Using Activity Approach to Design Mathematical Modelling-Based Learning for Promoting Grade7 Students’ Mathematical Modelling Competency

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Abstract

In teaching and learning mathematics, all courses around the world focus on problem solving skills in order for the student to apply this skill to solve problems in everyday life. However, when students encounter problems outside the classroom, they are not as familiar. The problem outside the classroom is that it does not look like a mathematical problem. So students cannot solve these problems. In order to deal with common problems, or so-called application problems, we must learn to enhance the learner’s skills in applied problem-solving that is mathematical modeling competency. In order to promote students’ modelling competency, the method is to provide the learner with an experience in mathematical modeling in the curriculum. The purposes of this study were to develop Mathematical Modeling-Based Learning and to promote student’s modeling competency. The results revealed that using this learning model has a positive effect on students’ mathematical modeling competency.

Keywords: Activity Approach, Mathematical Modelling, Mathematical Modeling-Based Learning, Mathematical Modeling Competency

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1 Introduction

In teaching and learning mathematics, all courses around the world focus on problem solving skills in order for the student to apply this skill to solve problems in everyday life. However, when students encounter problems outside the classroom, they are not as familiar. The problem outside the classroom is that it does not look like a mathematical problem. So students cannot solve these problems. It means that problem solving skills are generally not enough for students to solve common problems that are very different from the classroom (Kaiser, G., Blum, W., Ferri, R. B., & Stillman, G. (Eds.), 2011; Schoenfeld, A. H., 2013; Schoenfeld, A. H., 2013; Burkhardt, H., 2013).

In order to deal with common problems, or so-called application problems, we must learn to enhance the learner’s skills in applied problem-solving that is mathematical modeling competency. Because when students have the capacity to create mathematical models, it allows students to change the general problem situation into a mathematical form, then it takes steps in the mathematical process to deal with that mathematical problem, and interpret the answer to the original situation. For this reason, the enhancement of mathematical modeling competencies is important for learning mathematics (Kaiser, G., Blum, W., Ferri, R. B., & Stillman, G. (Eds.), 2011; Chan, E. C. M., Ng, D. K. E., Widjaja, W., & Seto, C., 2012; Schoenfeld, A. H., 2013; Schoenfeld, A. H., 2013).

In order to promote students’ modeling competency, the method is to provide the learner with an experience in mathematical modeling in the curriculum (Schoenfeld, A. H., 2013; Schoenfeld, A. H., 2013; Blum, W., 2013; Ferri, R. B. ,2013). The purposes of this study were to develop Mathematical Modeling-Based Learning and to promote student’s modeling competency. Each modules of Mathematical Modeling-Based Learning are designed with activity approach to train the learner to have the experience of modeling that will make the modeling competency of the student.
Mathematical Modeling-Based Learning with Activity Approach

For the development of mathematical modelling through activity approach, mathematical modelling process from Blum, W. (2013), Pollak, H., & Garfunkel, S. (2013), and Anhalt, C. O., & Cortez, R. (2015) was applied to be instructional sequences and activity approach here meant that students create mathematical models each step through the activities that the instructor has designed. For simplicity of reference, we would call the process of learning about mathematical modelling through the mathematical modelling process as *Mathematical Modelling-based Learning (MMBL)*. Because the learning activity about creating this model is based on the fact that students learn to create models from real activities, it is called as Mathematical Modelling-based Learning with activity approach. The key components of the learning activity are shown in Figure 1 and can be described as follows.

**Stage 1: Analyse the Situation or Problem**

1a) Identify problems from the external context (Mostly from everyday context) looking for answers or situation to understand and explain.

1b) Find more relevant information if needed.

1c) Make the situation or problem is reasonable and understand the question.

**Stage 2: Develop and Formulate a Model**

2a) Specify all required information.

2b) Identify the basic assumption needed.

2c) Converting the information provided in the problem together with the initial assumption into a mathematical problem which can find the answer.
2d) Use appropriate mathematics for the given data.

**Stage 3: Solve or Compute a Solution of the Model**

3a) Find the mathematical solution problems identified in the model.

3b) Analyse and implement the model.

3c) Check the correctness

**Stage 4: Interpret the Solution and Draw Conclusions**

4a) Interpreting mathematical solutions in terms of original situation.

4b) Construct a conclusion, where the solution indicates the original situation.

**Stage 5: Validate Conclusions**

5a) Reflects that the mathematical answer is sensible in terms of the original situation (ie, the value is in the actual sensible range).

5b) If the appropriate conclusions are consistent, consider the accuracy of the solution statement. If it does not fit properly or needs to be improved, go back to step 2 again (create and customize).

**Stage 6: Develop and Formulate a New or Modified Model**

6a) Modify the initial assumption, which follows what we know about the first solution, and transforms it into a new mathematical problem, or a new one to solve the problem.

6b) The relevant mathematical knowledge may differ from the first we perform.

6c) Perform various steps, including computation, interpretation, and re-examination.

**Stage 7: Report the Solution**

7a) Present conclusions and arguments related to joint conclusions.

And from the 7 stages of the learning process of modelling can be classified into three levels as follows.

**Structured modelling**
Students follow the step-by-step process in each element that is defined. This level of modelling is great for practicing and building on modelling competencies before stepping into a more self-practice.

**Guided modelling**
Students follow the step-by-step process in each element that provides the right advice for students. This level model is ideal for students who have some kind of modelling performance already.

**Opened modelling**
Students conduct a step-by-step process in each element based on the student’s concept. Creating this model is ideal for students with sufficient performance-related abilities.
For this research, it will be designed as a modelling learning, through activity approach, in which the design of the activity begins with structured modelling in the early plan, and then gradually becomes more guided modelling and finally becomes opened modelling.

3 Methodology

Research objectives
The purposes of the study were to develop mathematical modeling-based learning with activity approach and to investigate students’ modeling competency.

Participants
This study was designed to investigate the effect of using activity approach to create Mathematical Modeling-Based learning (MMBL) to students’ modeling competency. The subjects were 30 seventh grade students from Benjalakpittaya school, Sisaket Province, Thailand, in the academic year 2559.

Instruments
There were 5 lesson plans in incorporate content up to a maximum of seventh grade. Each MMBL was designed to support student to use modeling competency to perform modeling process through activity. To investigate the effect of using MMBL on the levels of students’ modeling competency, the subjective tests were created. The rubrics for scoring subjective tests based on essential features of modeling competency related were developed. In the rubric, each of the six levels of modeling competency applied from Gatabi, A. R., & Abdolahpour, K. (2013) and Leong, K. E. (2013) were defined and the following criteria.

- Level 0: The student has not understood the situation and is not able to sketch or write anything concrete about the problem.
- Level 1: The student only understands the given real situation, but is not able to structure and simplify the situation or cannot find connections to any mathematical ideas.
- Level 2: After investigating the given real situation, the student finds a real model through structuring and simplifying, but does not know how to transfer this into a mathematical problem (the student creates a kind of word problem about the real situation).
- Level 3: The student is able to find not only a real model, but also translates it into a proper mathematical problem, but cannot work with it clearly in the mathematical world.
- Level 4: The student is able to pick up a mathematical problem from the real situation, work with this mathematical problem in the mathematical world, and have mathematical results.
• Level 5: The student is able to experience the mathematical modeling process and validate the solution of a mathematical problem in relation to the given situation.

Procedures
A total of 30 seventh grade students involved in this study were engaged in MMBL with activity approach. The subjective tests were administered as posttest to students. The rubric score was employed to determine the level of students’ modeling competency through their performing in subjective tests.

Data analysis
Data from rubric for evaluating student’ modeling competency were analyzed using descriptive statistics to find frequency of students identifying particular student’ modeling competency levels.

4 An example of Mathematical Modeling-Based Learning with Activity Approach
Students were separated in 6 people per group by using equal ability criterion for each group. There were five groups to perform learning activities of each learning stage hereinafter.

Situation
Give the student 50 baht to buy 4 items of snack. How do students buy to keep the minimum balance?

Stage 1: Analyse the Situation or Problem
What is the problem?
Students bring 50 baht to buy 4 items of snack. Students must plan on purchased items of snack.
What is the preferred answer?
What are the four items of snack students will buy to return the least of money?

Stage 2: Develop and Formulate a Model
From the conditions in the situation of the problem, each student must purchase 4 items of snack with a total price less than or equal to 50 Baht. Each student helps to plan, create, and define models. The model will be in the form as follows.

\[ s_1 + s_2 + s_3 + s_4 \leq 50 \]

Stage 3: Solve or Compute a Solution of the Model
Each group of students goes shopping for 4 items of snack that have been preliminarily surveyed for a certain amount of money, which cannot exceed 50.
Stage 4: **Interpret the Solution and Draw Conclusions**
When the sum of money used to buy snacks 4 items, then removes them from the 50 Baht is the remaining money from the purchase. So the rest of the money will be interpreted as a cost-effective way to spend money.

Stage 5: **Validate Conclusions**
Students help determine which groups have the smallest cash back. It shows that it is the most cost-effective group.

Stage 6: **Develop and Formulate a New or Modified Model**
Have students plan another round to update the list of snacks to buy. To make the best use of money in the sense of the least money left.

Stage 7: **Report the Solution**
Students share results and conclusions, and explain why results and conclusions can be derived.

Figure 2. This image is from a learning activity using MMBL. The picture (a) is about the actual activity of the student in the purchase problem based on activity approach. For the picture (b), they are snacks come from snack food shopping that a modeling activity that results from student do real activities.

5 **Results**
The observation of students’ modelling competency from the support of Mathematical Modeling-Based Learning with activity approach would be determined by the subjective tests after the instructional sequence had been finished. The results show that the modelling performance of the learners is summarized in Table 1.
Table 1 the frequency of students identifying particular students’ modeling competency levels.

<table>
<thead>
<tr>
<th>Mathematical modeling competency level</th>
<th>The number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 0: The student has not understood</td>
<td>0</td>
</tr>
<tr>
<td>the situation and is not able to sketch</td>
<td></td>
</tr>
<tr>
<td>or write anything concrete about the problem.</td>
<td></td>
</tr>
<tr>
<td>Level 1: The student only understands</td>
<td>0</td>
</tr>
<tr>
<td>the given real situation, but is not able</td>
<td></td>
</tr>
<tr>
<td>to structure and simplify the situation</td>
<td></td>
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<tr>
<td>or cannot find connections to any</td>
<td></td>
</tr>
<tr>
<td>mathematical ideas.</td>
<td></td>
</tr>
<tr>
<td>Level 2: After investigating the given</td>
<td>0</td>
</tr>
<tr>
<td>real situation, the student finds a real</td>
<td></td>
</tr>
<tr>
<td>model through structuring and simplifying,</td>
<td></td>
</tr>
<tr>
<td>but does not know how to transfer this into</td>
<td></td>
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<tr>
<td>a mathematical problem (the student creates a kind of</td>
<td></td>
</tr>
<tr>
<td>word problem about the real situation).</td>
<td></td>
</tr>
<tr>
<td>Level 3: The student is able to find not</td>
<td>1</td>
</tr>
<tr>
<td>only a real model, but also translates it</td>
<td></td>
</tr>
<tr>
<td>into a proper mathematical problem, but cannot work with it</td>
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</tr>
<tr>
<td>clearly in the mathematical world.</td>
<td></td>
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<tr>
<td>Level 4: The student is able to pick up a</td>
<td>20</td>
</tr>
<tr>
<td>mathematical problem from the real situation,</td>
<td></td>
</tr>
<tr>
<td>work with this mathematical problem in the mathematical</td>
<td></td>
</tr>
<tr>
<td>world, and have mathematical results.</td>
<td></td>
</tr>
<tr>
<td>Level 5: The student is able to experience</td>
<td>9</td>
</tr>
<tr>
<td>the mathematical modeling process and validate</td>
<td></td>
</tr>
<tr>
<td>the solution of a mathematical problem in relation to</td>
<td></td>
</tr>
<tr>
<td>the given situation.</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 show that there are no students with lower level of mathematical modeling competency than level 3. There are 1 students who have the mathematical modeling competency to build up to level 3, 20 students who have the mathematical modeling competency up to level 4, and 9 students who have the mathematical modeling competency up to level 5. This means that 1 students is able to find not only a real model, but also translates it into a proper mathematical problem, but cannot work with it clearly in the mathematical world. The example of student work at this level is shown in Figure 3.
Figure 3 student work that is related to level 3 of mathematical modeling competency.
And for 20 students in level 4, this means that they are able to pick up a mathematical problem from the real situation, work with this mathematical problem in the mathematical world, and have mathematical results. The example of their work at this level is shown in Figure 4.

Figure 4 student work that is related to level 4 of mathematical modeling competency.
Moreover for 9 students in level 5, this means that they are able to experience the mathematical modeling process and validate the solution of a mathematical problem in relation to the given situation. The example of their work at this level is shown in Figure 5.
6 Conclusion

From observation of students' mathematical modeling competency via the instructional sequences of Mathematical Modeling-Based Learning with activity approach, the results revealed that using this learning model has a positive effect on students' mathematical modeling competency. Moreover, the results from students' performing through the instructional sequences were found that all of the students who learned in this course employed many skills in their learning such as investigation, collaboration, communication, decision, presentation, and so on. Thus, it was indicated that learning through the instructional sequences of Mathematical Modeling-Based Learning with activity approach promoted students' mathematical modeling competency need for their daily life.

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References