

COMPUTER SUPPORT FOR MATHEMATICAL WORD PROBLEM SOLVING

Guided by Thai Teachers' Views

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Abstract: This study investigates Thai teachers' views in teaching and learning mathematical word problem, and the technology implementation to enhance teaching and learning mathematical word problem. Data were collected by use of semi-structured interviews with 24 mathematics teachers. The result of this study showed that the students' major difficulty in solving mathematical word problem lies in the understanding of the problem and the translation of the problem into equations. Therefore, the teachers' suggestions led to the design of a tool to help improve students' performance in solving mathematical word problem.

1 INTRODUCTION

In elementary school mathematics education, the story problem or mathematical word problems are applied to daily situations as the initial stage of learning. Providing practice with real life problem situations can motivate students to understand the importance of mathematics concepts and help them to develop their creative, critical and problem solving abilities (Chapman, 2006). Moreover, a mathematical word problem is used to examine students' mathematics solving ability and can increase the students' interest as well.

Solving word problems is one of the most challenging tasks in mathematics for most students and they often display difficulties. Efforts have been made by researchers in trying to identify the difficulties faced by students in solving mathematical word problems and the reasons underlying these difficulties (Clement, 1982;

Cummins, 1991; Hegarty et al., 1992; Hegarty et al., 1995). One main reason that causes this difficulty is that solving word problems requires a range of skills such as reading, understanding the vocabulary, identifying relevant information, choosing the correct operation, writing related equations, solving the problem and expressing the answer correctly. However, students' major difficulty in solving a mathematical word problem lies in the understanding of the problem and translating the problem into equation.

Technology and computers have played a big role in improving the quality of education today. One of the most important tasks in mathematics education is the revision of curricula and teaching method to take advantage of electronic information technology. Technology can provide teachers and students with tools for solving mathematics, dynamic environments and creating solutions to problems of teaching and learning mathematics.

Therefore, to ensure that the student can cope with difficulties in solving mathematical word

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problems and to increase students' learning achievements and develop mathematical solving abilities, we design MathMaster based on Thai teachers' interview in a way that guides students through step-by-step instructions to form the equation. The interview questions concern difficulties in teaching and learning mathematical word problem, and technology implementation to enhance teaching and learning.

With MathMaster, students would acquire as much independent working experience as possible which provides them with confidence in solving the mathematical word problems.

2 RESEARCH METHODOLOGY

As part of the design of the project, the advice of the experts were sought.

2.1 Participants

Twenty-four teachers (3 male, 21 female) in primary school (Grade 4-6) from six local schools in Thailand were recruited for this study. They ranged in age from 25 to 61 (*mean* = 47.1, *sd* = 9.6) and years of teaching ranged from 3 to 43. Each of the teachers has earned a bachelor degree in different fields.

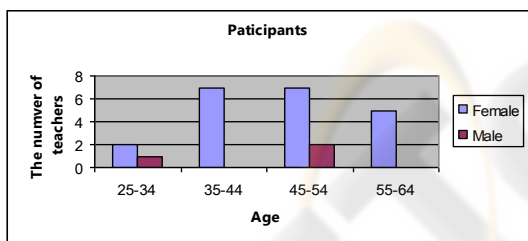


Figure 1: Participants' information.

2.2 Interview

The Thai semi-structured interviews consists of three main parts:

- The background information (age, sex, qualification, and years of teaching) and their experience with computer software and the internet;
- The difficulty in teaching and learning mathematical word problems in the classroom;
- The use of computer software to support teaching and learning mathematical word problems.

2.3 Procedure

Each teacher was interviewed individually in their school for approximately 20 minutes and their voices were recorded and transcribed later.

3 RESULTS

3.1 Teachers' Experience with Computer Software and the Internet

Twenty-one teachers have their own computer and fourteen of all teachers use the internet. The teachers' capability in using computer software is shown in Figure 2. Most of them have experience using basic computer software such as Microsoft Word, Microsoft Excel and Microsoft PowerPoint. Two teachers use other software such as Adobe Captivate and Geometer's Sketchpad (GSP). Moreover, sufficient computer capability for teaching and learning in three schools reflects the ratio of computers to students as 1:1 and in another three schools that ratio is 1:2.

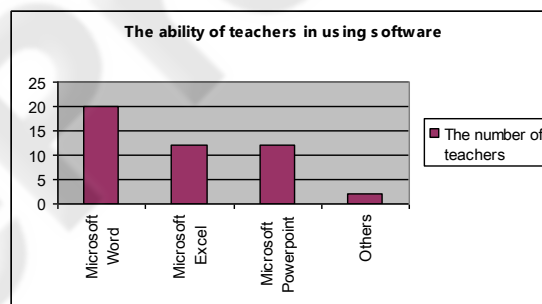


Figure 2: The ability of teachers in using computer software.

3.2 Difficulties in Teaching and Learning Mathematical Word Problems

All teachers use the traditional method (talk and chalk) in teaching mathematical word problems. One teacher includes the lesson online in the class and another teacher uses CAI (Computer-Assisted Instruction) and provides CAI for students who need more practice. The teachers were asked about the difficulty in teaching and learning in class. The main obstacles are the students' individual differences and insufficient time for teacher-student interaction. The teachers have to prepare the lessons to support all

students and each student is assigned different homework. A student's difficulty in learning mathematical word problems lies in three aspects: language and literacy difficulties, comprehension difficulties (a high percentage) and computation difficulties.

In language and literacy difficulties, there are a few students in the class that have difficulties such as:

- The students cannot read the whole sentence or some words.
- The students have to read the problem one more times in order to complete.
- The students do not understand some words in the problem.
- The students read quite slowly.
- The students do not want to read the word problem especially the long problem.

The teachers believe that the students have a deficiency of reading skills and reading practice since they were young, therefore the teacher help students by providing them with more reading opportunities and practices, using attractive stories and allowing students' peers to help.

In comprehension difficulties, most students face difficulty in analyzing the word problem, selecting the operator and forming the equation. The teacher realized that comprehension is the most important and difficult phase of individual thinking. Students have their own way to solve problems. Teachers normally found that:

- The students cannot determine what the problem requires, which are the information part and question part.
- The students always look for a keyword without reading the whole problem and make mistakes in selecting the operation.
- The students cannot form the equation.
- The students form the wrong equation.

Most teachers help students by asking them to do repeated reading, repeated answering and providing a clear presentation of the information and the question. Some of the teachers present the problem from simple to more complicated parts and allow the whole class to understand, or they separate students into small groups so that their friends can help find solution.

Computation difficulties, involve students' incorrect calculations and the student do not always transfer units appropriately. Some students lack computational skills especially in division and

multiplication. The teachers must let the student practice calculation more and remind students of the concept of addition, subtraction, multiplication and division.

The mathematical word problem contents that most teachers commonly found too difficult for students are the percentage, the fraction and the equation respectively.

3.3 Technology to Support Teaching and Learning Mathematical Word Problem

Due to the insufficient numbers of computers in schools and insufficient time allotment for use, most teachers do not use any technology in the classroom. Only two teachers use the mathematics lesson online and CAI in the classroom. Teachers believe the use of technology in the classroom can improve students' mathematical achievements and attitudes, and their understanding of mathematical concepts. The examples of the comments are such as:

- Computer software is convenient both at school and at home and saves time.
- Computer software can facilitate classroom learning.
- Computer software can attract students' interest.
- Computer software can help students practice both inside and outside of the classroom.
- Computer software can enhance students' understanding.

When asked about the role of computer software in teaching and learning in the classroom, all teachers agreed that computer software should be an alternative in the classroom and depend on the content of mathematics as well. The teachers suggest features of computer software that can be helpful for teachers and students; software should be easy to use, attractive to students such as use of colours, pictures, and animation, contain various and adaptive exercises, and have score collection.

The functionality should comprise a clear representation of meaning, phrase or sentence, the relevant information and question, a chance for computation, recommendation of the student's error and collection of the score and result, and adaptation from simple to more complicated problems. A teacher suggested that the computer software should read the problems aloud that should help students improve their reading skills.

4 MATHMASTER

Our primary goal is to find an approach to automatically convert a Thai mathematical word problem into a mathematics expression. Most word problems from any sources follow a three-component compositional structure (Gerofsky, 1996):

- A set-up component, establishing the characters and location of the putative story. It is often not essential to the solution of the problem.
- An information component, which provides the information needed to solve the problem.
- A Question.

Word problems are generally solved in two major steps. (1) the comprehension step (this step relates to carefully reading the question and translating it into appropriate numerical equations); and (2) the calculation step (this step involves a procedure in solving the equation to obtain the correct answer)

Our proposed architecture is shown in Figure 3. The initial design of MathMaster offers students an alternative approach to learn to solve mathematical word problems written in Thai with ease. MathMaster uses three main modules: word problem understanding, information extraction and equation formation.

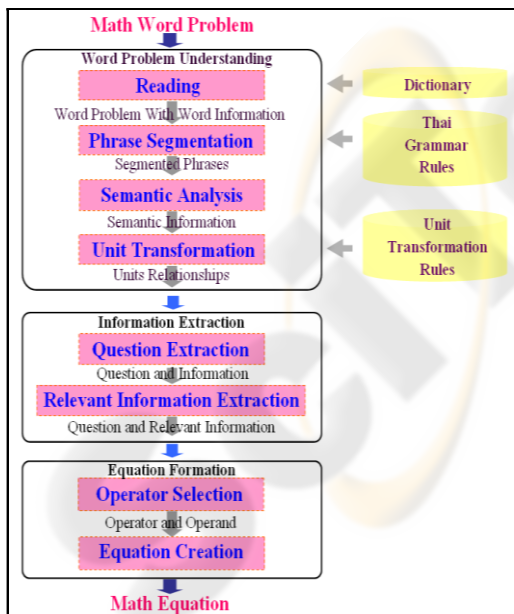


Figure 3: MathMaster Architecture.

The *Word problem understanding module* provides the word meaning to the student, if

requested, and guides the student through the question-answering process to make the story of the problem clearer. The *Information extraction module* extracts the questions asked in the problems which will be used as clues to eliminate irrelevant information. Then, the math operators and operands are selected for creating a complete equation in the *equation formation module*.

4.1 Word Problem Understanding

To understand the mathematical word problem, a student needs to know more, for example, the meaning of the words in the math context and the relationship between different units of measurement that appear in the same word problem. In other words, if the problem contains more than one measurement unit, e.g., centimetres, metres, and kilometres, these three different units should be converted into the same unit according to the clue suggested in the question. Therefore *word problem understanding* consists of four sub-modules: reading, phrase segmentation, semantic analysis and unit transformation.

The reading module provides the information of any word requested by the student. Information provided includes the word definition or meaning, examples of usage and pictures if possible. In Figure 4, a student requests the definition of “สองเท่า (twice)” by highlighting the word and Figure 5 presents the meaning of the word “สองเท่า(twice)” together with an example of how the word is used and a picture to aid easy understanding.

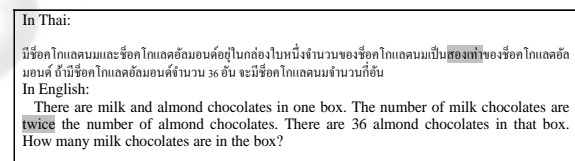


Figure 4: Example of word problem and marked word.

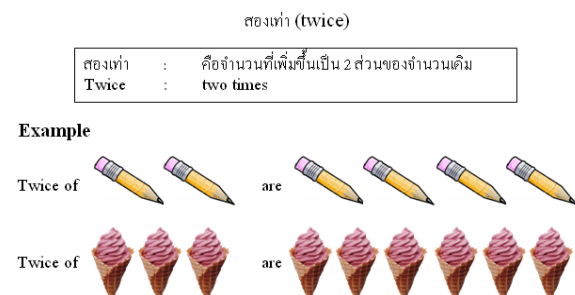


Figure 5: Example of information provided for the word “twice”

Due to the nature of the Thai writing system, a word problem is written in a sequence of alphabet symbols with no mark at the end of words, phrases or sentences. Unlike English, “ ” (space) is used as a word boundary and “.” (full stop) is used to mark the end of phrases and sentences. Therefore, in the phrase segmentation step, the input word problem must be segmented into short phrases based on the Thai grammar.

In semantic analysis, each phrase is analyzed in terms of meaning. MathMaster can help the student to understand phrases by asking a few questions. Figure 6 shows the example of information after semantic analysis.

<p>A set-up component: There are milk and almond chocolates in one box.</p> <p>An information component: The number of milk chocolates are twice the number of almond chocolates. There are 36 almond chocolates in that box.</p> <p>A Question: How many milk chocolates are in the box?</p>

Figure 6: Example of word problem and separated information.

In Solving mathematical word problems, a student must pay attention to units of measurement (e.g., เมตร-meter, นิ้ว-inch, ไมล์-mile) and quantity (e.g., โหล-dozen, แท่ง-stick, ชิ้น-item) since they have a great effect on the equation formation part. In the unit transformation step, all units referenced in the word problem are examined thoroughly before the unit conversion can be performed.

4.2 Information Extraction

To a student, determining the relevant information embedded in the problem is relatively difficult. This module was designed to identify the question asked in the problem and then uses keyword extraction from the question to search for the given information as illustrated in Figure 7.

<p>A Question: How many milk chocolates are in the box?</p> <p>Given information:</p> <ul style="list-style-type: none"> ▪ The numbers of milk chocolates are twice the number of almond chocolates. ▪ There are 36 almond chocolates in that box.
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Figure 7: Information Extraction.

4.3 Equation Formation

The given information, extracted in the previous step, specifies the operands and the operators to be used in equation forming. This step completes the process by forming the equation, “ $X = 2 \times 36$ ” for the previous example. For a more detail about MathMaster see Supap et al (2009).

5 CONCLUSIONS

Insufficiency of computer, time and available software causes most teachers to avoid use of any technology in the classroom. Generally, teachers tend to view computer software as a useful tool to teach mathematical word problems. They realize that students should have an opportunity to learn via computer software in the classroom. Therefore we suggest in this study that to design and develop the system that can help students and teachers in learning and teaching math word problem is useful.

MathMaster, an alternative educational tool, offers students the opportunity to comfortably learn how to solve mathematical word problems. It was designed to automatically interact with student via question answering process. Student can therefore independently practice with step-by-step assistance.

MathMaster is able to automatically translate a mathematical word problem written in Thai into mathematical language and clearly present each step. To perform a reliable translation, MathMaster must understand the terms in the mathematical context, determine what is to be solved, know the relationships between units referred in the problem, recognize the connection between objects mentioned in the relevant information, and select the appropriate operators and operands.

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APPENDIX

The interview questions

Part 1: Teachers' background and their experience with computer software and using the Internet.

1. Sex
2. Age
3. Qualification
4. Years of teaching
5. Teaching Grade
6. Do you have a personal computer to use at home?
7. What program can you use?
8. Do you have experience using the Internet?
If you have
 - 8.1 How long have you used the internet?
 - 8.2 For what purpose do you use the Internet?
9. How does the ratio between computer and student in computer lab?

Part 2: The difficulty in teaching and learning mathematical word problems in the classroom.

10. What are the problems in teaching mathematical word problems?
11. What do you think about the causes of each problem?
12. What did you do to solve the problems?
13. What does the content of mathematical word problems that student face difficulty?

Part 3: The use of computer software to support teaching and learning mathematical word problems.

14. Do you ever use computer software about mathematical word problems?
If yes,
 - 14.1 What is its capability?

- 14.2 What is your opinion toward that computer software? (advantage and disadvantage)

- 14.3 Do you ever use that computer software in the classroom? If yes, how do you implement that computer software in the classroom?

15. What do you think of the contributions of computer software about mathematical word problems for you?

16. What do you think of using such computer software about mathematical word problems in the classroom?

If you think it should be use

- 16.1 How do you implement computer software about mathematical word problems in the classroom?

17. What do you think about the capability or function of computer software that should support mathematical word problems teaching and learning?