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Designing Technology Supported Scaffolding for Fractions Learning in Primary Schools

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Abstract: In the field of Mathematics education, there are the urgent needs of developing technology supported adaptions for students with learning difficulties due to the nature of Mathematical problem solving, the disparities in Mathematics achievement and the importance of Mathematics subject in education and job market. In this paper, a technology-supported learning environment with the employment of mechanism of scaffoldings: scaffolding changes and scaffolding logic for fractions word problems solving among students with LD was introduced. Specifically, the literature and rationales of the system design and development were discussed and presented.
Keywords: maths education, computer-mediated scaffolding, learning difficulties

1. Introduction

The term Mathematics Learning Difficulty is used broadly to describe a wide variety of deficits in mathematical skills. "Individuals who exhibit learning difficulties may not be intellectually impaired; rather, their learning problems may be the result of an inadequate design of instruction in curricular materials. Further research shows the use of technology is effective not only in helping students with learning disabilities in solving mathematics word problems but also beneficial to their learning in solving word problems with fractions and it can promote the inclusion of students with various disabilities (Fichten et al., 2009). The notion of scaffoldings has great potentials on relieving learners' cognitive burden and with addressing the problem-solving process when integrated with appropriate pedagogical design, particularly, the computer-mediated scaffoldings (Quintana, et al., 2004). In addition, scaffoldings may relate not just cognitive skills but to other aspects such as emotive or affective factors (Yelland & Masters, 2007). Thus, we develop a technology-supported learning environment with the employment of mechanism of scaffoldings: scaffolding changes and scaffolding logic for fractions word problems solving among students with LD, which was few explored in Mathematics education. In this study, a web-based learning environment: ScaffoldiaMyMaths has been developed with unique features of adaptive scaffoldings. The rationales of the system design and development are discussed below.

2. Rationales of the system design and development

Scaffolding can be distinguished in four different dimensions, namely scaffolding scope, scaffolding intervention, scaffolding change, and scaffolding logic. In terms of scope, computer-mediated scaffolding can use either context-specific or generic scaffolding strategies due to theoretical models adopted by designers (McNeill & Krajcik, 2009). A generic scaffold is applicable to a wide range of units and context without changes in the scaffold itself (Stark, 2013). According to the theory of knowledge integration, context-specific scaffolding should be used and most previous studies in mathematical learning among primary school students have used context-specific ones (Hwang, Wu., & Chen, 2012) which are found to be effective. Based on these previous studies and the theory of knowledge integration, we will use context-specific scaffolding in this study. Second, there are four main categories of scaffolding intervention: conceptual, strategic, metacognitive, and motivation scaffolding (Hannafin, Land, & Oliver, 1999). Conceptual scaffolding highlights factors taking into consideration when solving a problem while strategic scaffolding proposes a target strategy like argumentation, problem solving or evaluation. Metacognitive scaffolding assists students to evaluate their understanding while motivation scaffolding enhances or maintains students' motivation in learning like self-efficacy and autonomy (Belland, Kim, & Hannafin, 2013). Researchers have shown the beneficial effect of conceptual and strategic scaffoldings on learning mathematics among primary school students. Based on these prior studies, we will adopt both conceptual and strategic scaffolding in this study.

3. The Features of ScaffoldiaMyMaths Learning Environment

The web-based learning environment: ScaffoldiaMyMaths has been developed to facilitate students learning to solve fractions word problems. In ScaffoldiaMyMaths, the instructional lessons will be composed of five sets of word problems: where each set is consisted of 10 tasks with the same underlying structure (i.e. solution rationale) but different surface characteristics (i.e. cover stories and values). For each task, we design the scaffoldings accordingly. Explanation prompts in the form of work-out examples and problems (EP) as the key representative scaffoldings will be designed (Atkinson and Renkl, 2003). To help the student in identifying a problem solution, the solution steps will be visually and listed according to the nature of the task and the setup of scaffolding condition below. Below is the basic interface of the system.

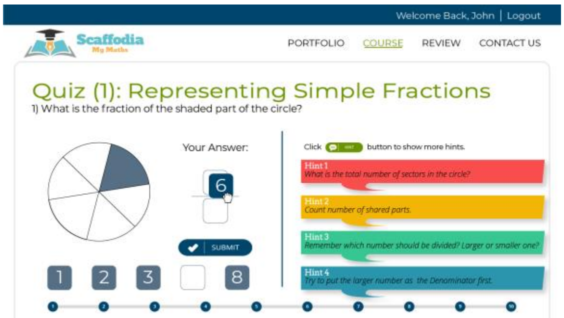

Figure 1. Student interface 1

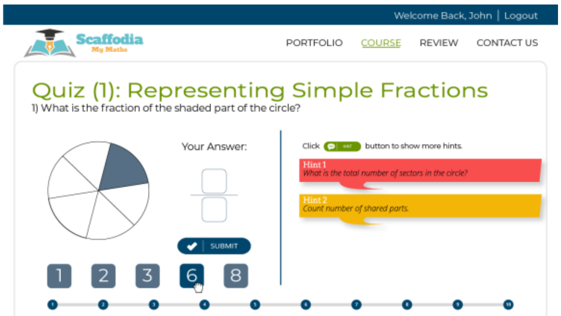

Figure 2. Student interface 2

The design of the four adaptive scaffolding conditions:
1) Fixed backward fading scaffolding condition: In the first task, the solution of the work-out example will be presented to participants with all four solution steps sequentially shown to the participants. In other words, participants will be asked to work through the example step by step by clicking on the "next step" button and the next step will be shown to them on the top of the earlier step. In the final step, the four solution steps will be presented to them at the same time as a complete work-out example on the screen. After the participant complete the first task, they will continue to inspect the second task by clicking on a "next problem" button on the screen. The presentation format of task 2 is the same as the one in Task 1. The third task is similar to Tasks 1 and 2 except that the final solution step will be disappeared and participants will be asked to anticipate the final step by themselves and input the solution in the box to be provided, otherwise they are not able to continue. If the participant provides a wrong answer, the final solution step with the correct answer will be provided to them for their feedback. Similarly, the fourth task will be the same as the third one in presentation of the solution steps. In the fifth and sixth tasks, the last two steps will be omitted while in the seventh and eighth ones, only the first solution step will be displayed. Finally, in the ninth and tenth tasks, all solution steps will be skipped.
2) Fixed fading and adding scaffolding condition: In this condition, the scaffolding is fading from the first task to the fifth task, and then the scaffolding is adding from the seventh task to the tenth one. In other words, in first and tenth tasks, all solution steps will be shown, in the second and ninth tasks, only the first three solution steps will be displayed, in the third and eighth ones, only the first two will be presented, and in the fourth and seventh ones, only the first step will be displayed. Finally in the fifth and sixth ones, all solution steps will be omitted.
3) Performance-based fading scaffolding: In this condition, the basic schedule is the same as the one in the first condition: fixed backward fading scaffolding condition. However, if the participant provide a wrong answer to any task, the fading schedule will be delayed until the participant is able to finish two consecutive tasks correctly.
4) Performance-based fading and adding scaffolding: In this condition, the original schedule is also the same as the one in the first condition: fixed backward fading scaffolding condition. However, the scaffolding can be added or faded based on the performance of participants. In the first and second tasks,

if participants are not able to provide a correct answer to these tasks, the fading schedule will be postponed until they are able to complete two consecutive tasks correctly. The fading schedule will continue if participants are able to provide the correct answers all along. However, if they are not able to do that in any task after the fading has begun, the adding scaffolding will be initiated. In other words, the former omitted solution step will be presented again. If the participants continue to provide wrong answer, the adding will be continued until all solution steps are shown again. The online platform ScaffoldiaMyMaths (final version) is designed to be run in these four different conditions, which gives certain extend of scaffolding to learners in the experiment.

4. Conclusions and Further Work

The impact of the computer-mediated scaffolding approach could potentially be context-sensitive to the school settings and environments in Hong Kong. The usability test and pilot study of the system will be conducted stage by stage and the cognition research will be further conducted. In sum, the adaptive scaffoldings will facilitate teachers' teaching students with less workload and more effective learning management. Most importantly, the well-tailored online lesson package with appropriate pedagogy will facilitate teachers' teaching for students both in and out of classroom. It will offer students with more inquiry time and consolidate what they have learned in class by themselves rather than receiving or training the solutions directly by their teachers. The nature of technology learning environment could better provide the parents with students learning track and improve parent assistance of their children out of school, especially the free and frequent access of the system by the low-income family.

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