Investigation of learning environment for arithmetic word problems by problem posing as sentence integration in Indonesian language

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Abstract. Arithmetic word problems remain one of the most difficult area of teaching mathematics. Learning by problem posing has been suggested as an effective way to improve students' understanding. However, the practice in usual classroom is difficult due to extra time needed for assessment and giving feedback to students' posed problems. To address this issue, we have developed a tablet PC software named Monsakun for learning by posing arithmetic word problems based on Triplet Structure Model. It uses the mechanism of sentence-integration, an efficient implementation of problem-posing that enables agent-assessment of posed problems. The learning environment has been used in actual Japanese elementary school classrooms and the effectiveness has been confirmed in previous researches. In this study, ten Indonesian elementary school students living in Japan participated in a learning session of problem posing using Monsakun in Indonesian language. We analyzed their learning activities and show that students were able to interact with the structure of simple word problem using this learning environment. The results of data analysis and questionnaire suggested that the use of Monsakun provides a way of creating an interactive and fun environment for learning by problem posing for Indonesian elementary school students.

1. Introduction

Arithmetic word problems remain one of the most difficult area of teaching mathematics. Indonesian Mathematics Teaching Monitoring and Evaluation result (P4TK ME) showed more than 50% teachers reported that most students have difficulty in solving word problems, due to not having a clear picture regarding the link between contextual daily state with the corresponding mathematical sentence, and not actively utilizing their mental state in problem solving [1].

Learning by problem posing, suggested as an important way to promote learner's understanding in arithmetic [2], involves generating new problems in addition to solving pre-formulated problems [3]. In Indonesia, practice of problem posing was introduced in National Conferences and Journal of Education [4] to improve the professionalism of mathematics teachers in conducting classroom. The application of new Competence-Based Curriculum (CBC/KBK) in Indonesia in 2004 then started new teaching method called Indonesian Realistic Mathematics Education (IRME/PRMI), in which problem posing method is encouraged as a means to improve students' problem development and problem solving ability [5]. Since then, various researches in problem posing practice has been conducted in Indonesia, reporting increased motivation and active performance in classroom and learning completeness percentage. However, reports of students in accustomed to problem posing task facing difficulty to carry out the learning and teacher needed extra time to evaluate the posed problems were observed [9].

In this study, we present a learning environment for posing arithmetic word problem of simple addition and subtraction called Monsakun, which require students to create problems instead of solving it, and to distinguish between necessary and extraneous information in the process of creating problem. Figure 1 shows the interface of Monsakun. In each assignment learners are provided with a set of sentence cards and requirements of the target word problem, then they pose problem by selecting and arranging appropriate cards. In this activity, learners do not make their own statements of problem, but they are required to distinguish the role of each sentence card and integrate them into problem, a process called "problem-posing as sentence-integration" [7]. Monsakun is developed based on Triplet Structure Model [8] and four schemas/story types or arithmetic word problem [9]. An arithmetic word problem is defined as consisting of two "independent quantity sentences" which describe numbers of objects and one "relative quantity sentence" which describe relation between the independent quantity sentences. Practical uses of Monsakun in several Japanese elementary schools have been reported [7][10] and in-depth analysis of students' log data were also conducted [11][12]. An experimental use of Monsakun for Indonesian and English university students showed their acceptance of our arithmetic model [13].

Our problem posing learning environment provides a way for students to touch and work directly with the structure of arithmetic word problem. Moreover, the dummy/distractor sentence cards give students opportunity to distinguish extraneous and necessary information in a word problem [13], a practice rarely seen in classroom situation. It addresses the issue of assessment and feedback time faced by the teachers by automatic agent-assessment method. The problem of math and language concept comprehension faced by some students is addressed by providing a closed problem space using simple sentence cards, which students can easily select and arrange to create a problem. The closed problem space also enables the recording and analysis of students' log data, which can give insight to their comprehension of arithmetic concepts and processes.

This research investigates the introduction of Triplet Structure Model for arithmetic word problem and Monsakun experimental use by Indonesian elementary school children living in Japan. With respect to the drawback of problem posing practice in Indonesian classroom as explained above and the usefulness of Monsakun practice in Japanese classroom situation, we believe that this software has a potential to provide a meaningful activity for Indonesian teachers as well as students in carrying out problem posing practice from early school grade.

To establish the position of this research in related field, we have investigated 70 literature/researches regarding problem posing in Indonesia in the past 17 years (1999-2015), including conference papers, journal papers, theses, and books. Among them, only 20% researches were conducted in elementary school, showing that this method of learning is not often investigated in low grade school compared to higher school. Moreover, we only found 3 researches of problem posing using interactive software, all of them used in middle/high school. Thus, our contribution is to pioneer the study for the implementation of interactive learning environment for problem posing in elementary school grade.

2. Experimental Method

Our target subjects were ten Indonesian children (age 9-11) who lived in Japan and went to Japanese elementary school. The age range were chosen because they have learned basic mathematics/arithmetic concept of addition and subtraction in Indonesian, and they have sufficient language ability.

The experiment was carried out in one day and divided into four sections. Firstly, students were given an extraneous problem test which consist of 20 simple addition or subtraction word problems. Second, the researcher, under supervision of an expert, conducted a teaching activity to introduce the Triplet Structure Model. Afterwards, students were given a task to pose problems using provided simple sentences. The third section was Monsakun use, followed by questionnaire.

The instruments used in this study are: (1) Extraneous problem test to measure students' arithmetic ability, (2) analysis of Monsakun log data to find out students' problem posing performance, and (3) questionnaire result to investigate students' acceptance of our learning model.

3. Results and Discussion

3.1. Extraneous Problem Test

The first section of this study was extraneous problem test. Students were randomly given one of two types of test consisting of 20 simple addition/subtraction word problems containing extra/superfluous information to be answered in 30 minutes. The material of the test was consulted beforehand to an Indonesian elementary school mathematics teacher as an expert in this field, and both type of the test have the same level of difficulty. Students were asked to read the sentences carefully, crossed out unnecessary sentences, write the corresponding calculation formula and the answer for the problem. An example of the test is provided in figure 3.

Although the instruction was to cross out the extra information, not all students did it well, so a score is given if the final answer is right. The mean score for the extraneous problem test was 70.5% of 20 problems (M = 14.1, SD = 4.84). As this type of word problem is generally not included in the Indonesian textbooks, it was the first time that the students encountered this exercise, and the mean score shows they had enough ability to distinguish extraneous information in simple word problems. As a comparison, extraneous problem test performed by Japanese elementary school students in a study of Monsakun practical use [14] resulted in mean score of 82% for high performance students (n=40) and 14% for low performance students (n=38).

3.2. Teaching of Problem Posing based on Triplet Structure Model

The second section was conducting teaching activity to introduce the concept of simple sentence problems based on Triplet Structure Model, four schema (story type) of arithmetic word problem, and exercise of problem posing in addition and subtraction. The teaching was necessary since according to the expert, Indonesian students in lower grade of elementary school are usually taught to solve word problems by paying attention to specific keywords such as "sum", "total of" for addition or "less", "decreased by" for subtraction, while the Triplet Structure Model put emphasis on the type of sentence and relation between them instead of focusing on keywords.

To begin the teaching activity, the translation from a conventional word problem to simple sentences are introduced. For example, figure 2 shows combination story problem translated into three sentences. Then, two types of sentences in Triplet Structure Model and types of story problem was explained, and then students were asked to construct simple sentences and identify their types. The target of this activity was to give students' understanding of the construction of a simple word problem in our model. Similar to the teaching in Japanese elementary school using Monsakun [10], the explanation was conducted using paper cards and whiteboard. Students were actively involved in this section by answering questions and offering opinions.

After the four story types have been explained, students were given a task to pose problems using provided simple sentences. This exercise aimed to confirm their understanding towards our model. An example of the exercise is shown in figure 4. Fifteen sentences consist of 6 independent quantity sentences and 9 relative quantity sentences was provided. Five sentences have unknown quantity. From the sentences, it is possible to pose four types of story with multiple combination of correct problem. Students were asked to pose one of each, and random students were appointed to explain their answer in front of the class. Students were also actively involved in this exercise.

3.3. Monsakun Experimental Use and Log Data Analysis

In the third section of this study, the Indonesian students used Monsakun to practice problem posing of addition and subtraction. 90 minutes of total time (excluding break time) were allocated for the students to work through all assignments from Level 1 to Level 5. Scene of students' experience with

Monsakun are shown in figure 5. We found that students posed 2,222 problems in total, which averages in 2.46 problems per minute. Without the use of a fixed problem space system like Monsakun, it is thought that students won't be able to pose such many problems in a short time in classroom situation. Furthermore, teachers' problem of needing extra time to grade students' problem exercise in conventional class is solved by automatic assessment system in this learning environment.

After the experiment, the log data was analyzed and presented in figure 6. Level 2 and 4 were omitted from the analysis because they only contain 3 assignments from one story type, while Level 1, 3 and 5 contain 12 assignments from all story types. The average of steps and mistakes at Level 5 is higher than ones at Level 1 and 3. This is the same trends as of Japanese students, which shows that posing problems with reverse thinking problems and calculation formula (Level 5) is difficult for both Japanese and Indonesian elementary school students [16].

The average steps and mistakes show increasing rate from Level 1 to Level 5, a trend also observed in previous practical use of Monsakun in Japanese elementary school students [10]. However, the average number is considered high compared to either the Japanese elementary school students [15]. We assume that the difference came from Indonesian students' short exposure to this new learning method (one experimental session consisting 60 minutes teaching and 90 minutes of system use), while the Japanese students had longer exposure (9 classroom sessions: 35 minutes teaching & 10 minutes system use, totaling 315 minutes teaching and 90 minutes of system use). Nevertheless, the Indonesian students expressed high interest during the Monsakun use.

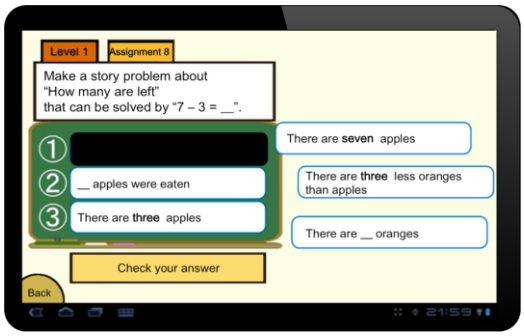

Figure 1. Monsakun interface.

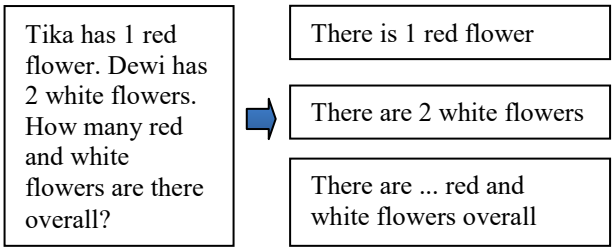

Figure 2. Example of translation from conventional word problem to three simple sentences.

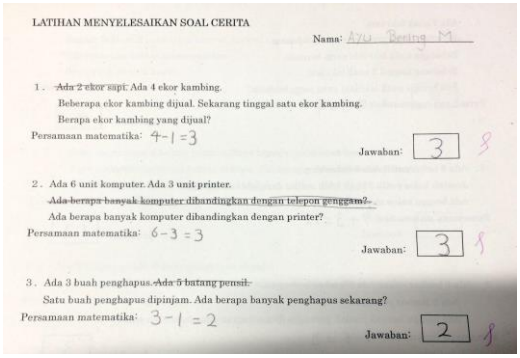

Figure 3. Example of extraneous problem test (in Indonesian language).

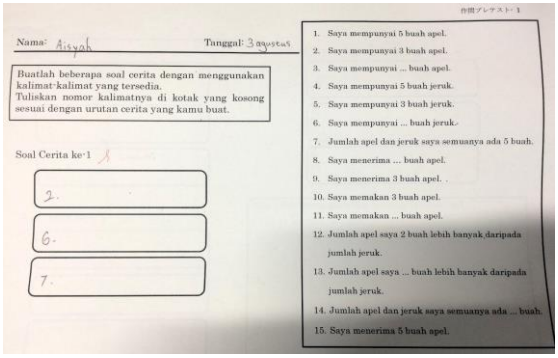

Figure 4. Example of student's answer in a problem posing task (in Indonesian language).

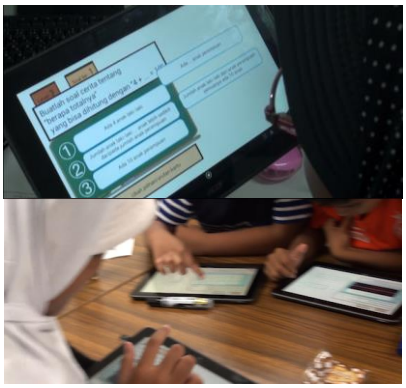

Figure 5. Scene of Indonesian students used Monsakun in Indonesian language.

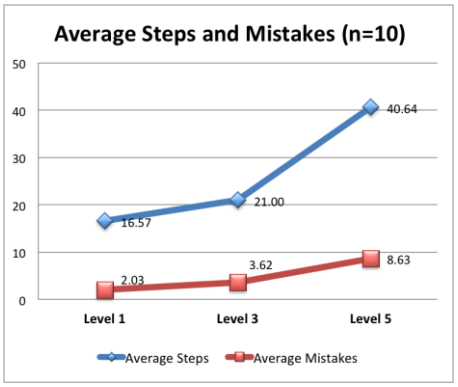

Figure 6. Average steps and mistakes for assignments in Level 1, Level 3, and Level 5.

The conventional teaching method in mathematics conducted one-way by the teacher rarely provides chance for students to become active learners. In contrast to this, we observed students initiating discussion among themselves or with the teacher during this section regarding the assignments and how to pose the correct problem in different story type. We believe that the use of Monsakun encourage this interaction, which in turn promote a deeper understanding about the structure of word problem.

3.4. Questionnaire

Table 1 shows the questionnaire result of Monsakun experience use for Indonesian children (n=10). We observed that most students found posing arithmetic word problems are enjoyable (Q1), however, posing problems were not easy (Q2). Students thought that posing problems are useful for arithmetics (Q3, Q4). Monsakun was fairly easy to use for them (Q5), but they needed more effort to understand the assignments and feedbacks (Q6, Q7). They expressed interests to attend classes that use problem posing activities (Q8). Based on the questionnaire results, we concluded that Monsakun is acceptable and useful as problem posing learning environment for Indonesian elementary school students.

Table 1. Questionnaire about Monsakun use.

	Questions	Strongly Agree	Agree	Weakly Agree	Weakly Disagree
1	Do you enjoy posing arithmetic word problems?	**70%**	30%	0%	0%
2	Are arithmetic word problems easy to pose?	20%	**30%**	**30%**	20%
3	Do you think that posing problems is a good learning method for arithmetic?	**50%**	20%	20%	10%
4	Do you think that posing problems made it easier to solve problems?	**40%**	**50%**	10%	0%
5	Do you think that it easy to use MONSAKUN?	**40%**	**50%**	10%	0%
6	Were the assignments and sentences easy to understand?	10%	**40%**	**50%**	0%
7	Were the feedbacks easy to understand?	**30%**	20%	**30%**	20%
8	Would you like to attend arithmetic classes where problem posing is used?	20%	**30%**	**40%**	10%

4. Conclusion

In this study, we investigated the introduction of Triplet Structure Model for arithmetic word problem and Monsakun experimental use by Indonesian elementary school students living in Japan. In the extraneous problem test, we checked that Indonesian students had good enough ability in solving word problems compared with Japanese students.

The questionnaire result shows that even though posing problem is not too easy, they enjoyed posing problems with Monsakun. Students were able to pose a lot of word problems. This number of problems could not be achieved in usual classroom situation. The averages of steps and mistakes at Level 5 are higher than ones at Level 1 and 3. This trend are also observed in the previous practical use of Monsakun by Japanese elementary school students.

The result of data analysis and questionnaire shows that problem posing by sentence integration based on Triplet Structure Model is accepted by Indonesian students. Furthermore, the use of Monsakun could provide a way of creating an interactive and fun environment for learning by problem posing for Indonesian elementary school students.

The limitation in this study are the small number of subjects and the short investigation/observation time. Ideally, the proposal of a new learning system is preferably done in multiple sessions spread in several weeks, including statistically measurable pre-test and post-test. However, we hope that this research will encourage others to continue, verify, expand, or apply it for further improvement.

5. References

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