.



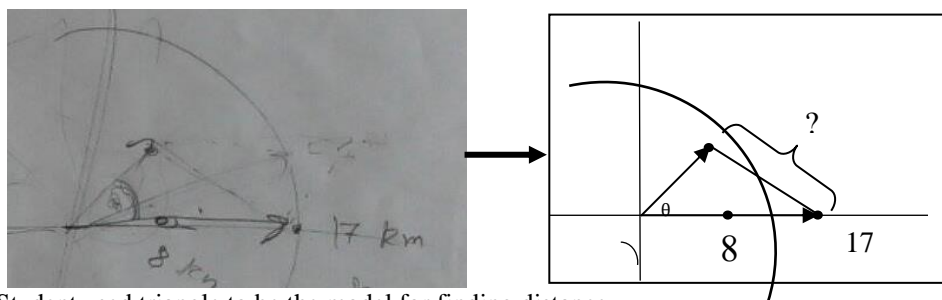
**Figure 10** Student compared their solution with the shortest and the longest distance. And they knew the solution had to be between 9 and 25.

5) From real world meaning of solution to evaluation (revise model or accept solution): Student realized that there are many distance between Alin's house and Alan's house, so they decided to revise their mathematical model.

Student revised model.



**Figure 11** Student specified angle and distant, they found that the distance face to the angle 53 and 307 have equal length.



**Figure 12** Student used triangle to be the model for finding distance.

$$\begin{aligned}
 a^2 &= b^2 + c^2 - 2bc \cos A \\
 &= 289 + 64 - 2(17)(8) \cos 30^\circ \\
 &= 353 - 272 \left( \frac{\sqrt{3}}{2} \right) \\
 &= 117.4413902 \\
 a &= 10.873
 \end{aligned}$$

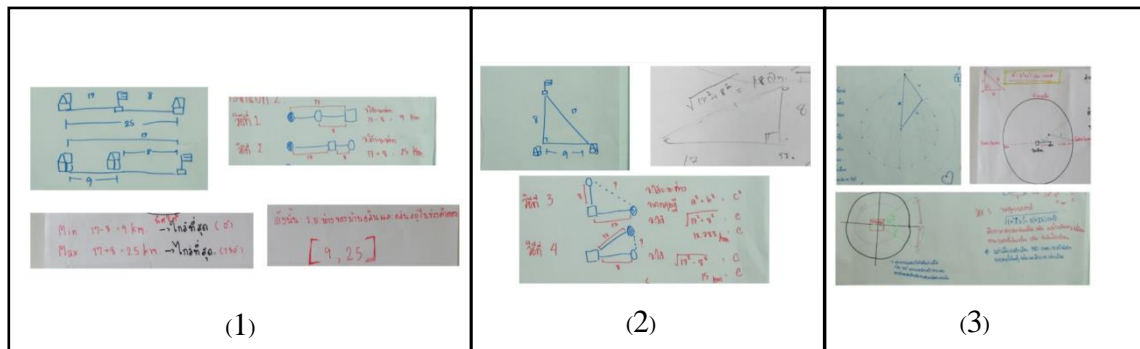
**Figure 13** Student considered triangle, they predicted they can use Trigonometry to get answer, they found out the way to receive the distance from Law of Cosines.

**Third step:** Whole class discussion and comparison



**Figure 14** Students' works were presented on the board for comparing and discussing.

**Fourth step:** Summing-up by connecting students' emergent mathematical ideas



**Figure 15** Students' ideas were formed into 3 groups (1) using line to find distance, (2) using right triangle to find distance and (3) using circle to identify positions and find distance.

## 6. Conclusion

After studied students' mathematical modelling in classroom using students from open approach found that:

First step, posing open-ended problems: Teachers posed the problem situation in order to persuade students into real world situation. Teachers also intimated this situation as students' problem.

Second steps, students' self-learning: Students solved their problems by themselves. students' mathematical modelling. Teachers did not interfere in students' self-solution process however, they might make some questions to urge his/her students like "Are there the other ways to solve the problem?"

Third step, whole class discussion and comparison: Any ideas from students' solution or mathematical model was presented in classroom. Therefore, students compared their mathematical model with the others. The comparison is the factor to encourage students back to review or revise their mathematical model and understand the ideas of other students then fulfill their own modelling process.

Fourth step, summing-up by connecting students' emergent mathematical ideas: Teacher and students summarized the emerged ideas. Teacher assigned students to group the ideas and described the reasons to group the ideas.

Mathematical activities in classroom using open approach provided students with the opportunity to solve the problem themselves, student learning began with meaningful things in the real world of students, moving them into mathematics by solving problems and thinking.

## 7. Acknowledgment

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