Learning Support Interface for Arithmetic Word Problem Based on Eye Movements Reduction

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Abstract. Learning process in arithmetic word problem consists of three learning steps; extracting key numbers from problem text, creating equations, and deriving the answers of equations. When learning with computer using digital learning tools, learners sometimes are not able to concentrate on the learning since they have to move their eyes frequently between several learning tools, such as a tool that displays problem text and a memo tool. This research aims at developing a learning interface that consists of textbook window and memo window and a support functions that realize smooth learning with minimum eye movements between them. In the textbook window, learners can select key numbers by selecting them using a mouse. Selected numbers are copied to the memo window automatically. After learners create equations and derive answers in memo window, descriptions in memo window are copied to the textbook window automatically. Based on these functions, learners' unnecessary eye movements between two windows can be reduced.

Keywords: learning support interface, eye movement, arithmetic word problem.

1 Background and Objective

With the development of the e-Learning, learners are given learning materials from new learning devices, such as web browser and smart phones, while considering their ideas on memo tools. Under such learning environment, learners sometimes are not able to concentrate on the learning since they have to move their eyes frequently between two different tools. Such learners can be seen especially when they solve problems that consist of several solving processes and that need learning materials to be checked repeatedly in order to derive their answer.

Many traditional researches try to create real world-like learning interfaces [1-3]. Most of them develop tools that learners can manipulate as the same way as how they do in the real world, such as digital pens. These researches support only specific learning activity, such as writing. A few researches consider drawbacks that are caused by the eye movements between plural learning activities with different learning tools, such as reading text in browsing tool and creating ideas in memo tool.

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This research focuses on the arithmetic word problems and aims at developing the learning interface that realizes smooth learning between different learning tools. This research firstly analyzes the eye movements that occur during the learning activities in arithmetic word problems. Then, we develop the learning support interface which can reduce unnecessary eye movements between a tool that displays text and a memo tool.

2 Learning Support Interface for Arithmetic Word Problems

Learning process in arithmetic word problem consists of three learning steps; extracting key numbers, creating equations, and deriving answers of the equations. During the learning, learners tend to use two learning tools, such as a textbook which describes the problem text and a memo in which their ideas can be written down freely. We have conducted the preliminary experiment in order to analyze which learning tools are used during which learning steps and in which steps eye movements occur frequently. In the experiment, three undergraduates in our university were asked to solve problems while wearing special glasses with camera (Figure 1). Problem texts were shown in a computer and paper memo is prepared on the desk. By analyzing the eye direction and descriptions in memo, applied tools for each learning step are determined.

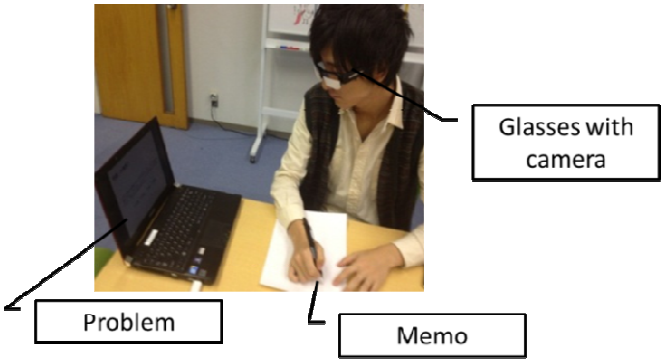

Fig. 1. Environment of preliminary experiment

As a result, learners tended to extract key numbers/words by observing problem text and write them in the memo. The equations were created by combining the extracted key numbers from problem text and were solved in memo. The answers of the equations became candidates of the next key numbers and sometimes are written in the memo again as next key numbers. The eye movements between problem text and memo can be seen during the key number extraction and creation of equation.

Based on the result, we have designed the interface which reduces unnecessary eye movements between problem text and memo (Figure 2). Our interface consists of two windows: textbook window and memo window. Problem texts are shown in the textbook window, and creation of equations and derivation of their answers are available in the memo window. In addition, in the textbook window, key numbers can be selected from the problem text by selecting them using mouse and selected numbers are copied to the memo window automatically. Also, created equations and answers in memo window are copied to the textbook window so as to make learner select next key numbers easily.

Figure 3 shows developed textbook window and memo window as a prototype. In the textbook window, problem text and equations that are derived by learner in the memo window are appeared. Learners can select key numbers/words from text by selecting them using mouse. Selected key numbers/words are allocated as texts on the buttons in the memo window. By clicking these buttons, texts on the buttons are inputted to equation creation area so that learners can create the equation easily. Learners are also able to modify texts and add answers of equations in the equation creation area. When equations are created and equation completion buttons are pushed, texts in the equation creation areas are copied to the end of the problem text in the textbook window.

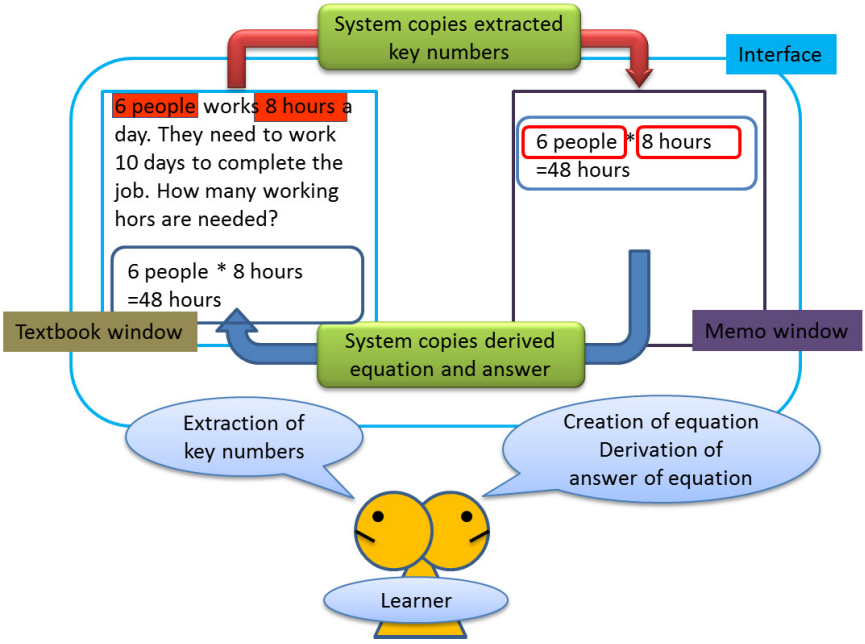

Fig. 2. Interface design

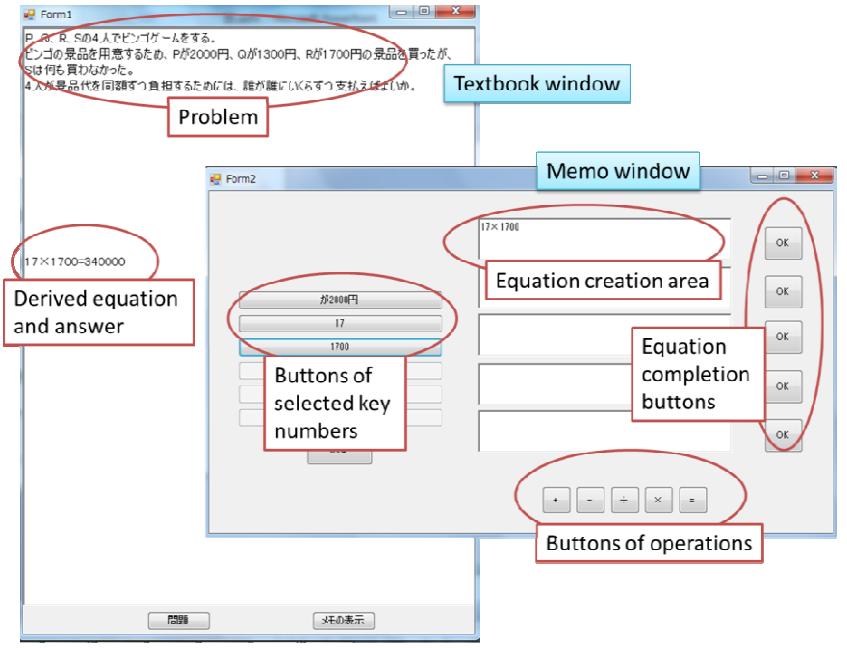

Fig. 3. Interface

3 Experiment

Eight undergraduate students in our universities (*A* to *H*) were asked to solve two arithmetic word problems (*a*, *b*). For one problem, they were asked to use our interface with full screen (interface *I*). For the other problem, they were asked to use paper memo (interface *II*). In both environments, problems were shown on our textbook window.

Table 1 shows the numbers of eye movements for each student who could derive the answer for both problems. Only four students (*A* to *D*) could reach to the answer. Based on the result, average number of eye movements using our interface was 4.5 times smaller than that of using a paper memo. In addition, for all students, the number of eye movements using our interface was smaller than that of using a paper memo. Therefore, our system could successfully reduce the number of eye movements between two different learning tools.

Table 1. The number of eye movement

	Interface *I* /problem *a*	Interface *I* /problem *b*	Interface *II* /problem *a*	Interface *II* /problem *b*
Student *A*	8	-	-	10
Student *B*	-	6	8	-
Student *C*	4	-	-	12
Student *D*	-	7	13	-
Average	6.3		10.8	

Our interface restricts the type of learning activities that can execute in each window. We have asked if their solving processes were changed by using our interface. Some students commented positively that they could execute each learning activity carefully by using our interface. However, some other students told us that they were uncomfortable with the restriction. So, in future, we need to investigate the effect of our interface from viewpoints of the learning performances.

4 Conclusion

In this paper, we have developed learning support interface for arithmetic word problem. In our interface, key numbers selected from a textbook window are automatically copied to a memo window, and equations that are derived in a memo window are added to the problem text in the textbook window. Based on these functions, the number of eye movements during the learning has been reduced.

Currently, in order to utilize our interface, texts of word problems should be embedded into the system beforehand. If learners can select problems that are provided in the web and can input them into the system by themselves, our interface can be used more widely. Therefore, we need to develop the mechanism which can obtain texts from indicated web site and set them as a problem text in the textbook window.

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