Supporting Mathematical Communication in Word Problem Solving Through a Cognitive Tool

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Abstract: Word problem solving is one of the most challenging tasks in mathematics for most students. It requires the solver to translate the problem into the language of mathematics, where we use symbols for mathematical operations and for numbers whether known or unknown. From a study conducted on Malaysian school students, it was found that majority of them did not write their solution to the word problem using correct mathematical language. Intrapersonal and interpersonal communications are important in mathematics learning especially in word problem solving. It is therefore the main aim of this paper is to present a model that promotes the use of mathematical language which is used as a basis in designing a learning environment for word problem called MINDA. From the experimental analysis conducted on MINDA, it was found that the mathematical communication and their word problem solving achievement of students have improved.

Key-words: word problem solving, cognitive tool, mathematical communication, intrapersonal communication, interpersonal communication.

1 Introduction

Various studies have indicated that many students worldwide faced difficulties in solving word problem [1], [2], [3]. They have signified that poor performance of students in word problem has been attributed to difficulties in reading comprehension, abstract reasoning and strategy use. Generally, students' major difficulty in solving word problems lies in the understanding of the problem and translating the problem into equations. Some factors contributing to students' difficulty in solving word problems are lack of knowledge of problem type, limited strategies in solving word problems and lack of skills in computational algorithms. There is still the need to find new approaches to improve students' achievement in solving word problems.

2 Research Problem

A study was conducted on 57 seventh grade students of a local Malaysian school. One of the main objectives of the study is to investigate students' ability in solving fraction word problems. The instrument for the study was a set of mathematical problems involving fractions that consists 10 word problems. One of the observations made from the study is that almost all the students have poor mathematical communication skills [4]. Thus, the students' lack of concern of the mathematical syntax and grammar is a possible contributing factor to their difficulty in word problem solving.

Although a lot of research has been carried out relating to students performance in solving word problems, but there is very little work that has been done which dealt with mathematics as a language [5], [6]. Students' lack of exposure in learning the language of mathematics creates countless difficulties in learning the subject regardless of the level of education they are in. It is the root of the problem in learning mathematics especially in the area of word problem solving.

3 Communication in Word Problem Solving

Solving word problems involves the communication of the solution steps effectively to one's self and others. This part is the most challenging to most students. Students need to learn a written language to convey their solutions or ideas. They have to use correct and accurate syntax and grammar of the mathematical language.

Intrapersonal and interpersonal communications are very important in word problem solving. They affect the cognitive process of the problem solver and help them reflect on their task of finding the solution to the given word problem. The importance of intrapersonal and interpersonal communication in word problem solving was not being given the proper attention before.

Communication can be described as a hierarchy of processes. For the purpose of the study, the integration of the hierarchical model of human communications by Losee [7] and the "sawtooth" communication model by Watzlawick [8] has been adopted. Figure 1 depicts this communication model developed.

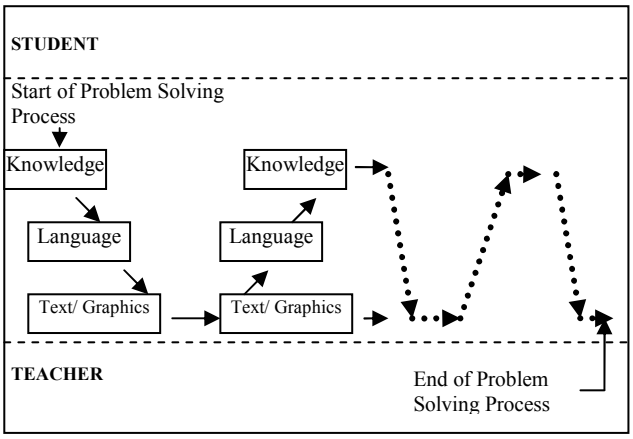

Figure 1
Communication Model of Study

The effective way in improving communication is through writing because formality in using a language can easily be implemented in writing. Therefore, it is important for students to be given training in proper solution writing of word problem so as to ensure successful intrapersonal and interpersonal communication. They need to represent the problem with correct mathematical equation using clearly written and well-defined known and unknown variables. Figure 2 describes a convention used in defining variables and constructing the related equation. The convention promotes effective communication of solution between the problem solver and the teacher.

Problem:
Normah has $7\frac{3}{5}$ *metres of ribbon. She wants to cut it into equal lengths of* $\frac{2}{5}$ *metres. How many* $\frac{2}{5}$ *-metre lengths of ribbon will she get?*

Defining variables	R= length of ribbon C= length of cut ribbon N= total number of cut ribbon
Inserting known values	$R = 7\frac{3}{5}$ m $C = \frac{2}{5}$ m
Constructing equation	$N = R \div C$
Solving equation	$N = 7\frac{3}{5} \div \frac{2}{5}$ $= \frac{38}{5} \times \frac{5}{2}$ $= 19$
Writing final answer	Normah gets 19 cut ribbons altogether

Figure 2
Solution Writing Convention

The Cognitive-Communicative (C-C) model is developed for the purpose of enhancing mathematical communication among learners. The C-C model is given in Figure 3.

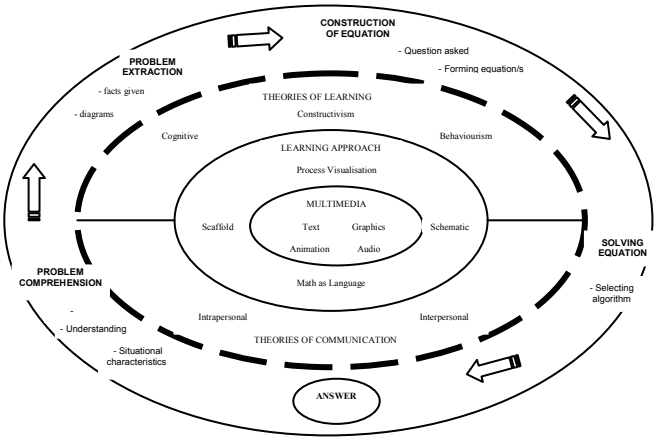

Figure 3
The C-C Model

The cognitive and the communicative aspects of the model have significant influence on the steps, strategies and approach of the word problem solving. In other words, the strategies chosen (rewording, schema and keyword strategy) and the instructional approach selected (graphics/diagrams, worked examples and scaffolding) take into account the principles of Cognitive Learning Theory and Communication Theory. Figure 4 shows the components of the C-C model for a computer-based learning environment.

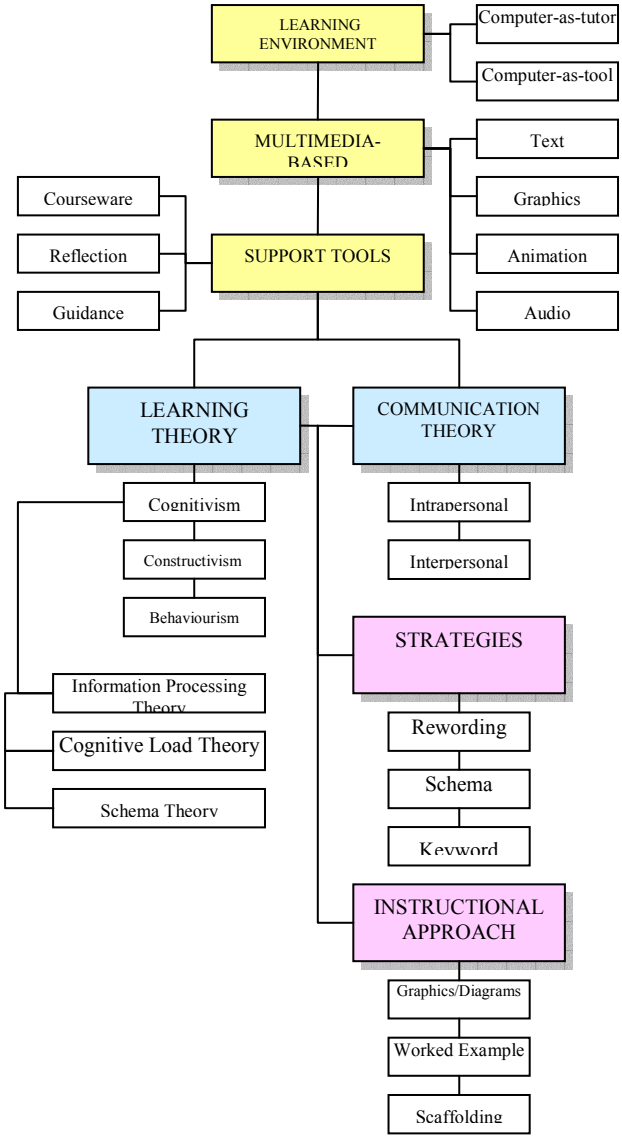

Figure 4
Components of the C-C Model

4 MINDA: A Learning Environment for Fraction Word Problems

The communication aspect which is being highlighted in this research is the written communication between learner and himself and communication between learner and the teacher. Since computer is a good source for communication, it is thus a good platform to implement the proposed approach in a system that can help students improve their word problem solving skills.

A learning environment called MINDA which applies the requirements set by the C-C model is developed for fraction word problems. Basically the environment is a representation of the problem-solver's mind during word problem solving, thus justifies the given name 'MINDA" since '*minda'* is the Malay word for '*mind'*. MINDA comprises of two main systems; Word Problem Lab (WPL) and the Learning Courseware (LEARN). Figure 5 displays the modules of MINDA. MINDA incorporates several word problem-solving resources and tools such as reflection tool, fraction calculator/ converter, mathematics glossary and visualization tool.

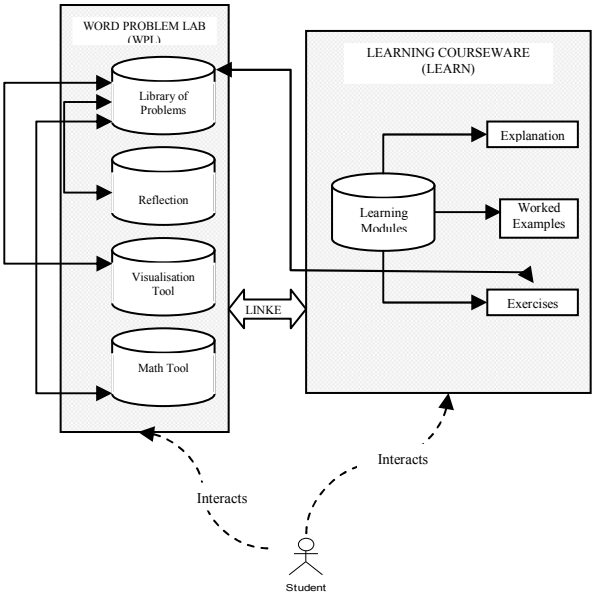

Figure 5
Modules of MINDA

The WPL is a cognitive tool that focuses on visualisation of the problem solving process. It includes the main five steps in problem solving; Comprehension, Extraction, Construction of Equation, Solving of Equation and Writing of Answer. Figure 6 depicts the interface of WPL. Since WPL adopts the client/server architecture, learner and teacher can stay connected during the learning process. Thus, for each step of the word problem solving process, the learner can submit his answer which allows the teacher to view the learner's written solution on her computer. The teacher can give comments on the learner's answer before he proceeds to the next level of problem solving process. It is through the submission of the problem solution that the learner needs to apply correct mathematical language for successful communication with himself and the teacher. The proposed solution writing convention is used to ensure effective communication.

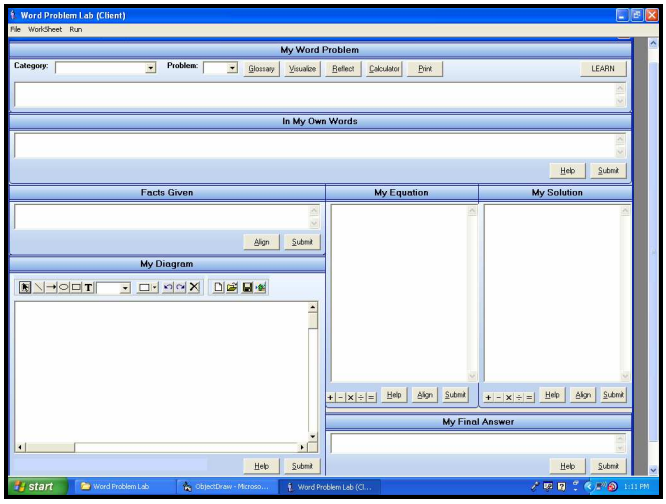

Figure 6
Print Screen of Interface of WPL

On the other hand, the learning courseware, LEARN is in the form of a tutorial on solving word problems involving fractions. Word problems can be categorised in various ways but for the purpose of this study, the problems are divided according to their situational types. The four types of word problems included in this study are Quantity of Objects, Height/Length/Distance, Money and Weight. Figure 7 displays the main menu of LEARN and Figure 8 presents the flow of activities in WPL.

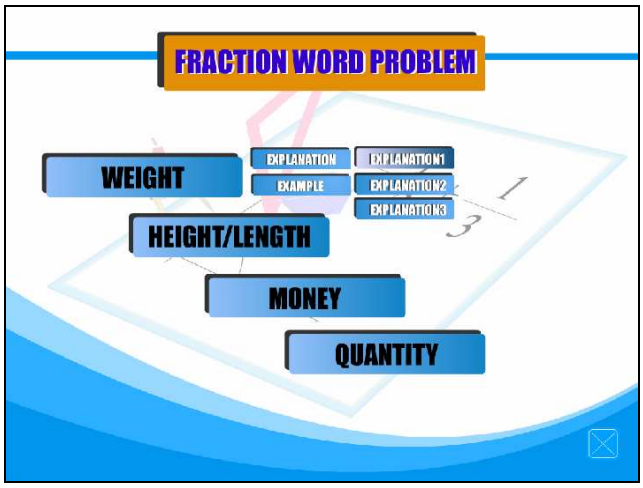

Figure 7
Print Screen of Main Menu of LEARN

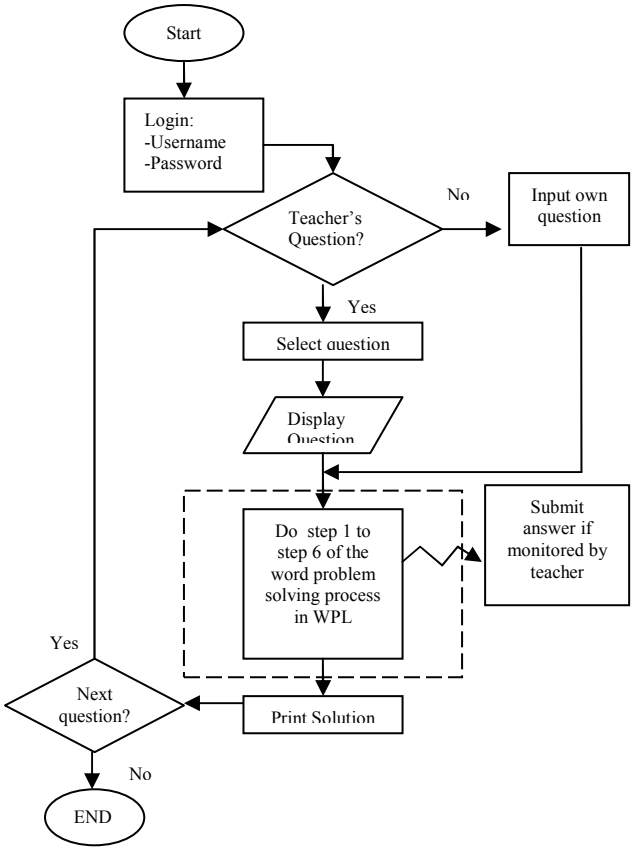

Figure 8
Activity Flow of WPL

4 Conclusion

MINDA has been evaluated and tested with 58 school students. The results indicate that MINDA has a positive effect on the students' achievement in fraction word problem solving. The achievement made by the experimental group in the posttest is very encouraging. Comparing the learning gain which is measured by the absolute difference and the normalized learning gain, it was observed that the performance of the experimental group has improved greatly.

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