Development and a Practical Use of Monitoring Tool of Understanding of Learners in Class Exercise

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Abstract. In mass teaching, the learning goal is often set focused on the average students. The advantage of this is that learning outcome can become homogenized and be reached a certain level. On the other hand, students above or below the level cannot get enough support. Information communication technology enable teachers look over the progress of learners. Learning management systems and classroom management systems collect learners' answers to exercises, learners' behavior on the systems and so on. These data are expected to lead information that teachers keep track of progress of learners and identify which learner need support. In addition to this, this study aims at develop a monitoring tool of understanding of learners in class exercise. The result of practical use of this shows teachers accept this tool and actually they have given individual guidance not depending on their usual understanding of students.

Keywords: Learning by problem-posing · Monitoring tool · Teacher support

1 Introduction

Teachers diagnose the learners' cognitive and affective state from students' facial expressions, attitude, responses to teacher's questions and so on. Especially, they focus on the students who have low academic abilities or are not-good attitude and manage classes. In this study, understanding of learners refer to that teachers diagnose learners' cognitive and affective states. A popular way for teachers to understand learners is to walk around the class and check how students are doing while the class exercise. It is called "Kikan-shido", another name of it is "between desk instruction", that is a method of monitoring and guiding student activity in class [1, 2, 7]. This study aims at developing a system help teachers to find students need instruction based on their understanding free from teachers' preconception.

This study developed a system to support teachers' understanding of leaners in the class exercise with Monsakun that is an environment of learning by problem-posing as sentence integration [4, 5]. This system provides teachers not only learners' answer and summary of correctness but also types of mistakes happened in their exercise. This system has been practically used for 64 h by five teachers in three elemental schools.

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2 Teachers' Activity in Class Exercise

2.1 Individual Guidance in Class Exercise

Instruction in class has two types: mass instruction and individual instruction. In classroom, teachers can conduct individual instruction in class exercise by walk around the class and check how students are doing. Mass instruction usually focus on students have middle academic abilities. Such instruction make students have high academic abilities bored and make students have low academic abilities feel too much difficulty. Especially, individual instruction in class exercise gives teachers chance to understand students more and to compensate for lost learning of low ability students in mass instruction. However, it is difficult for teachers to find students need instruction while walking around the class. What teachers can usually do is to estimate their understanding from students' facial expressions, attitude and description on notebook or worksheet. It is difficult for teachers to check all the students and instruction might be biased. In addition to that, teachers' estimation not always same as students' understanding.

2.2 Teacher Support for Learner Understanding

There are many systems supporting teachers' learner understanding: audience response system (clicker), learning management system (LMS), display sharing. These systems make teachers possible to total and look over learners' answer as well as to provide feedback to learners immediately [3, 6]. This increases the interactivity between teachers and learners in classroom, however, this is just overview of learners and it is difficult for teachers to check learners individually or point by point. This enable teachers to understand students without walking around. How to deal with this information is lay in the hands of teachers and it depends on the teachers' ability. It is very difficult for teachers to gather information of students within a class period in conventional classroom because it takes much time and energy. These systems make it convenient for them to do so as much as possible within a class period. On the other hand, the information provided these systems is a kind of raw data that teachers need to process for understanding learners.

This study aims at providing teachers with information about learners' thought in addition to concrete answers in an exercise. This means that the system tells teachers not only concrete learners' answer and the correctness but also the cause of error and the history. These information helps teachers to understand learners more deeply and more quickly within a class period. This is expected to facilitate teachers to find students that teachers would guide and to be helpful for good guidance to the students.

3 Support of Learner Understanding for Individual Guidance in a Class

3.1 Necessary Information for Individual Guidance in a Class Exercise

What teachers do in the class exercise are to find the impasse in students by the observation of them, to guide students individually, and to understand students in the class as the whole and make a future plan. This study lists necessary information for individual guidance in a class as the following information about (1) learning progress to find the impasse in students, (2) learners' thinking for adaptive feedback, (3) the state of class as the accumulation of each student's state. While the first one is available in the conventional systems, the second on is the characteristic of this study. The second one also contribute to differentiate the proposed system from the conventional ones in the third point.

3.2 Requirements of Monitoring Tools for Individual Guidance in a Class Exercise

This study develops a monitoring tool of learning state of learners in a class exercise that also provides the information about learners thinking. The purpose of the tool is the facilitation of teachers to understand students within a class exercise and to find students that teachers would guide in the exercise. Concretely speaking, the following three functions are the requirement of the monitoring tool for individual guidance in a class exercise:

1. to provide each student's progress on the seat configuration for finding students need guidance,
2. to provide the trends of errors in addition to the numbers of trial and correct answer for facilitating teachers' adaptive guidance, and
3. to provide the summary of state of students as the whole class for future planning.

4 Development of a Monitoring Tool for Individual Guidance in a Class Exercise

This study develops a monitoring tool for individual guidance in a class exercise with the learning environment of arithmetic word problems for elementary school students by problem-posing as sentence-integration, called Monsakun Touch. In conventional class exercise, teachers estimate learners' understanding from students' facial expressions, attitude and description on notebook or worksheet. However, through the practical use of Monsakun, it is difficult for teachers to estimate learners' understanding in class exercise with tablet computers because teachers are not familiar with the such situation and difficult to put their experience. Through the interviews with teachers have used Monsakun in their class, they feel difficulty in guiding students in the class exercises with it. In Monsakun Touch, students pose problems by piece together sentences provided by the system as stated below. In this exercise learners continue to pose

problems until they can pose a problem meet the requirement. This style of exercise can record all the learners' answers and enable to analyze the trend of errors and estimate students' understanding as the cause of errors. The monitoring tool provides the information about learning progress and the analysis of it for the better guidance of teachers to students within class exercises.

4.1 Monsakun Touch

Monsakun Touch is a learning environment of arithmetic word problem for elementary school students by problem-posing. This is based on Triplet structure model [5] that defines problem posing of arithmetic word problem with only one arithmetic operation as a structure of three sentences composed of objects, numerical quantities and a predicate. With this definition Monsakun can diagnose posed problems automatically and give feedback about the correctness to the learners. This resolve the bottleneck of learning by problem-posing in which teachers have difficulty in diagnosis of posed problems by learners because learners pose a wide variety of problems in free problem-posing. This also provides learners with many more opportunities for conducting learning by problem posing. Figure 1 shows the screenshot of Monsakun.

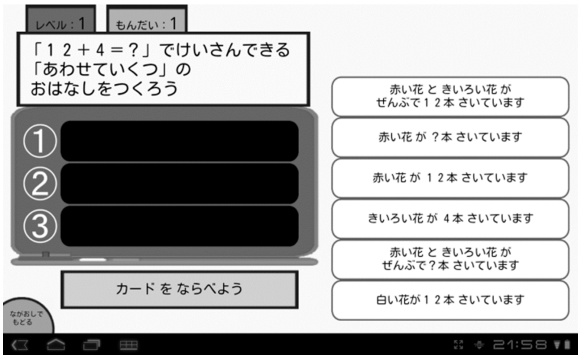

Fig. 1. Monsakun touch

In Monsakun, learners pose problems meet the requirement on the left top with three sentences from six sentences on the right. For example, in this exercise, the required problem is the combination of "There are 12 red flowers", "There are 4 yellow flowers" and "There are ? red and yellow flowers altogether". If learners can pose a problem with "There are 12 white flowers" instead of "There are 12 red flowers", it does not consist with "There are ? red and yellow flowers altogether" about the objects. Triplet-structure model defines the requisite conditions of an arithmetic word problem with only one arithmetic operation as calculation structure, story structure, object structure, numerical quantities relation and sentence structure and problem posing is defined the task to compose sentences meet all the conditions [7, 9]. Based on the definitions of arithmetic word problems and problem-posing task, Monsakun can diagnose the correctness of posed problems by learners and identify the reason of errors in posed problems.

4.2 Development of Monsakun Analyzer for Teachers

One form of practical use of Monsakun in class is individual use of it as class exercise. The role of teacher in this use is to find learners who need help and provide adaptive guidance fit to the students' impasse. Monsaku Analyzer is the tool to support teachers in such situation. This overlays an overview of learners' state on the seat configuration of students. Students are distinguished with colors by the correct rate with a threshold set by teachers. The screenshot of this is shown in Fig. 2.

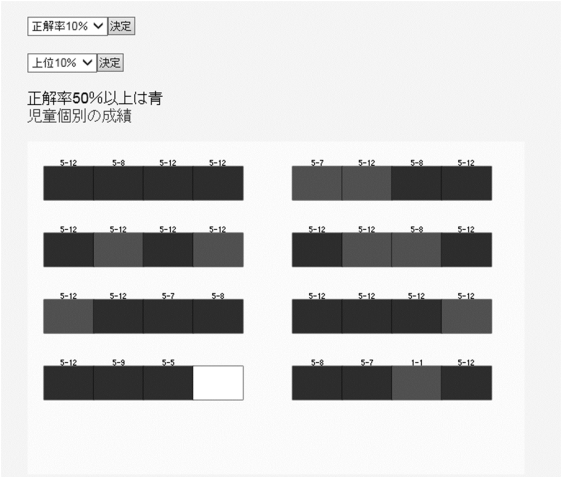

Fig. 2. Display of associate the correct rate and the seat of the student

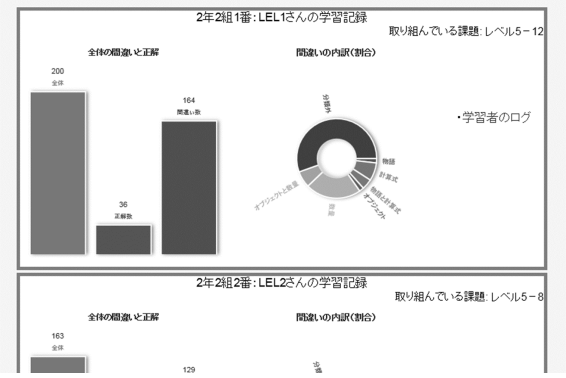

Fig. 3. Displays of the data about the learning processof each learner

From here teacher also check the state of each student. Figure 3 shows the screenshot of the summary of a learner's state including the number of assignments the learner has tackled, the numbers of correct and incorrect answers, and the trend of errors. Figure 4 shows the screenshot of the history of answers with the diagnosis of each error. In

addition to the individual student data, this also shows the data of whole class for the help of teacher's future planning of classes. Figure 5 shows the screenshot of the summary of whole class.

Fig. 4. Displays of the learning log data of each learner

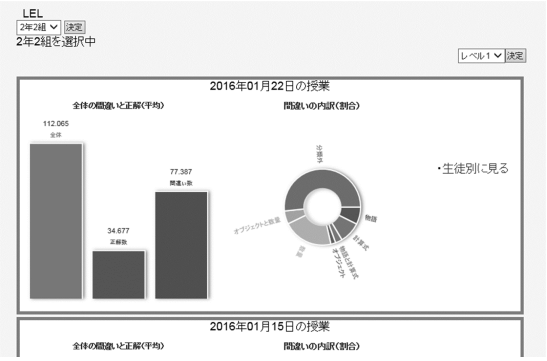

Fig. 5. Displays of the data about the learning process of each class

5 Practical Use of the Monitoring Tool

5.1 An Overview of the Practical Use

The monitoring tool is practically use in two elementary schools. In an elementary school (school A) the tool was used for 11 class periods in third grade class with 39 students. We interviewed the teacher about the usability of it after the classes. In the other school (school B) the tool was used for 2 class periods in each of second and third grade class with 31 and 26 students respectively. We also interviewed the teachers and analyzed the relationship between individual guidance and the learners' performance in school B.

5.2 The Result of Interviews

In the interview with the teacher in school A, he said the monitoring tool was useful in class exercise. He actually used the tool check each learner's progress and gave guidance to students made many mistakes. He said class exercise with monitoring tool makes him easier to find students need guidance and to make future plan based on the state of whole class. In the interview with the teacher in school B, teachers said the information from the monitoring tool is useful so that teachers can find the unexpected impasse of learners that they have considered high ability students as well as learning state of each and whole of students. They also said that it is also useful to analyze the exercise after class. From these results, the subjective impression of teachers on the monitoring tool is positive.

5.3 Analysis of Teachers' S Activity

From a subjective inquiry with the interviews to teachers, it is found that they have given individual guidance to students based on the information from the monitoring tool. To confirm the effectiveness of the monitoring tool, we investigate the relation among the teachers' guidance, their usual understanding of students and the performance in Monsakun at the data of school B. The teachers' guidance is counted with the video-recording of the classes. Teachers' usual understanding of students is checked by the score of a test about the problem-solving in arithmetic word problems done before the use of Monsakun. The performance in Monsakun is measured by the percentage of correct answers. The assumption in this study is that teachers choose students to give guidance depending on the performance on Monsakun if they use the monitoring tool. If teachers gave guidance depending on their usual understanding of student, for example, the past achievement, attitudes and behavior of students in everyday school life and so on, they give guidance to students scored low in pre-test more than one scored high.

Firstly, we investigate the relation between the teachers' guidance and the result of pre-test. Especially, we check whether the guidance depends on the pre-test. That is, we test the following two assumptions:

- The Lower group of students in pre-test got individual guidance at the same rate of higher group students in the pre-test.
- Lower group of students in Monsakun got individual guidance more than higher group students in Monsakun.

In the analysis between the pre-test and the individual guidance, students are distinguished into higher and lower students by the average od the score of the pre-test.

Table 1 shows the average and the standard deviation of pre-test in second grade students in school B. Table 2 shows the presence or absence of individual guidance distinguished by the result of pre-test. With two-sided Fisher's exact test using a level of significance of 0.05, there is no significant difference between the higher and lower group in the pre-test.

Table 1. Average and standard deviation about the second grade

Average in the pretest	Standard deviation in the pretest
6.87	2.012328

Table 2. A result of teaching about the second grade (based on pretest)

	w/teaching	w/o teaching	Total	
Higher group in the pretest	9 (42.9%)	12 (57.1%)	21	p = 1.0000
Lower group in the pretest	4 (40.0%)	6 (60.0%)	10	
Total	13 (41.9%)	18 (58.1%)	31	

Table 3 shows the average and the standard deviation of pre-test in second grade students in school B. Table 4 shows the presence or absence of individual guidance distinguished by the result of pre-test. With two-sided Fisher's exact test using a level of significance of 0.05, there is no significant difference between the higher and lower group in the pre-test.

Table 3. Average and standard deviation about the third grade

Averagein the pretest	Standard deviation in the pretest
8.61	1.856382

Table 4. A result of teaching about the third grade (based on pretest)

	w/teaching	w/o teaching	Total	
Higher group in the pretest	11 (64.7%)	6 (35.3%)	17	p = 0.4185
Lower group in the pretest	4 (44.4%)	5 (55.6%)	19	
Total	15 (57.7%)	11 (42.3%)	26	

There are no significant differences in both case. This shows teachers gave individual guidance to students not depending on teachers usual understanding of students in both case.

In the analysis between the individual guidance and the percentage of correct answers in Monsakun, we use the decision tree analysis with CART (Classification and Regression Trees) algorithm to decide the threshold to distinguish the higher and lower students in the percentage of correct answers. The target variable is the presence or absence of individual guidance and the categorical variables are the result of pre-test and the percentage of correct answers in Monsakun. Figures 6 and 7 show the results of decision tree analysis of second and third grade students, respectively. In the nodes, "yes" and "no" show the presence and absence of individual guidance and the left numbers are the number of students not given guidance and the right numbers are the number of ones

given. “rate” refer to the percentage of correct answers in Monsakun and “pre1” refer to the result of pre-test.

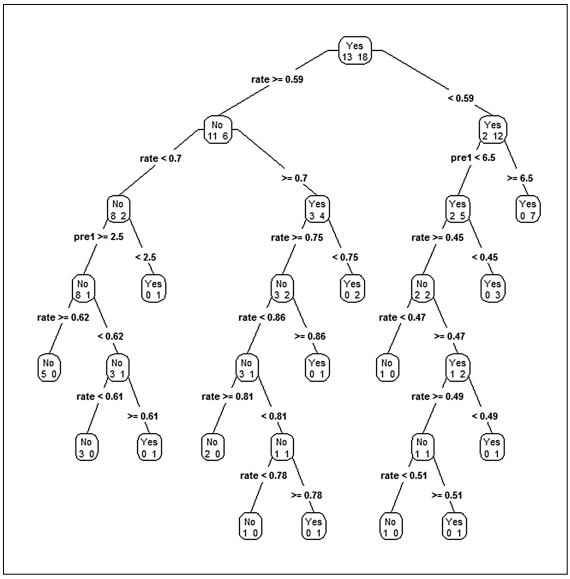

Fig. 6. A result of the decision tree analysis in the second grade

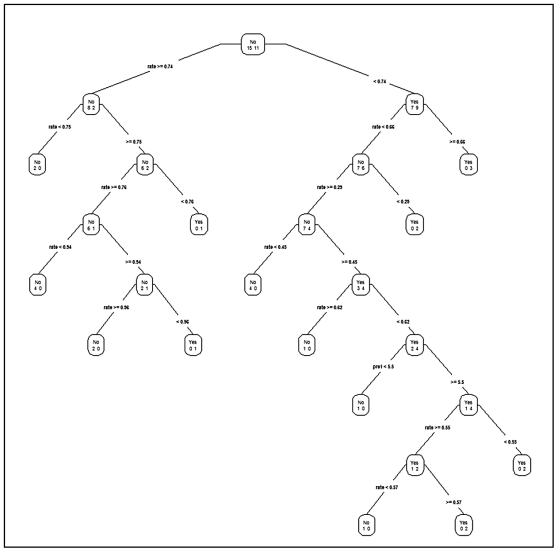

Fig. 7. A result of the decision tree analysis in the third grade

Bothe decision tree of second grade students primary categorizes students by the percentage of correct answers in Monsakun. The percentage is 59% in the second grade and 74% in the third grade.

The relation between the performance in Monsakun and the individual guidance. Table 5 shows the presence or absence of individual guidance distinguished by the performance in Monsakun. With two-sided Fisher's exact test using a level of significance of 0.05, there is significant difference between the higher and lower group on the performance.

Table 5. A result of teaching about the second grade (based on performance of Monsakun)

	w/teaching	w/o teaching	Total	
Higher group	6 (35.3%)	11 (64.7%)	17	$p = 0.0094$
Lower group	12 (85.7%)	2 (14.3%)	14	
Total	18 (58.1%)	13 (41.9%)	31	

Table 6 shows the presence or absence of individual guidance distinguished by the performance in Monsakun. With two-sided Fisher's exact test using a level of significance of 0.05, there is significant difference between the higher and lower group on the performance.

Table 6. A result of teaching about the third grade (based on performance of Monsakun)

	w/teaching	w/o teaching	Total	
Higher group	2 (20.0%)	8 (80.0%)	10	$p = 0.1092$
Lower group	9 (56.3%)	7 (43.7%)	16	
Total	11 (42.3%)	15 (57.7%)	26	

From the results of analysis among the teachers' guidance, their usual understanding of students and the performance in Monsakun at the data of school B, at least, teachers gave individual guidance not depending on their usual understanding of students. However, we cannot say they have found students have had the impasses in the exercise with Monsakun.

6 Conclusions

This study developed the monitoring tool of class exercise with Monsakun for supporting teachers to find students need their guidance. We define the information necessary for instruction in class exercise as information about (1) learning progress of each student, (2) learners' attempts and errors, and (3) the summary of whole class as the accumulation of students. The development of the monitoring tool aims at providing the information to the teachers in real-time in class exercise.

In this paper, we report the analysis result of the practical use of the tool in terms of (1) and (2). The results show teachers accept this tool and actually they have given individual guidance not depending on their usual understanding of students. However,

the effectiveness of the tool is partially shown in the statistical test, only in the second grade.

The future works of this study are the following. Firstly, it requires further investigation of the effectiveness of this system. We need more data to show the evidence that teacher can find students require teachers' guidance. Secondary, we develop functions to support (3) the summary of whole class as the accumulation of students. The reflection after class is also important for teachers. Combination of information about learners' activity with teachers' individual guidance activity is useful for teachers to make future plan of classes.

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