Learning by Problem-Posing with Online Connected Media Tablets

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Abstract. We have developed an interactive environment for learning by posing arithmetic word problems that can be solved by either an addition or subtraction. Through experimental use of the environment on desktop computers, we have confirmed that problem posing with the environment is useful for arithmetic learning. In this paper, as the next step, we implemented the environment on media tablets connected by wireless LAN. Because of this implementation, we have realized development of environment for using usual classroom, visualization of the student's learning performance and suggestion of teaching a method of problem posing. Through this practice, we have confirmed that the first grade students were able to pose problems in the environment, and the teaching and learning by using environment were accepted by the teacher and students as the effective teaching.

Keywords: Problem-posing, Sentence-integration, Media tablet, Interactive learning environment, Online.

1 Introduction

In this paper, learning by problem-posing with online connected media tablets is described. It is pointed out by several researchers that learning by problem-posing is effective activity for promoting to master the use of solution method [1-3]. Targeting arithmetic word problems that can be solved by either an addition or subtraction, we have continuously investigated computer-based learning environment with agent-assessment problem-posing [4]. Currently, we have been developing a type of problem posing environment "MONSAKUN" where problems are posed as sentence integration. MONSAKUN has been practically used in an elementary school [5, 6]. In these previous researches, MONSAKUN was used by students who have already learned the targeted problems. Therefore, problem-posing was an advanced practice for the students and the purpose of the learning with the environment was sophistication of their ability. In contrast, the subjects of this practice were the first grade

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students who just have finished learning arithmetic word problems that can be solved by one operation addition or subtraction in their class before this practical use. Therefore, a teaching for problem posing and its practice have been needed for the practical use. So, we have to include the learning by using MONSAKUN to the usual class. For this purpose, we required to dedicate three problems as follow: (1) To be used MONSAKUN in the usual classroom, (2) Visualization of the student's learning performance on MONSAKUN, (3) Teaching the method of problem posing for exercising MONSAKUN. In order to solve these problems, we have developed "MONSAKUN Touch" composed of media tablets connected through wireless LAN. In this paper, MONSAKUN touch and its visualization system for monitoring learner's problem posing behaviors are described. Practical use of MONSAKUN Touch is also reported.

2 Problem Posing as Sentence Integration and Its Task Model

In MONSAKUN, the learner poses the problem by selecting three cards to given sentence cards and arranging them in proper order. Proper cards consist of two type card that is expressed by existence and relation. And, one sentence card consists of object, value, and event. Fig. 1 shows the example of problem posing as sentence integration. The learner given sentence cards from S-1 to S5. In this case, by using the Sentence-1, Sentence-5 and Sentence-3 in this order, the learner can pose the problem that can be solved by "8-5". We call this calculation as calculation operation structure. Then, if the calculation is expressed along the cover story of the problem, the calculation is expressed by "5+?=8". We call this calculation as story operation structure. In addition, this problem is expressed by a cover story that called as "combine". Cover story is generally classified "combine", "compare", "increase" and "decrease"[7]. The task of problem posing is set these expression structure and cover story.

The task model of problem posing is shown Fig. 2 [8]. When learner poses the problem, he/she has to decide the calculation operation structure that is addition or subtraction. The calculation operation structure are translated some story operation structure. Learner also decides this structure. Story operation structure has the corresponded cover story. When learner decided these structures, learner decides a sentence cards. Then, learner has to consider the correspondence of object, value and events, and order of each sentence cards for each cover story. This task called as "deciding problem sentence". Actually, in MONSAKUN, the task model that the leaner has to consider is restricting by task of problem posing and given sentence cards. Until now, we have explained the task model of problem posing top-down. However, learner also can consider and pose the problem on the basis of the task model of problem posing bottom up. Therefore, this task model doesn't represent the process of problem posing, but the restriction for posing problem is contained. A level of the task of problem posing in MONSAKUN based on this task model.

In the case of problem posing that can be solved by one operation addition or subtraction, if an operation of calculation operation structure is same as an operation of story operation structure, such a problem called "forward-thinking problem". On the

contrary, an operation of calculation operation structure is different from an operation of story operation structure, such a problem called “reverse-thinking problem”. Because the cover story doesn’t accord with the calculation like “combine” and subtraction, reverse-thinking problem is more difficult than forward-thinking problem. That is, the learner is more required to comprehend the relations between two structures.

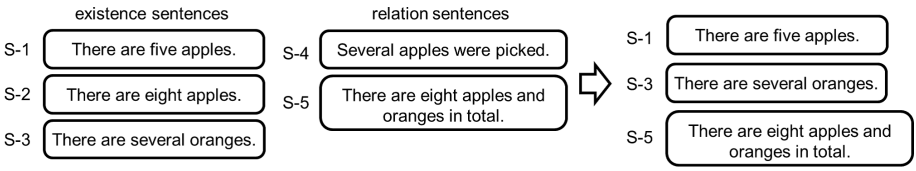

Fig. 1. Example of problem-posing as sentence integration

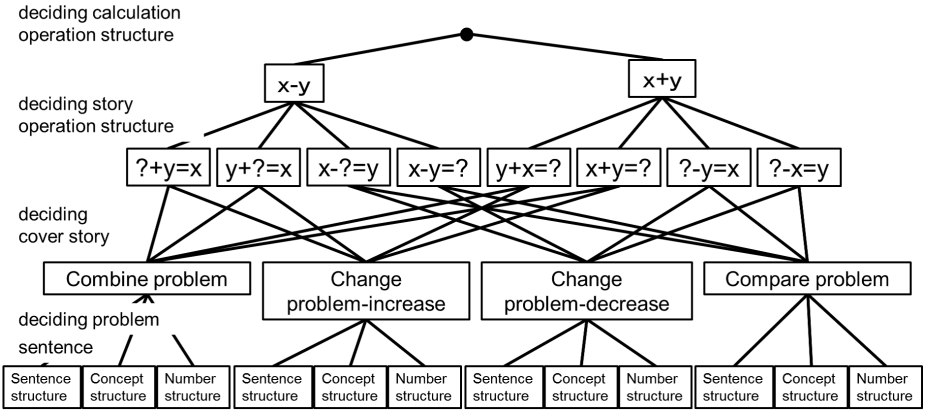

Fig. 2. Task model of problem-posing as sentence integration

3 MONSAKUN Touch and Visualization System

3.1 Framework of Learning Environment

The system architecture is shown in Fig. 3. The students pose problem by using MONSAKUN Touch, then, MONSAKUN Touch send their learning data to server via wireless LAN. After that, the teacher can examine the student's learning data with the visualization system. In this practical use, because there is no significant intelligence infrastructure in usual classroom, we use the laptop as sever. MONSAKUN Touch is developed in Android, visualization system is in PHP, and RDBMS is MySQL. By using this environment, the teacher was able to teach arithmetic word problem by problem-posing in a usual classroom. And, the teacher is able to lecture to his/her stalemate, and consist of next class on the basis of these learning data.

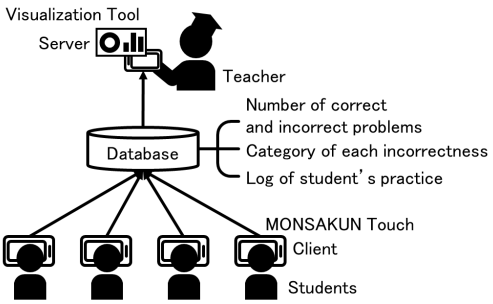

Fig. 3. Framework of learning environment

3.2 MONSAKUN Touch

In this section, we explain about MONSAKUN Touch that can be used in usual classroom. Until previous research, MONSAKUN could be used only in a computer room because previous version of MONSAKUN was implemented on the desktop PC platform. Therefore, we have implemented MONSAKUN on media tablet platform so that

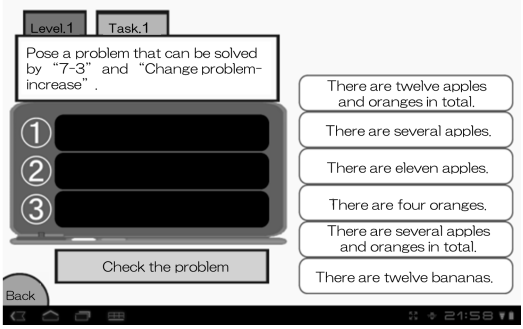

Fig. 4. Interface of MONSAKUN Touch

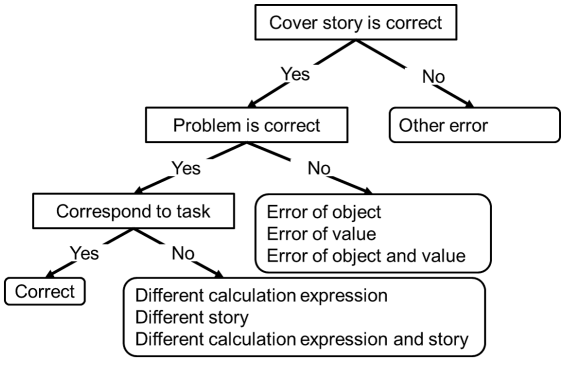

Fig. 5. Processing for diagnosing the posed problem

the teacher was able to use it in usual classroom. This version called as "MONSAKUN Touch". Fig. 4 show interface of MONSAKUN Touch. The left side is problem composition area. On the top of this area, a calculation expression and story is given as problem posing task. Several sentence cards are presented on the right side. The learner poses the problem by moving a simple sentence card with a finger and putting a card into blank on left side. Then, the learner can tap a diagnosis button under the problem composition area. At the same time, the system diagnoses the posed problem based on the flow of Fig. 5, and shows the results of the diagnosis and message to help the learner's problem-posing on another window. The messages composed of two kinds of indications, one is indication of correct or incorrect of the posed problem and the other is indication of wrong points shown in Fig. 5. These errors are also used by visualization system for categorizing student's error.

The flow of exercise of MONSAKUN Touch is, first, the learner login by selecting his/her student number. Second, He/she selects a level from lv.1 to lv.6. Then, he/she also sets ON/OFF of feedback, and moves a specific task. If the learner poses all problems in selected level, this level is end.

3.3 Visualization System

We have also developed a visualization system that is shows a student's learning data to a teacher with graph. As well, the learning data consists of the number of correct and incorrect posed problems, the category of incorrectness, and the log of student's practice. When the teacher input ID and password, he/she can browse the main interface shown in Fig. 6. The main interface shows a number of problems that was posed by the students, the correct one and incorrect one in left side. In right side, this interface shows the rate of incorrectness category with doughnut chart. Also, the visualization system has two interfaces. One is the error check interface that shows the students' error on MONSAKUN Touch. This interface is shown in Fig. 7. The other is the progress check interface that shows the progress of students' problem posing exercise on MONSAKUN Touch. This interface is shown in Fig. 8. The teacher can switch over these interfaces with clicking on a link in the upper part of interface.

First, we describe the error check interface in Fig.7. In this interface, the teacher can browse the student's error on MONSAKUN Touch every level on list. This list shows the kind of problem posing task and the number of student's total errors in each level. When the teacher select one level from the list, the interface show the amount of each error with bar graph in left side and the rate of incorrect category with doughnut graph in right side. Then, the teacher can browse the same data about each task on the selected level by clicking "Check the error of each task" at the bottom. The problem posing task, correct cards and dummy cards are also shown in case of visualized task. Second, we describe the progress check interface. The teacher can browse the number of student who learns each level on MONSAKUN Touch with list like the error check interface. When the teacher select one level from list, the interface show the name of students who learn selected level. Then, the teacher can browse the same data about each task of the selected level by clicking "Check the progress of each task" at the bottom. These data are gathering and visualizing in real time. For this, because the teacher can confirm the student's learning data immediately, he/she can

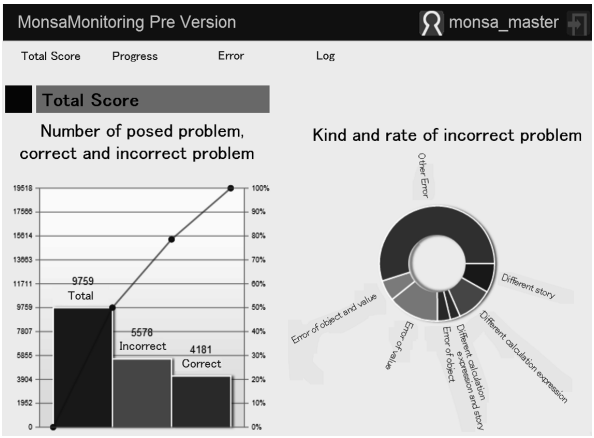

Fig. 6. Main interface of visualization system

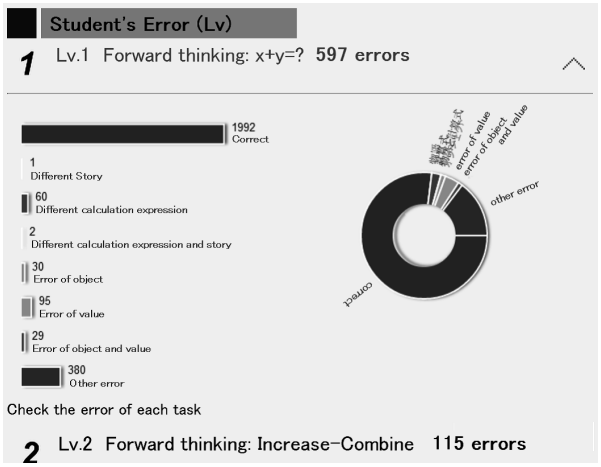

Fig. 7. Interface for confirming incorrectness in each category

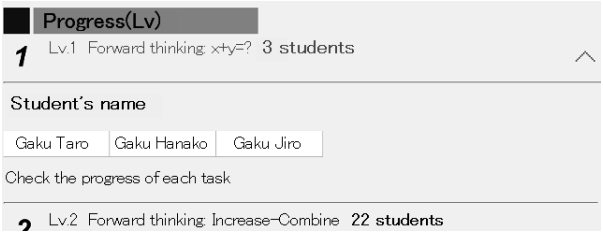

Fig. 8. Interface for confirming progress

adjust their contents and progress of teaching in real time. And the recorded data can be used for consisting next class. As other function, each student's log of problem posing in MONSAKUN Touch is shown.

4 Practical Use of MONSAKUN Touch and Teaching Method

4.1 Procedure of Practical Use

The subjects are 40 students in the first grade of an elementary school attached to Hiroshima University (but one student absent from all classes). The subjects have just learned the arithmetic word problem that can be solved by one operation of either addition or subtraction. The scene of using MONSAKUN Touch is shown in Fig. 9. This practice used nine lesson times (45 minutes per lesson, 3 weeks, 9 days). The students took a questionnaire after the period. One lesson consists of teacher's teaching (30min) and exercise of MONSAKUN Touch (10min), but each time changes depending on the progress of the lesson. Problem-posing exercises on MONSAKUN Touch and teaching by the teacher were divided into 6 levels.

Contents of each level are shown in Table 1. These contents of each level were classified by three scales that are the kind of problem, the calculation of problem posing task, the kind of cover story. These contents of each level were decided by the consultation of the teacher and us on the basis of the task model. In the exercise of MONSAKUN Touch, if the subjects finished problem posing at all tasks, they repeat same level. If the students finished all task of level 5, the teacher allowed students to learn level 6. Three teaching assistants have supported setting of the wireless LAN and operation of the MONSAKUN Touch, but they didn't support learning contents.

Fig. 9. Scene of using MONSAKUN Touch

Table 1. Levels of MONSAKUN Touch

Lv	Thinking	Operation	Cover story
1	Forward thinking	Story	Combine Increase Decrease Compare
2	Forward thinking	Story	Increase-Combine
3	Reverse thinking	Story	Combine Increase Decrease Compare
4	Reverse thinking	Story	Increase-Combine
5	Reverse thinking	Calculation	Combine Increase Decrease Compare
6	Random	Random	Random

4.2 Teaching Method of Problem Posing by Teacher

We designed a teaching method of problem posing based on the task model that requiring the exercise by using MONSAKUN Touch. Class of problem posing by using

MONSAKUN Touch consists of (1) Teaching the method of problem on the basis of the task model, and (2) Exercise by using MONSAKUN Touch. In (1), first, the teacher attaches a task of problem posing and some sentence cards on a blackboard. The task of problem posing consists of calculation and cover story. The sentence cards consist of correct cards and dummy cards. Second, the teacher let the students think about a necessary card and an unnecessary card for posing correct problem. Then, the teacher teach the students a constitution of the sentence cards in the given cover story, a correspondence of the object between the sentence card, a combination of value and an order of sentence cards. The preparing dummy cards are available for posing problem if the students don't pay attention to these restrictions. However, as necessary, the teacher explain the situation that dummy cards available. In class, the students learn the problem structure by exercising MONSAKUN Touch after (1). In this research, first, the students use MONSAKUN as introduction of new task of problem posing. Second, the teacher teaches the students about the method of problem posing. Finally, the students use MONSAKUN as confirmation of teaching. This class has been performed belong each level in Table 1.

4.3 Analysis of Log Data

The average number of the posed problems and the rate of correct problems in the learning by problem posing on MONSAKUN Touch are shown in Fig. 10. The time of each practice on MONSAKUN Touch is different because of adjustment of lessons. It is said that the number of posed problem in each practice with MONSAKUN Touch is more than without MONSAKUN Touch. Also, the teacher said that the students posed problem seriously and the suggested class appropriate for him to perform during the nine lessons. Therefore, we believed that learning by problem posing on suggested class was carried out sufficiently. In the class of level 5 (7th lesson), the number of posed problem is high (13.5 per 3 minutes), but the rate of correct problems is extremely low (9%). This indicates that the students posed problem by trial and error for the difficulty of reverse-thinking problem. Because the teacher gives importance to voluntary awareness of students, this tendency continued during this class. After that, in the second class in level 5 (8th lesson), the teacher taught the students that the calculation operation is different from story operation in reverse-thinking problem. This is one of the important features in the reverse-thinking problem. Therefore, the rate of correct problems improves a little in this class. In addition to this improvement, 22 students advanced to level 6 in 9th lesson. It is important that the students can be aware of "the calculation operation is different from story operation in reverse-thinking problem" because it was difficult to let them be aware it by the problem solving practice. This awareness is scaffolding for learning at second grade and above. The problem posing task in level 6 is set random and practice time varies every students. Therefore, Fig. 10 and the following results are analyzed without the level 6.

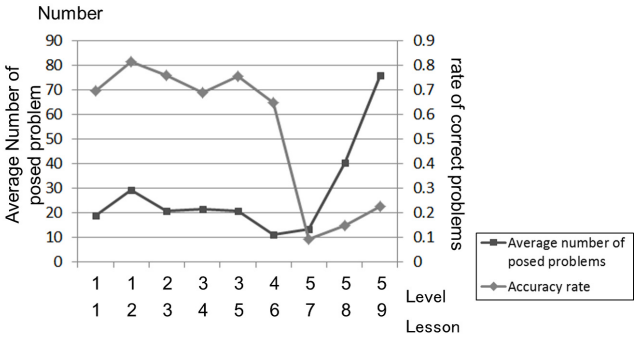

Fig. 10. Result of log (N=36)

4.4 Questionnaire and Students Remark

The results of the questionnaire are shown in Table 2. Almost students agreed with problem-posing exercise by using MONSAKUN and effective to learn. But, we supposed, because of level 5, many students answered the problem-posing is difficult. The teacher agreed that it is easy to teach problem-posing using a media tablet in the usual classroom, and he said that he want to use the MONSAKUN in his class continually. But, he suggested that it is necessary to improve the sentence of feedback and to expand the kinds of feedback. In this practical use, the teacher confirms the utility of visualization system, and he said that this system was effective to adjust the class but its interface and visualized data have still to be improved. Also, he described questionnaire that "it is easy to discuss the problem structure by using the problem posing as sentence integration", "it is important to teach problem posing in usual classroom for using MONSAKUN Touch". These result suggested that the teacher and students agreed that the class of problem-posing exercise by using MONSAKUN Touch. But it is indicated that feedback of MONSAKUN Touch and interface of visualization system needs some improvement.

Table 2. Result of questionnaires (N=38)

Number	Asking	Strongly Agree	Agree	Disagree	Strongly Disagree
(1)	Do you enjoy posing problems in arithmetic?	35	3	0	0
(2)	Are arithmetic word problems easy to pose?	8	7	19	4
(3)	Do you think that posing problems is a good learning method of the arithmetic?	36	2	0	0
(4)	Do you think that posing problems made it easier to solve problems?	20	17	1	0
(5)	Do you think that it easy to use MONSAKUN Touch?	37	1	0	0
(6)	Are feedbacks easy to understand?	20	15	2	1
(7)	Would you like to attend arithmetic classes where problem posing is used?	36	2	0	0

5 Concluding Remarks

In this paper, we have described the practical use of the learning environment for problem posing with online connected media tablets. For using the interactive environment in the general classroom, we have been required to realize: (1) To be use MONSAKUN in the usual classroom (realized system called MONSAKUN Touch implemented media tablets), (2) Visualization system of the student's learning performance, (3) Teaching the method of problem posing. Then, in this class, the teacher taught the method of problem posing on MONSAKUN Touch on the basis of the task model of problem posing that were implemented MONSAKUN Touch. Before and after this teaching, the teacher was able to monitor the student's learning data on MONSAKUN Touch with visualization system. Through this practice, we have confirmed that the first grade students were able to pose problems in the environment, and the teaching and learning by using environment were accepted by the teacher and students as the effective teaching.

In our future works, improvement of visualization system and constitution of class by using visualization system is very important. Sophistication of the task model of problem-posing and evaluation of learning effect of the teaching method with MONSAKUN is also an important future work.

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