Small Group Learning with Digital Pens in High School Physics

Ming-Hong CHIU[a], Chi-Jen LIN[b*]
[a]*National Lo-Tung Senior High School, Taiwan*
[b]*Department of Learning and Digital Technology, Fo Guang University, Taiwan*
*cjlin@mail.fgu.edu.tw

Abstract: Physics learning was known to be hard for high school students and it was known that there was a gender difference in this perspective. One important method to promote student learning achievement in physics is to increase the opportunities to receive feedbacks during problem-solving practices, and small group learning is one of such a good method. Another method is to provide multiple viewpoints to assist student learning, and digital pens is a potential tool to achieve this goal. The experimental results showed that female students are more benefited from small group learning and male students may suffer in learning retention when digital pens were used in small group learning setting.

Keywords: small group learning, digital pen, physics concept

Introduction

Physics has been perceived as a hard subject by most high school students in Taiwan. One of the reasons that make physics hard to be mastered was that most students did not know how to solve problems with physics concepts properly, thus they tended to acquire superficial problem solving techniques [1]. Without interacting with physics teachers, students were unaware whether their learning was superficial or not. The authors believe that increasing student opportunities to receive feedback during their problem-solving practices at their early learning stage is crucial to improve their learning. However, due to limited time in the classroom, a physics teacher can spend time only with partial of the students in a class, and the rest of the students in the class are, unfortunately, on their own. The solution to this situation is the well-known two sigma problem [2], which is a search of group instruction methods that are as effective as one-to-one tutoring.

In a physics class, besides the teacher, more capable students are the potential helpers to enhance student learning. Peer instruction [3] is an instruction method that matches students pairwise in order that the interaction between the two students helps their learning. However, it was found that if the two students in a pair were both less capable students, the learning outcomes might be worse than they studied alone. With careful assignment of the group leaders, the discussion in the small groups may result in learning enhancement. Thus, it is interesting to investigate whether such a small group learning method will enhance physics learning. Another method to improve student learning is provide students with multiple viewpoints. We use digital pens to achieve this goal. The effects of introducing digital pens will also be investigated to see if there exists any further enhancement. As gender was also known to be significant factor in physics learning [4] [5] [6], we will also investigate how the gender factor influence student learning under relevant situation.

1. Characteristics of Digital Pens

The usage of digital pens is quite the same as those of ordinary pens, even their appearance is the same (as shown in Figure 1). The main differences between a digital pen and an ordinary pen are that a digital pen comes with an internal camera to capture what was written using the digital pen and a wireless transmitter to transmit what the camera captured to a whiteboard or a computer. The configuration of transmission target is up to the teacher. Thus, a teacher can monitor answers of all the student groups and react accordingly at one location when all the groups use digital pens (teacher time saving feature). The monitoring screen can also be displayed to all students to demonstrate various solutions of a problem. The benefit of introducing digital pens is that it does not require additional training for students to use them. However, to ensure the proper capturing function of the cameras, specially prepared paper, which comes with invisible printed dots, must be used for writing. In this study, we use digital pens as a tool for demonstrating alternative solutions in order to investigate whether students learning will be further improved in the small group learning format.

Figure 1. Digital pen(bottom) and ordinary pen(above).

2. Two-staged Experiment

Due to the nature of this study, a two-staged experiment was planned. The goal of the first stage experiment was to investigate whether the small group learning format outperformed the individual learning format, and the goal of the second stage experiment was to investigate whether the introduction of digital pens did further improve physics learning in the small group format.

2.1 Experimental settings

The learning topic of the first stage experiment is the unit of gravity on earth, while the learning topic of the second stage experiment is the unit of satellite movement. Each topic was taught for two contiguous weeks with a total of eight classes. The class delivery format was consisted of three parts: concept introduction, problem-solving demonstration, and student problem-solving practices. The learning format of the control group and experimental group differed only at the third part, that is, the student problem-solving practice part. In the individual learning setting, or the control group of the first stage experiment, each student solved problems by themselves, while the teacher walked through the classroom to assist those who need help. In the small group learning setting, which includes the experimental group of the first stage and the control group of the second stage, a class of students was divided into eight groups. Each group was required to work out a solution and their solutions were reported to the whole class after all the groups completing

their solutions. The group leader was chosen by the teacher according to their previous physics learning performance. Eight top ranked students were divided into the eight groups and were assigned as the group leader. The group leader was in charge of coordinating the group solution among the group members and reporting the group solution to the whole class. The teacher played the role of commentator during their reports. In the digital pen learning settings, students also learn in the group format, except that group leaders use digital pens as their written tools and group solutions were shown on a common display that was visible to the whole class.

2.2 The participants

The subjects come from two classes of high school students of eleventh grade. One of the classes served as the control group and the other served as the experimental group. There are 44 students in the control group with 13 female students and 31 male students, and 37 students in the experimental group with 23 female students and 14 male students. Before the two-staged experiment, a formal learning performance assessment was performed for the two classes. The results showed that there were no significant statistical differences between the previous physics learning performance of the two classes, with the average of learning performance of the control group slightly better than that of the experimental group. The two classes were taught by the same teacher.

In each stage of the experiment, a pretest and a posttest of the learning unit were conducted. In the second stage, a delayed test was also performed to investigate the retain effects of the intervention of digital pens. The scores of these tests were the number of problems the students solved correctly. There were totally ten problems in each test.

3. Experimental Results

3.1 Small group may suffer from classroom order degeneration

Before the formal two-staged experiment, a prior experiment, which was arranged in the same setting as the first stage experiment, was conducted for the same subjects. To our surprise, the results showed that the learning performance of students in the individual learning setting was significantly better than that of in the small group learning setting. After reviewing the classroom process, it was found that the subjects chatted much more often in the small group learning setting than their previous classes. That is, classroom order degenerated during the experiment. For the rest of the classes the student attended, their format was individual learning. The discussion nature of the small group was novel to the students and they misused the opportunities of learning discussion by chatting. However, it was also noticed that one of the groups that was close to a video recorder chatted much less than the other groups. Consequently, in the experiment, we set up a video recorder for each group in order to prevent unnecessary chatting. This strategy worked well in the experiment.

3.2 Small group learning outperforms individual learning

Table 1 denotes the student performance in the first stage experiment. The numbers in the table denote how many problems the student correctly solved in the tests. The result of t-statistics of the pretests indicates that there is no significant difference between the student performance in the control group and the experimental group. On the other hand, the students in the experimental group outperform the students in the control group. That is, small group learning is better than individual learning. This result is a support that more

capable students in the small group do help enhance the learning of the other group members.

Table 1. Student performance in the first stage experiment (n=81)

		N	Mean	SD	Learning gain
Control group	pretest	44	3.30	1.81	2.97
	posttest	44	6.23	1.66	
Experimental group	pretest	37	3.08	1.48	4.08
	posttest	37	7.16	1.48	

4. Conclusions

In this study, we investigated the effectiveness of small group physics learning by assigning more capable students as group leaders, whether the introduction of digital pens in the small group learning can further improve student learning, and whether gender difference exists in these investigations. The results showed that such a small group learning method did improve student learning and the learning gains of female students were greater than those of male students. However, introducing digital pens in the small group learning format, which was a means to provide students with multiple viewpoints, did not produce additional learning gains.

References

[1] Crouch, C.H. & Mazure, E. (2001). Peer Instruction: Ten years of experience and results. *American Journal of Physics*, 69(9), 970-977.

[2] Bloom, B. S. (1984).The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring. *Educational Researcher*, 13, 4-16.

[3] Mazure, E. (1997) *Peer Instruction: a User's Manual*. Prentice Hall, New Jersey.

[4] Cavallo, A. M. L., Potter, W. H., & Rozman, M. (2004) Gender Differences in Learning Constructs, Shifts in Learning Constructs, and Their Relationship to Course Achievement in a Structured Inquiry, Yearlong College Physics Course for Life Science Majors. *School Science and Mathematics*, 104(6), 288-300.

[5] Hazari, Z., Tai, R. H., & Sadler P. M. (2007) Gender differences in introductory university physics performance: The influence of high school physics preparation and affective factors. *Science Education*, 91(6), 847-876.

[6] Kost, L. E., Pollock, S. J., & Finkelstein N. D (2009) Characterizing the gender gap in introductory physics. *Physical Review Special Topics - Physics Education Research*, 5(1), 010101.