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A Case Study of Interactive Environment for Learning by Problem-posing in Special Classroom at Junior High School

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Abstract: We have developed a learning environment for problem-posing as sentence integration. In this exercise, a learner is required to select and arrange given simple sentence cards for posing problems. On the other hands, learners write problems from scratch in usual problem-posing. Because it is very difficult for learners with reading disability to write a sentence, they cannot exercise by usual problem-posing virtually even though a teacher would like to teach the arithmetic word problems to them through problem-posing exercise. However, several learners with reading disability are able to read a simple sentence. So, we assumed that these learners realize to exercise problem-posing by problem-posing as sentence integration. Moreover, its practical use targeted as sixteen junior high school students in special classroom is reported.

Keywords: Problem-posing as sentence integration, arithmetic word problem, special classroom, reading disability

1. Introduction

Special classroom is small-group class that consists of a student with special needs. The special needs include learning disabilities, communication disorders, emotional and behavioral disorders, physical disabilities, and developmental disabilities. Teacher provides them an education that addresses their individual differences and needs. There are many learners who have reading disability in learning disabilities. It is very difficult for them to read and write a sentence. A teacher teaches them the arithmetic word problem as easily as possible (William, 2007; Xin et al, 2005). In school, if the learner difficult to read the simple sentence, the teacher often explains the arithmetic word problem by using some picture. It is hard for a teacher to teach the arithmetic word problems in special classroom.

Problem-posing is suggested as an effective way for improving learner's understanding of mathematical concepts and the development of mathematical thinking (Silver, 1997; Singer and Moscovici, 2008). In this exercise, a learner is given an assignment, and then, he/she is required to pose a problem by writing it from scratch. The teacher of special classroom would like to teach the arithmetic word problem by problem-posing but learner with reading disability is not able to pose an arithmetic word problem because of their disability. We have designed and developed a learning environment for posing an arithmetic word problem (Hirashima, 2007; Yamamoto et al, 2012, 2013, 2014). In this problem-posing, the learner is required to select and arrange a few sentences in order to pose the problem. We call this exercise problem-posing as sentence integration. By using this learning environment, the learner can understand a problem structure to pose the problem. Actually, we have confirmed that the learner improved their understanding of problem structure after they have learned the arithmetic word problem by using our environment in regular class.

We assumed that the learner with reading disability can pose an arithmetic word problem and understands a structure of arithmetic word problem by using our learning environment if he/she is able to understand a simple sentence. The purpose of this research is to realize the learning of problem-posing in special classroom by using our learning environment. Previously, a teacher in special classroom requested us to use our learning environment in his class because he has same

assumption. A result of this experimental use has suggested that the learners with reading disability who cannot exercise usual problem-posing could exercise the problem-posing by using our learning environment (Yamamoto, 2016). We don't find a research that the learner with reading disability realized to exercise problem-posing. However, there are only two subjects in this experimental use.

In this paper, we report a case study of our learning environment for a sixteen learners with intellectual disability who belongs to special classroom at junior high school in Hiroshima. A purpose of this paper is to verify an assumption that our learning environment realizes that the learner with reading disability can exercise problem-posing and understand the problem structure.

2. Problem-posing and Reading Disability

2.1 Problem-posing

We focused on an arithmetic word problem that can be solved by one-step addition or subtraction in this research. Figure 1 shows usual problem-posing of the arithmetic word problem. In this exercise, leaners are required to pose the problem that is satisfied a given assignment like calculation. Then, they pose the problem from scratch by writing sentence. On the other hands, we have defined the problem-posing as sentence integration that required learners to pose the problem by selecting and arranging a three simple sentences from a given simple sentences (Figure 2). In this exercise, they need to read and understand each given sentences that consist of quantity, object and attribute. For example, in the first sentence of Figure 2, the quantity is "five". The object is "apple". The attribute is "There are" that expresses existence of quantity. We call this simple sentence the independent quantity sentence. The third sentence of Figure 2 has the attribute that is "altogether". This attribute expresses the relation between the quantity of apple and orange. This simple sentence called the relative quantity sentence. These simple sentences show the quantitative concepts. In our research, the arithmetic word problem is expressed by three quantity sentences because the arithmetic word problem that can be solved one-step addition or subtraction consists of three quantities: operand, operant and result quantity. We call this model as triplet structure model (Hirashima et al, 2014).

Assignment: Pose problem that can be solved by "8-5".
Answer: There is one big tree. Tree has six apples and there are several oranges on other tree. A number of apples and oranges are eight. How many oranges are there?

Figure 1. Usual Problem Posing.

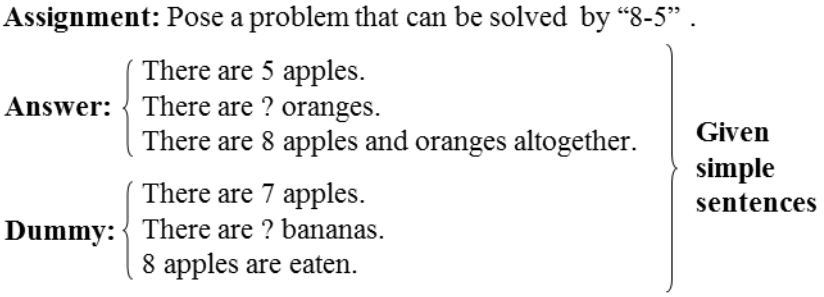

Figure 2. Problem-posing as Sentence Integration.

2.2 Relation between targeted reading disability and problem-posing as sentence integration

There are several learners with reading disability in special classroom. They need a long time to recognize each word more than regular learners. Moreover, it is known that most learners with reading disability cannot write a sentence correctly. Thus, they cannot exercise by usual problem-posing because of their disability. So, the learner with reading disability often finds difficulty in reading sentence but several learners are able to read the simple quantity sentence. They are our targeting learner because the arithmetic word problem composed of three simple quantity sentences in triplet

structure model. We have already performed an experimental use in special classroom in which there are two targeted learners at elementary school. The results of the experimental use suggested that they are able to pose the problem and improve their ability for posing the arithmetic word problem. However, there are a few subjects in this experimental use. Therefore, we verify the realization of problem-posing as sentence integration for our targeted learners by additional practical use so that anyone who understands the quantitative concepts are learn by problem-posing as sentence integration in special classroom.

3. Learning environment for problem posing as sentence integration

3.1 Exercise on Learning Environment

Functions for exercising the problem-posing as sentence integration targeted as the arithmetic word problem are implemented on a learning environment called MONSAKUN Touch (Yamamoto, 2016). MONSAKUN Touch runs on Android tablet. In this learning environment, the learner can select a level of assignment after login. If the level is selected, MONSAKUN Touch displays the main interface for problem-posing. This interface presents an assignment of posing problem like "Make a word problem about 'How many are there overall' that can be solved by 8-3". The assignment shows the calculation and story. The learner poses the problem by selecting three simple sentence cards from given cards and arranging them in proper order. Given sentence cards are consists of both correct and dummy cards that leading to errors. If the learner posed a problem, diagnosis button will be active. After the learner taps this button, MONSAKUN Touch diagnoses and generate a feedback his/her posed problem in real-time. If the learner finishes answering all assignment in selected level correctly, the interface for posing problem changes to the interface for selecting level.

3.2 Level of Assignment and Kind of Error

Table 1 shows a level of assignment on MONSAKUN Touch. A different of each level is a kind of posed problem, a given calculation and a given story. The story is divided into addition story and subtraction story. Addition story is usually expressed by increase story or combine story. Subtraction story is usually expressed by decrease story or comparison story. For example, the following story is decrease story.

{There are "?" apples. 2 apples are eaten. There are 3 apples.}

We are able to solve this problem by "3+2". We call this calculation for solving problems the calculation numerical relation. And then, the numerical relation of this problem expresses as the subtraction story that is "?-2=3". We call this calculation based on story the story numerical relation.

In above problem, story numerical relation and calculation numerical relation are deferent. We call this type of problem "reverse thinking problem". If story numerical relation and calculation numerical relation are same, then such problems are called "Forward thinking problem". Reverse thinking problem is much harder than forward thinking problem. The level of assignment is designed to be the step by step based on these definitions. The errors of posed problem are shown in Figure 3. We analyzed these errors in the experimental use.

Table 1: Level of Assignment.

Level	Kind of posed problem	Given calculation	Given Story
1	Forward thinking problem	Story numerical relation	Combine, Increase, Decrease, Comparison
2	Reverse thinking problem	Story numerical relation	Combine, Increase
3	Reverse thinking problem	Story numerical relation	Decrease, Comparison
4	Reverse thinking problem	Calculation numerical relation	Combine, Increase
5	Reverse thinking problem	Calculation numerical relation	Decrease, Comparison
6	Random	Random	Random

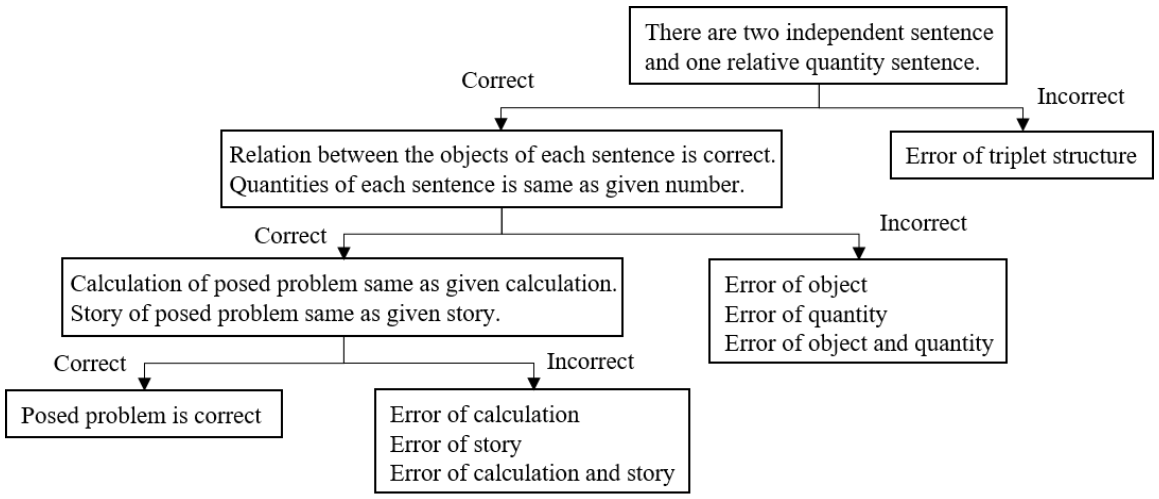

Figure 3. Diagnosis of Posed Problem by MONSAKUN Touch (Yamamoto, 2016).

4. Experimental Use

4.1 Method

The subjects were sixteen students in special classroom at junior high school in Hiroshima. They have already finished learning the arithmetic word problems. They were divided into three groups. First, nine subjects has our targeted reading disability (targeted subjects). Second, six subjects doesn't have reading disability (non-targeted subjects). Third, one subject has massive reading disability. All subjects are mild or medium intellectual disability. Intellectual disability is known as general learning disability and mental retardation but it is defined by an IQ score under 70. Because third group subject cannot read a word, the teacher announce for her a given sentence cards, assignment and feedback on MONSAKUN Touch. In this experimental use, we were examined these assumption: (a) If the subjects can read the simple quantity sentence, they can exercise by the problem-posing as sentence integration, (b) MONSAKUN Touch is useful for teacher to realize the lesson by problem-posing.

This experimental use has been performed during five lessons (forty-five minutes per one lesson). (Step.1) The subjects work on a pre-problem-posing by using MONSAKUN Touch in one lesson. In this exercise, teacher didn't support subjects for posing problem. (Step.2) Lectures of arithmetic word problem by using MONSAKUN Touch are performed in three lessons. First lesson is composed of teacher's lecture about triplet structure and exercising by MONSAKUN Touch (level one) with teacher's support. Other lessons are only exercising by MONSAKUN Touch with teacher's support. In this time, the teacher uses a monitoring system for observing the learners learning data. Second lesson deals with level two and three. Third lesson deals with level four and five. If subject finish to exercise the targeted level, they are repeat to exercise the targeted level and previous level. (Step.3) Post-problem-posing by using MONSAKUN Touch is performed in one lesson. The teachers answered a questionnaire and an interview after all lessons finished.

4.2 Results

4.2.1 Analysis of Log Data in Pre and Post Problem-posing

Average number of posed problem per minutes is 3.1 problems in all subjects. Average number of posed problem by targeted subjects is 3.96 problems. In regular classroom at elementary school, students posed 2.8 problems per minutes. Thus, the subjects in special classroom are posed problem same as the subjects in regular class by MONSAKUN Touch.

Next, we categorized this analysis based on kind of posed problem and given calculation. In the log data of level two and three at non-targeted subjects, there was only a significant difference in the error of triplet structure between pre- and post-problem-posing (Paired t-test, p=.03), and effect size is

large ($|d|$=1.72). Next, the analysis of log data of targeted subjects is described. In the analysis of level one, there was a significant difference in the error of triplet structure between pre- and post-problem-posing (Paired t-test, p=.04), and effect size is large ($|d|$=1.7). Also, there was a significant difference in the error of quantity and object between pre- and post-problem-posing (Paired t-test, p=.02), and effect size is large ($|d|$=1.5). In the analysis of level two and three, there was a significant difference in the error of triplet structure between pre- and post-problem-posing (Paired t-test, p=.002), and effect size is large ($|d|$=2.3). There was no significant difference in each error of level four and five between pre-problem-posing and post-problem posing because the assignments of level four and five are very difficult for a learner in regular class. The details of log data are omitted because of page limits.

In addition to these results, one subject with massive reading disability has caused the one error of triplet structure in post-problem-posing exercise, first. However, she didn't cause the error of triplet structure from twice to fourteen times diagnosis. This result suggested that the problem-posing as sentence integration is effective method for massive reading disability student.

Table 2 shows the number of subjects who finished each level. From the results of Table 2, all subjects learned the method of posing problem because their reached levels are improved. From mentioned above, we demonstrate the assumption (a). However, they couldn't improve their ability of problem-posing in level four and five. For improving these results, we need to sophisticate the level of assignment more gradually.

Table 2: Number of Subjects who finished Each Level.

		Lv.1	Lv.2	Lv.3	Lv.4	Lv.5
Non-targeted Subjects (N=5)	Pre-problem-posing	5	5	5	1	0
	Post-problem-posing	5	5	5	2	1
Targeted Subjects (N=7)	Pre-problem-posing	7	4	4	0	0
	Post-problem-posing	7	7	7	2	2

4.2.2 Analysis of Questionnaire and Interview

The result of questionnaire for teacher is shown in Table 3. From the question (1), they find it is very hard for them to teach problem-posing without MONSAKUN Touch in special classroom. They also said that teachers need to have enough experience in order to teach problem-posing. One teacher answered neutral because she has never taught problem-posing. These teachers consider that MONSAKUN Touch is useful software to teach the arithmetic word problem in special classroom but a learner with reading disability can read and understand the simple sentence. Therefore, three teachers answered question (2) "neutral" but they would like to use MONSAKUN Touch continually.

In the results of interview, these teachers suspected that subjects are able to pose problem by using MONSAKUN Touch but most subjects have difficulty in exercising by problem-posing and they cannot concentrate on a problem-posing for a long time. These teachers also suspected that some subjects can learn the arithmetic word problem by using MONSAKUN Touch before experimental use but many subjects cannot learn because of their disability. However, all subjects concentrated on a

Table 3: Result of Questionnaire for Teacher (N=4).

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
(1) Is it easy to teach problem-posing without MONSAKUN Touch?	0	0	1	0	3
(2) Is it effective to use problem-posing as sentence integration for reading disability leaner?	0	0	3	0	1
(3) Is it easy for you to use MONSAKUN Touch in your class?	1	2	1	0	0
(4) Would you like to use MONSAKUN Touch in your class continually?	3	1	0	0	0

problem-posing during lesson and the number of error was decreased. Besides, most subjects answered that the problem-posing as sentence integration is difficult exercise but they enjoy learning by problem-posing and want to learn again. These results are better than the results that the teachers suspected. These results also demonstrate the assumption (b).

5. Conclusions

We designed and developed the learning environment for problem-posing as sentence integration. On this learning environment, learners pose the arithmetic word problem as selecting and arranging given simple sentence cards. In usual problem-posing, learners need to write an arithmetic word problem with some sentences. So, learners with reading disability cannot exercise problem-posing because they feel difficulty in writing sentence and reading long sentence. However, we assumed that these learners exercise the problem-posing by using our learning environment if they can read the simple sentence. Through the experimental use of the system, it was confirmed that the learners could pose the problem. Moreover, the teachers accepted that our learning environment is effective for targeted learner. It is believed that the leaner with reading disability who can read the simple sentence could learn by problem-posing for our learning environment.

As our future works, we have to sophisticate the level of assignment and analyze the results of this experimental use in more detail. Furthermore, we are going to perform the experimental use continually for confirming the effect of our learning environment.

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