Ogata, H. et al. (Eds.) (2015). Proceedings of the 23rd International Conference on Computers in Education. China: Asia-Pacific Society for Computers in Education

Using Digital-Pen-based Learning System with Collaborative Learning Activities to Improve Mathematics Achievement in Taiwanese Elementary Courses

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Abstract: Mathematics education in Taiwanese elementary schools is mainly conducted in a conventional way by giving lectures. A teacher would pass on knowledge to students by giving lectures, and this type of traditional teaching method is prone to cause poor learning performance. Most studies have indicated the use of a collaborative learning approach to improve mathematics performance. This research proposed the use of digital pen learning system (DPLS) to conduct implementation of collaborative learning in Taiwanese elementary mathematics courses. A quasi-experimental design was adopted to establish all of the teaching and learning activities, which involved 64 third-grade students for four weeks. Finally, the results showed that the learning performance of the two experimental groups was significantly better than control group.

Keywords: Digital pen system, collaborative learning, mathematics performance

1. Introduction

Mathematics is a subject which is significant to most of the people as science, mathematics and technology is important and being emphasized in national development plans. Currently, elementary schools in Taiwan still adapt the approach of giving lectures to teach and learn mathematics. Taiwanese elementary school teachers usually pass knowledge on to students by giving lectures, and the teacher is the center of this type of teaching. Students would listen to the lectures and learn their lessons independently. Long lectures tend to become tedious, and it is very difficult for students to remain focused in long lectures (Llamas-Nistal, Fernández-Iglesias, González-Tato, & Mikic-Fonte, 2013). In a traditional mathematical learning approach, the focus is often on the process and skill of solving mathematical problems. The lack of effective learning strategy is the main reason for low learning performance (Alvarez, Salavati, Nussbaum, & Milrad, 2013; Weinstein & Mayer, 1986). Therefore, related studies (Lopez-Morteo & López, 2007; Lazakidou & Retalis, 2010; Tsuei, 2012; Nussbaum, Alvarez, Mcfarlane, Gomez, & Claro, 2009) have suggested the use of digital pens and collaborative learning methods to improve mathematics performance.

We propose to use a digital pen learning system (DPLS) in combination with the collaborative learning approach to implement mathematics learning in Taiwanese elementary courses (Su, Yang, Hwang, & Zhang, 2010; Su, Yang, Hwang, Huang, & Tern 2014; Su, Huang, Yang, Ding, & Hsieh, 2015). Teachers involved in the teaching environment could use the DPLS to carry out the collaborative learning activities with ease. They could also grasp and analyze students' learning situations immediately. The teachers and students also shared their digital handwriting to enhance interaction in the classroom. A quasi-experimental design was used to proceed the teaching and learning activities, which involved 64 third-grade students at an elementary school in northern Taiwan. The activities lasted for four weeks with a total of eight hours of mathematics learning activities. The subjects of the experiment were divided into three groups. The experimental group A used the DPLS and collaborative learning approach. Experimental group B used the DPLS and lecture approach. Control group used conventional pen and paper and lecture approach. In addition to exploring learning performance, we studied and analyzed the learning motivation and learning attitude of the students.

2. Methodology

2.1 Participants

There were sixty-four students involved in this study who were registered the third-grade mathematics course at an elementary school in northern Taiwan. All third-grade students of elementary school from three classes participated in the experiment. Two of the classes was designated as the experimental group A and experimental group B, and the other one classes were designated as control group, respectively. The numbers of students in the three groups were 21, 23, and 20, respectively.

2.2 Digital Pen Learning System (DPLS)

The construction of the DPLS software framework was based on an Anoto software development kit. The teachers used the system to produce and print out worksheets before classes began and used it to provide instant feedback on roll calling, answers, and discussions, as showing in figure 1. The DPLS also stored information on the students' learning status, provided students with reviews of the entire learning process, and allowed teachers to keep track of students' learning status by recording their handwriting. In addition, the DPLS also provided an easy way to set up answers such as integer and decimal. Student only needed to put his answer in the blank square, the DPLS automatically checked to see if the answer was correct.

Figure 2 shows the test Management interface page, where a user can quickly search test papers by category names or unit names to find the test, make modifications, or delete it. After a test is selected, the DPLS provides a preview function that allows the user to reconfirm the selection, enter the number of test copies, and print out the test papers.

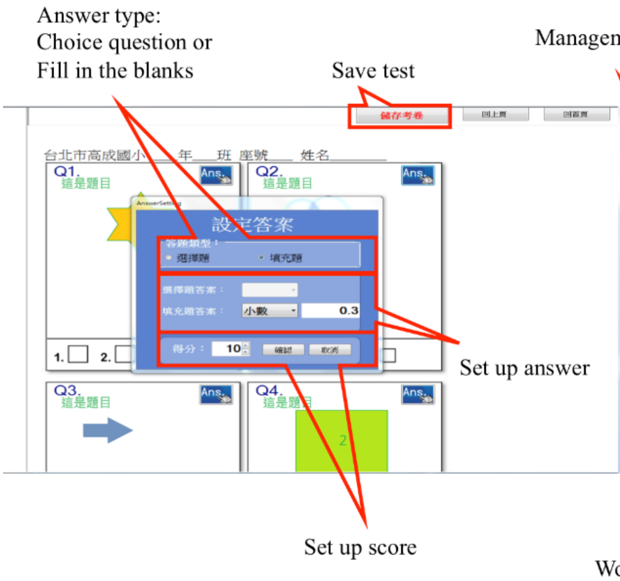

Figure 1. Math test interface.

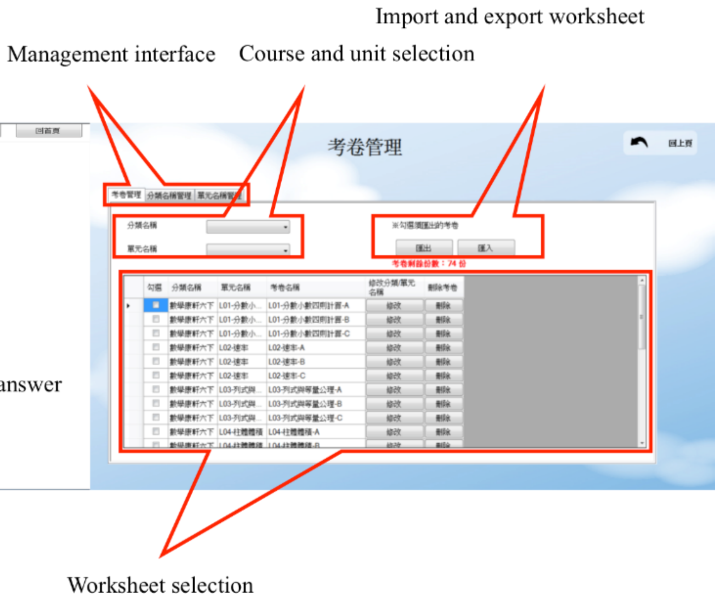

Figure 2. Test management interface.

The DPLS also has a handwriting-playback function, as showing in figure 3. Students can use this function to share ideas with each other, save time for writing on the blackboard, and present their thinking flow in its entirety. The teacher can use this function to see a pause moment in a student's thinking to determine what kind of problems the student may have encountered, and then provide assistance to the student. The DPLS can keep a complete record of the students learning scores, as showing in figure 4. The scores are shown in two colors, red and green. A red score indicates a failing score, and a green score indicates a passing score. Teachers can use this function to examine every student's learning status.

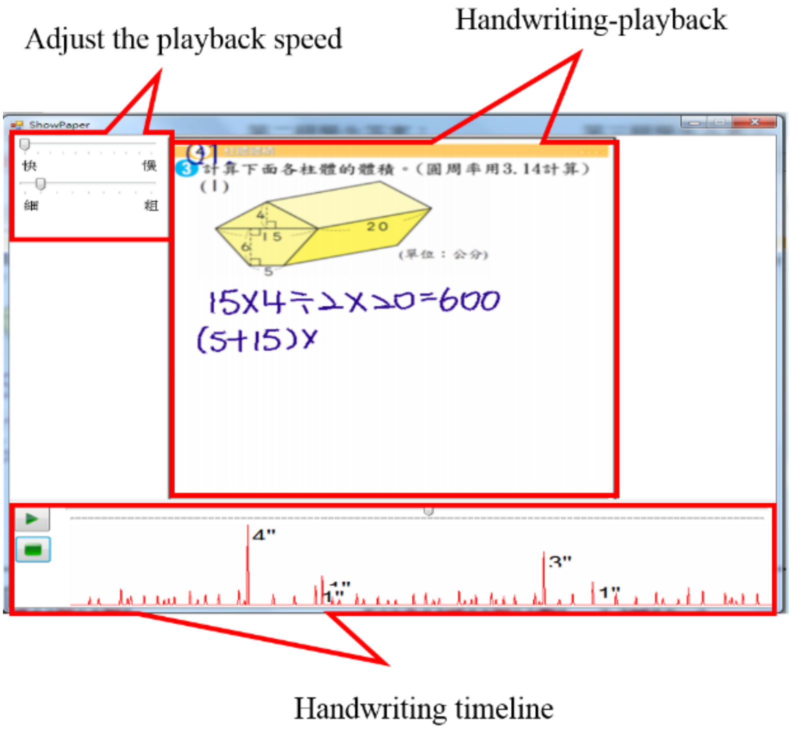

Figure 3. A handwriting-playback function.

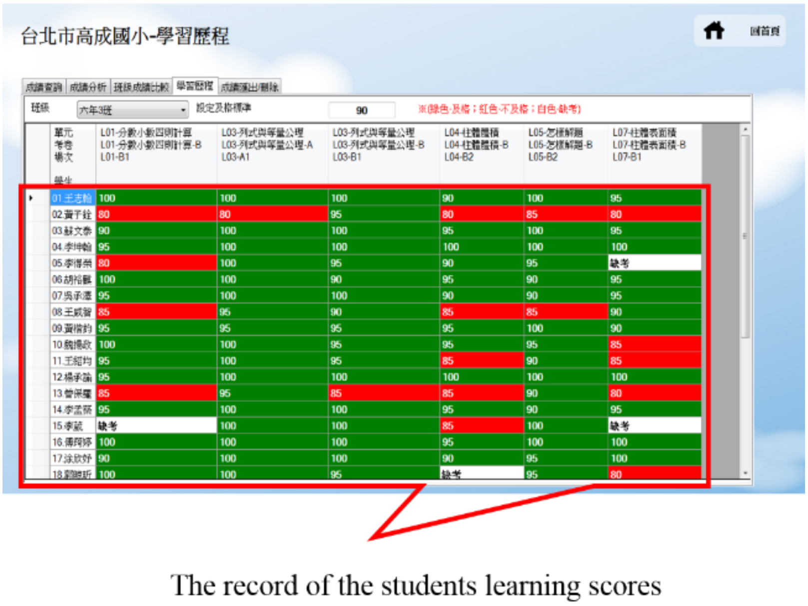

Figure 4. Learning portfolio of students.

In summary, the DPLS has not only kept the conventional way of note-taking and answering test questions on paper but also transformed paper notes into digital notes. As a result, teachers can effectively use the digital notes for reviewing and teaching, and students can use paper notes to engage in discussion and making corrections.

3. Experimental Results

Before the learning activities began, a pretest was conducted to determine the level of the students' basic mathematics knowledge. Before a one-way analysis of variances was conducted, a Levene's test was conducted to make sure the variances in the sample pretest of the experimental group A, experimental group B, and control group were not in contradiction with the basic assumption so that the one-way analysis of variances could proceed.

The results of the one-way analysis of variances showed that there was no significant difference in the pretest scores of the experimental group A, experimental group B, and control group. This indicates that there was no significant difference in the three groups' level of prior knowledge before the experimental teaching activities began. At the end of the learning activities, a post-test on the content of the mathematics course was conducted to evaluate the difference in the students' responses to the three teaching modes. Before an analysis of covariance (ANCOVA) was made, a Levene's test on the samples from the three groups was conducted, and the homogeneity test showed no significant difference. Therefore, the analysis of covariance could proceed. We used the results of the pretest as covariance, the three learning approaches as independent variance, and the post-test scores as dependent variance to exclude the interference effect of pretest scores. Table 1 shows that the analysis results was significant ($F = 3.30$, $p < .05$), indicating that the difference between the three groups' samples was significant. Therefore, adjusted average numbers were used to make a post hoc comparison. The comparison shows that the post-test scores of the experimental group A and experimental group B are significantly different ($p < .05$) and that the post-test scores of the experimental group A and control group are also significantly different ($p < .05$).

Table 1: Descriptive data and ANCOVA results of students' learning performance.

Variable	Groups	N	Mean	*S.D.*	Adjusted mean	*F(2,60)*	Post hoc
Post-test	(1) Experimental Group A	21	67.86	18.27	67.51	3.30*	(1)>(2)
	(2) Experimental Group B	23	54.57	20.39	54.62		(1)>(3)
	(3) Control Group	20	51.25	25.54	51.55		

4. Conclusions and Further Works

This research was built upon a combined framework of DPLS in combination with the collaborative learning approach to support the teachers in carrying out a feasibility study on collaborative learning on mathematics courses. This research also explored and analyzed students' learning performances. The experiment results show that the post-test scores of experimental group B were not as good as that of the experimental group A. Control group used conventional pen and paper and a conventional lecture teaching method that was similar to control group's learning method. There was no significant difference in the two groups' learning strategies, and the major difference was that experimental group B used a digitally aided tool. The result of a previous research indicated that, no matter how advanced the learning tool is, there will be no significant improvement in a student's learning performance without an effective teaching strategy (Herrington & Oliver, 2000; Hwang, Chu, Shin, Huang, & Tsai, 2010; Su, Yang, Hwang, & Zhang, 2010; Su, Yang, Hwang, Huang, & Tern 2014; Su, Huang, Yang, Ding, & Hsieh, 2015). Therefore, the results show that there is no significant change in experimental group B and control group's learning performance.

In future works, we suggests that the design of learning activities could be expanded to more disciplines and to situational application related technologies, such as augmented reality, context awareness, and physiological awareness.

Acknowledgements

This study is supported in part by Ministry of Science and Technology, Republic of China, Taiwan under contract numbers MOST 104-2517-S-008-001 and MOST 104-2511-S-008 -011.

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