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An interactive e-book approach to supporting flipped learning in an elementary school math course

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Abstract: In this paper, interactive e-books were developed to enable students to learn at home in the flipped learning mode. Using the interactive e-books, students can learn by themselves before the class and apply what they have learned to the classroom activities later in schools. Moreover, the teachers can monitor the students' learning status based on the e-book learning logs recorded in a cloud system. To evaluate the effectiveness of the proposed approach, an experiment was conducted in an elementary school math course. A total of 45 students participating in the experiment were assigned to an experimental group and a control group. The students in the experimental group learned with the proposed approach, while those in the control group learned with the conventional technology-enhanced learning. From the experimental results, it was found that the proposed approach significantly improved the students' learning achievement.

Keywords: interactive e-books, flipped classroom, flipped learning, cloud system

1. Introduction

Recently, scholars have emphasized the importance of conducting students-centered activities in school settings (Hwang, 2014); moreover, they have pointed out the importance of fostering students' active learning and problem-solving competences in developing the student-centered learning activities (Agbatogun, 2014; Kamarainen et al., 2013). It is apparent that nowadays teachers play the role of a learning promoter rather than a knowledge provider; that is, they play the role of encouraging students to construct knowledge during the learning process. Among various learning modes, flipped classroom has been considered as an effective learning mode for helping students engage in active learning as well as meaningful peer-to-peer and peer-to-teacher interactions during the in-class learning process (Forsey, Low, & Glance, 2013). This can overthrow the direct instruction in the traditional instruction and focus on leading students to apply knowledge to practical applications and engaging them in higher-order thinking.

However, researchers have also pointed out several challenges of conducting the flipped classroom in school settings. For example, teachers need to make lot of efforts in designing learning activities for helping students learn effectively and meaningfully whether in the class or out of the class (Schultz, Duffield, Rasmussen, & Wageman, 2014). In addition, in the out-of-class learning stage, students need to learn by themselves which might cause them high cognitive load when facing too much online information at the same time (Kim, Kim, Khera, & Getman, 2014). More importantly, teachers are unable to know individual students' learning status before the class without any assistance.

Consequently, more and more discussions about the lead-in of technologies for improving the quality of flipped classroom have been made in recent years (Galway, Corbett, Takaro, Tairyan, & Frank, 2014; Kong, 2014). With the help of computer and communication technologies, teachers can manage learning activities online and monitor students' learning status in an efficient way. On the other hand, students can browse learning materials (e.g., videos and web pages) by themselves in a systematically way with the learning guidance provided by the learning system. For instance, some learning management system can assist teachers to schedule the learning plan of individual students and monitor their learning situations (LaRue, 2012). Several studies have further demonstrated that the appliance of technology can engage students to learn effectively and assist teachers to control their students' learning pace and performance, whether students in the class or out-of-class (Mason, Shuman, & Cook, 2013; Teo et al., 2014).

In this study, interactive e-books were developed for assisting students' flipped classroom learning; in particular, guiding them to learn at home in an effective way. In the meantime, the e-book system can automatically record students learning status for helping teachers monitor students' performance and provide assistance in the class accordingly. To evaluate the effectiveness of the proposed approach, an experiment was conducted to investigate whether the interactive e-book in flipped classroom improved the students' learning achievements in comparison with the conventional technology-enhanced learning approach.

2. Literature Review

2.1 Flipped Classroom

In recent years, the educational paradigm has greatly shifted into students-centered learning mode. At the meantime, more technologies have been integrated into the educational scenes, which leading multiple learning modes provided for students to have various learning ways (Li, Verma, Skevi, Zufferey, Blom, & Dillenbourg, 2014). Among various learning modes, "flipped classroom" has been regarded as an extraordinary learning method that engages students in applying their learning knowledge and conducting higher order thinking, rather than receiving direct teaching instruction (Davies, Dean, & Ball, 2013; Flumerfelt & Green, 2013).

The concept of the flipped classroom was proposed by Jonathan Bergmann and Aaron Sams (2012). They proposed that in this learning mode, students could prepare for classes by watching the videos, and could thus form the basic knowledge before class. In the in-class activities, more discussions or practices could be conducted to engage students in more in-depth learning and help them clarify any misconceptions (Bergmann & Sams, 2012).

There are many examples adopting the flipped classroom in courses (Hung, 2015; Teo et al., 2014). For instance, Gilboy, Heinerichs, and Pazzaglia (2015) used the flipped classroom in nutrition course. In this activity, students needed to preview the learning contents and write down the questions they encounter before the class. In the in-class stage, the teacher and students have face-to-face interaction and discussion of these questions. The results showed not only students' learning results are increased but both the students' and teachers' satisfaction with the course tended to be high. Another example in the USA is applied in a chemistry course, which students needed to watch the video and answer the designated questions before class. On the other hand, in the in-class activity, the teacher guided the students to discuss any high-error-rate questions. Through flipped learning, students' academic performance and learning confidence were increased (Fautch, 2015).

Stone (2012) stressed that educators need to make extra efforts in order to meet the expected outcomes of the flipped classroom. Although teachers do not have to prepare the traditional teaching contents, they still have to prepare the content for individualized learning and teaching. Therefore, teachers have to consider the educational value of flipped classroom to lead their students applying learning knowledge with the teachers' guidance (Spencer et al., 2011; Francl, 2014). Certainly, teachers can use technology and teaching strategies to successfully adopt flipped learning for students to achieve the expected outcomes (Bergmann, Overmyer, & Wilie, 2011).

2.2 The challenge of flipped classroom

Previous studies have discussed the technology supported in the flipped classroom, and demonstrated that the enhancement of technologies can effectively present the learning content for students, whether in-class or out-of-class activities (Hung, 2015; Kim et al., 2014). Moreover, teachers can apply some technology in organizing their teaching materials and video (Hwang, Lai, & Wang, 2015). For instance, Bergmann and Sams (2012) applied teaching video in their chemistry courses to solve students learning problems. On the other hand, Teo et al. (2014) also provided a chemistry learning platform for students to understand the basic concept of chemistry and the complex practical procedures through those demonstration videos.

However, some researchers still pointed out the shortcomings of the flipped classroom duo to the lack of learning guidance (Li et al., 2013). Without proper guidance, students might get lost in the out-of-class learning activities. In the out-of-class learning environments, there is plenty of information on the Internet; some of them can force students learning, while others might influence students' concentration. At this circumstance, the guidance and assistance of sustaining students' out-of-class learning become important.

In the past decade, Electronic books (e-books) have been regarded as an alternative media of introductory-level textbooks in educational scenes. One potential advantage of e-books is the flexibility and accessibility to conduct in regular courses; others include more visually appealing content, such as animation and video clips (Woody, Daniel, & Baker, 2010). Moreover, it is a proper technology that assists teachers to organize their teaching materials and guidance effectively. Based on the assistance, e-books can guide students to learn in a well-constructed learning procedure and become good partners with students in their out-of-class learning activities.

For instance, Korat (2010) integrated e-books into students' language and literacy learning courses, and found that students who read the e-books performed better in word reading than students who did not read the e-books. On the other hand, Li, Chen, and Yang (2013) have applied cognitive maps in e-books for improving students' reading comprehensive abilities. The results showed this learning mode can help students gain better reading performance.

Therefore, in this study, an interactive e-book approach was proposed for helping students to learn at home. With the help of the e-books, students read the learning materials following the guidance provided by the teacher and take quiz to evaluate their learning performance at home; moreover, their learning logs are recorded by the e-book system for teachers' reference in conducting classroom activities.

3. An interactive e-books in math courses

To boost students to have active learning, the interactive e-book approach was developed and integrated into a flipped classroom. The system consists of an e-book reading system, a teacher management system, and a cloud system, as shown in Figure 1. The e-book reading system provides the e-books for students to read before their class. The cloud system stores the e-books and students' learning logs. The teacher management system provides the functions for teachers to upload e-books, monitor students learning performance and analyze their learning behaviors

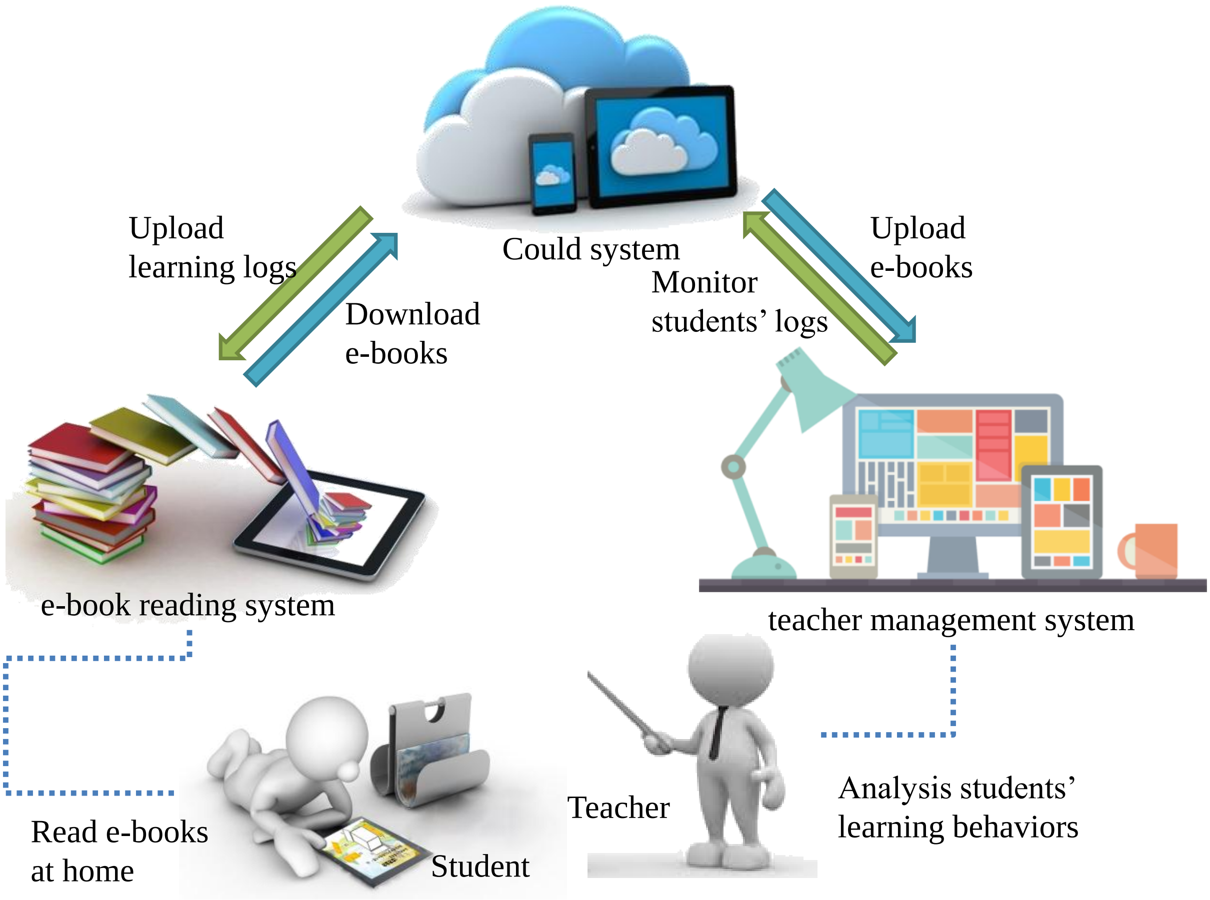

Figure 1. Structure of the interactive e-book approach

After logging in the interactive e-book, students can start the self-learning process. They can read learning materials, which could be in the form of text, photo, graph, or videos with various interactive interfaces. In addition, there are several quiz mechanisms provided by the e-book system, including multiple choices, matching, dragging, and fill-in-the-blank. Figure 2 shows the interface of dragging quiz.

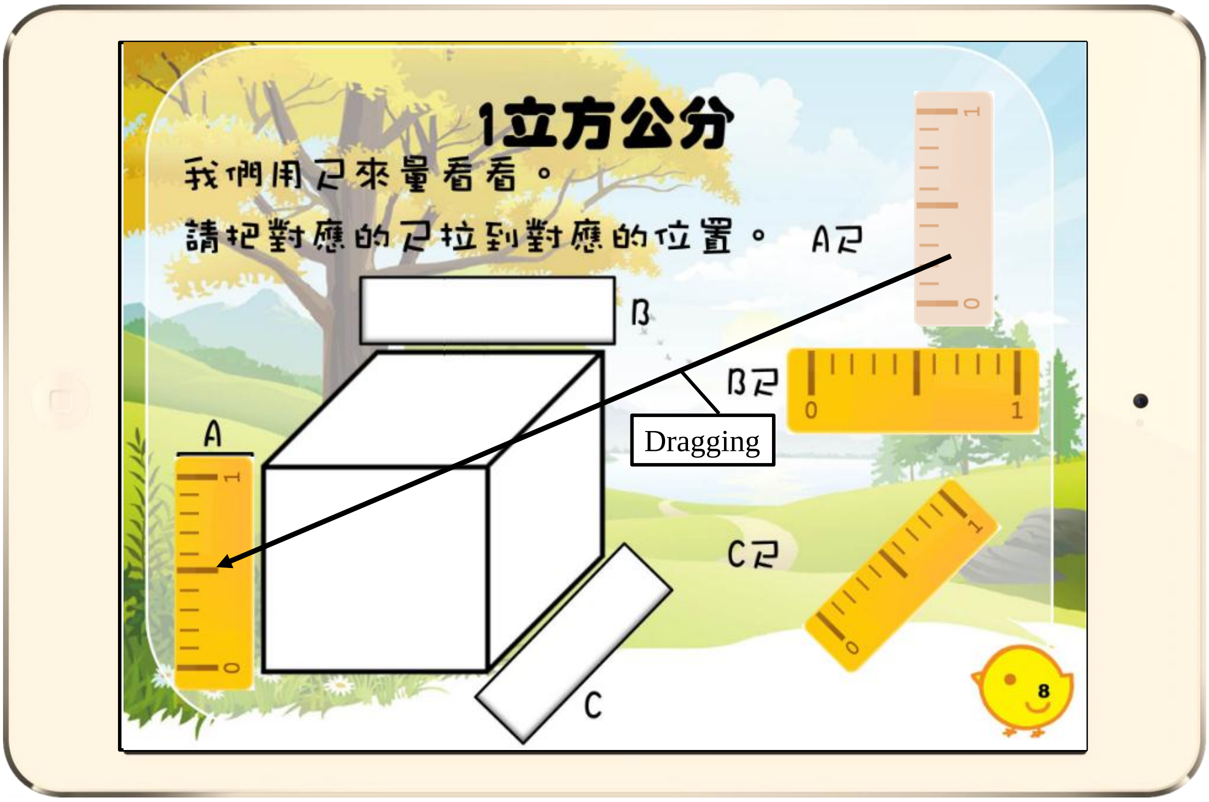

Figure 2. Interface of the interactive e-books, dragging

The interactive e-books can guide students to learn the correct concept by providing appropriate feedback. For instance, if students fail to answer a quiz, the interactive e-book immediately provides relevant feedback and asks them to answer the quiz again. Moreover, if the students fail to answer the quiz for the second time, the system provides some hints or supplementary materials to them before asking them to answer the quiz again, as shown in Figure 3.

Figure 3. The interactive feedback provided through the e-books

After the students finish reading the e-books, the e-book system calculates students' learning scores and uploads the scores to the cloud system, as shown in Figure 4. The system also records the learning logs of individual students, including the time and operations, in the cloud system. Therefore, teacher can check students' learning logs and performance in the cloud system, as shown in Figure 4.

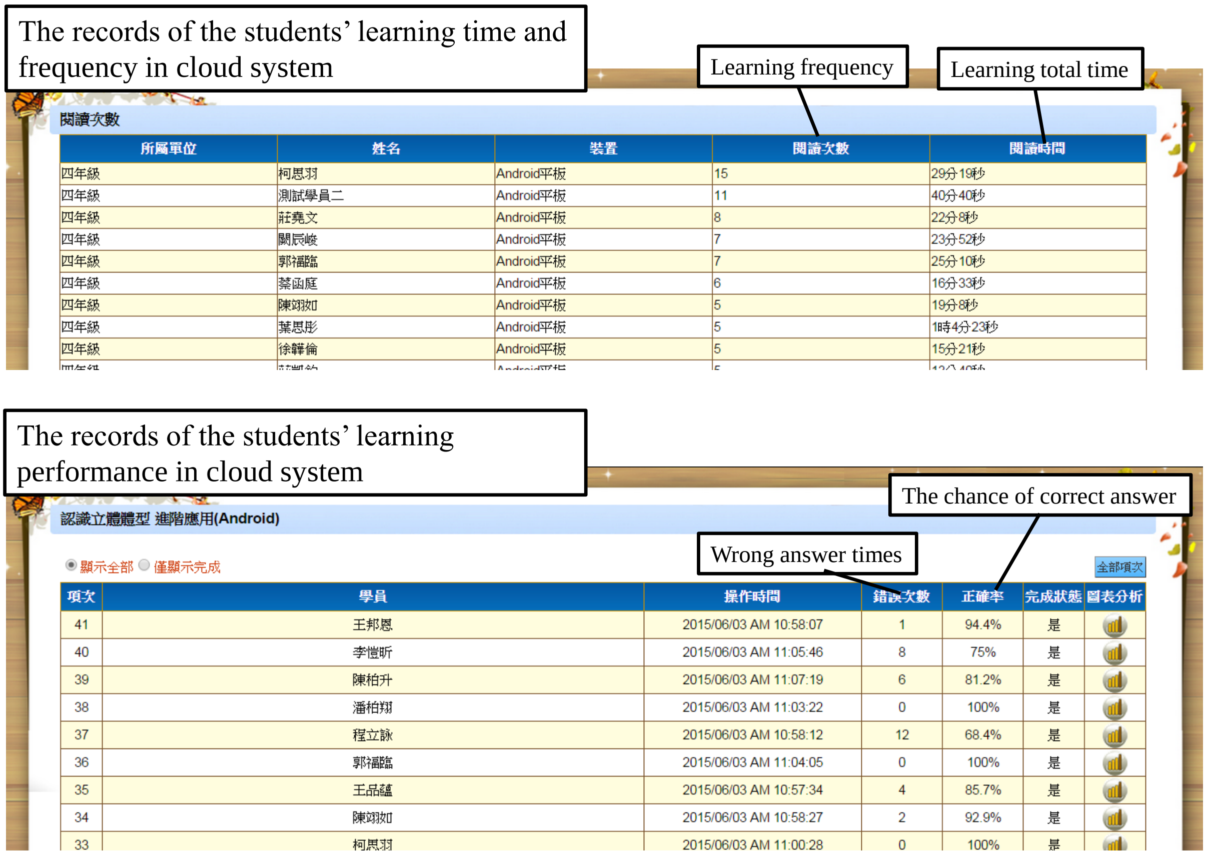

Figure 4. The learning log and performance of the interactive e-books in the database

4. Methodology

4.1 Participants

In this study, the students included two classes of fourth graders in an elementary school. All the students have the basic math concept of area and perimeter. One class was randomly assigned to be the experimental group and the other class was the control group.

The experimental group, including 24 students, learned with the interactive e-book approach in the flipped classroom. On the other hand, the control group with 21 students learned with the conventional flipped learning, that is, the students watched some videos and read some learning material before they went into the class. Both group conducted conventional technology-enhanced learning in in-class activities.

4.2 Measurement

The measuring tools of this study included the pre-test, post-test, and the questionnaires of meta-cognitive awareness. The test sheets were developed by three experienced teachers. The pre-test aimed to evaluate the students' prior knowledge of the math course in the "Area and perimeter" unit. It contained five multiple-choice items (10%), 2 matching items (16%), 17 fill-in-blank items (34%), and 10 question-and-answer items (40%), with a perfect score of 100. The post-test contained ten multiple-choice items (50%), five matching items (25%) and five question-and-answer items (25%) to assess the students' competence in identifying various volume and calculate those complex volume. The perfect score of the post-test was 100. The KR20 coefficient was 0.66, indicating an acceptable internal consistency reliability of the post-test (Kuder & Richardson, 1937).

The meta-cognitive awareness questionnaire originated from the questionnaire developed by Schraw and Dennison (1994). It consists of 10 items with a five-point Likert rating scheme. The Cronbach's alpha value of the questionnaire was 0.91.

4.3 *Experimental procedure*

The experimental procedure is shown as Figure 5. The learning materials for both groups were identical, while their learning approaches were different. At the beginning of the learning activity, all the students in two groups took the pre-test and the pre-questionnaire. After completing the pre-test, the teachers in both classes introduced the syllabus and the learning goal for the students. The learning course was divided into two units, which students learn the unit 1 in the first week and unit 2 in the second week. During the out-of-class learning activities, the students in the experimental group read the learning materials (videos, photos, graphics, and text) and took the quiz related to the learning content via the e-books. On the other hand, the students in the control group learned with the conventional flipped learning approach; that is, they read the same content (i.e., learning sheets and learning guidance in the printed materials and videos on the web). According to the learning logs, both groups of students spent one hour per week on average for the out-of-class learning tasks.

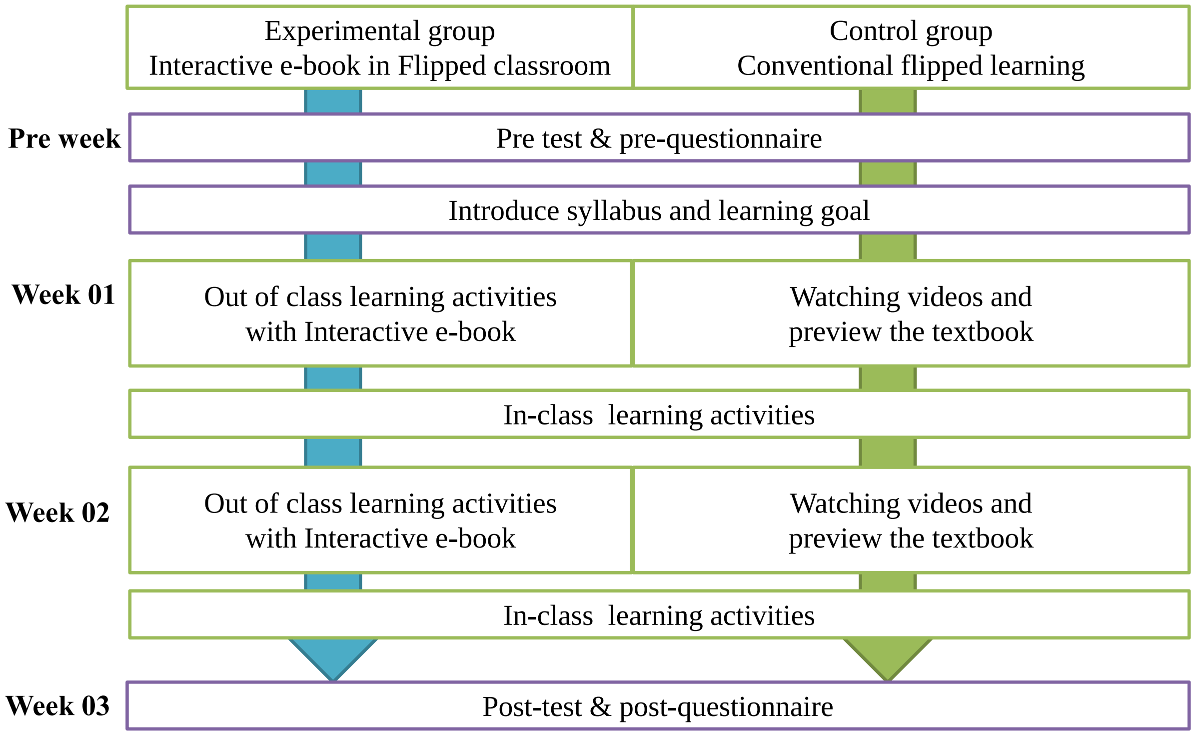

Figure 5. Diagram of the experiment design

During the in-class activities, both group of students learned with the technology-enhanced learning activities, in which the teacher provided remedial instructions based on concepts related to the high-error-rate questions in the out-of-class learning activities and interacted with the students via the electronic whiteboards, as shown in Figure 6. The students' high-error-rate questions were automatically records in the learning system. After the learning activity, all of the students completed the post-test and the post-questionnaire. It should be noted that the post-test items were different from the quiz in the interactive e-books or the questions provided in the learning sheets in the out-of-class stage.

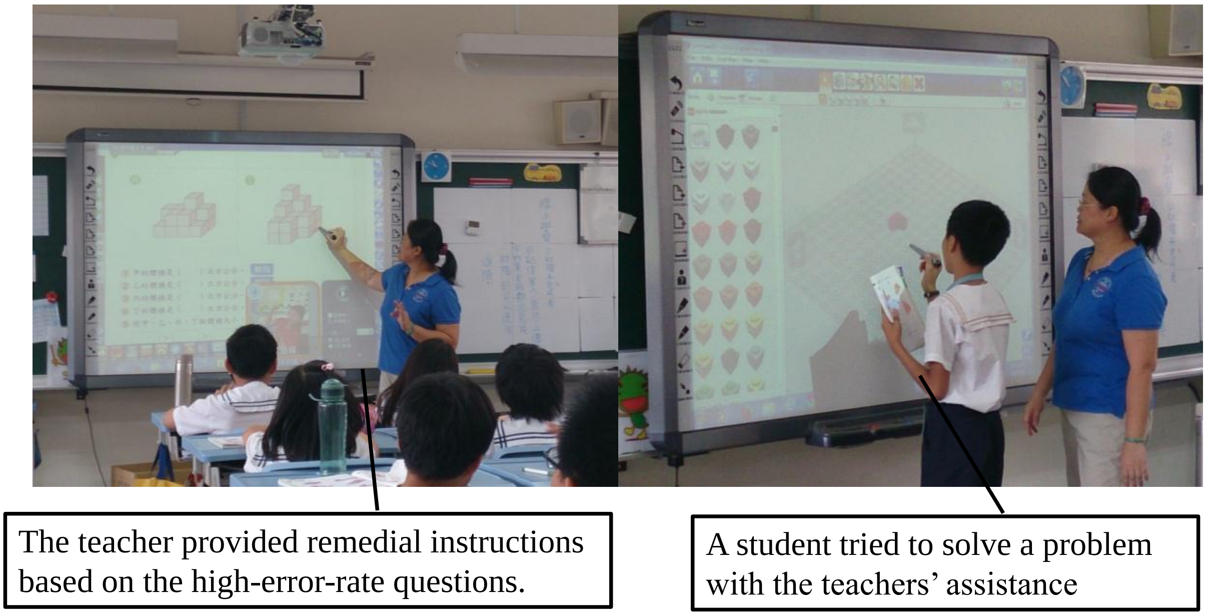

Figure 6. Scenario of the in-class activities

5. Results

5.1 Analysis of Learning achievement

In order to examine the different of learning achievement in two groups, an analysis of covariance (ANCOVA) was conducted. The ANCOVA can be used to adjust for preexisting different in nonequivalent groups, which made the prior knowledge of the two groups more similar (Miller & Chapman, 2001). Table 1 shows the ANCOVA result of the post-test scores of the two groups. The adjusted means and standard error of the ratings were 80.11 and 2.46 for the experimental group, and 71.87 and 2.63 for the control group. It is found that the learning achievement of the two groups are significantly different (F=5.24, p<.05). As the adjusted mean of the experimental group (80.11) was significantly higher than that of the control group (71.87), it is concluded that the interactive e-books supporting in flipped classroom had a significant impact on improving the students' learning achievement regarding the math course.

Table 1. ANCOVA result of the learning achievement post-test of the two groups

Group	N	Mean	S.D.	Adjusted Mean	Std. Error.	F
Experimental group	24	80.50	7.16	80.11	2.46	5.24*
Control group	21	71.43	17.63	71.87	2.63	

* p<.05

5.2 Analysis of meta-cognitive awareness

During the out-of-class learning, the students were engaged in such self-learning activities as learning the concept without teacher's assistance, solving quizzed themselves, and clarifying their misunderstood, and making reflection. Those activities are highly relevant to meta-cognitive awareness, which refers to what individuals know about the cognitive process and status of themselves and others (Schraw & Dennison, 1994).

In this study, the means and standard deviations of the meta-cognitive awareness pre-questionnaire ratings were 3.96 and 0.91 for the experimental group, and 3.63 and 0.80 for the control group. The t-test result shows no significant difference between the pre-questionnaire ratings of the two groups (t=1.28, p > .05), showing that the two groups of students had equivalent meta-cognitive awareness before participating in the learning activity.

Table 2 shows the t-test result of the meta-cognitive awareness post-questionnaire ratings of the two groups. The means and standard errors of the ratings were 3.83 and 0.64 for the experimental group, and 3.38 and 0.80 for the control group. It is found that the post-questionnaire ratings of the two groups are significantly different (t=0.99, p<.05), suggesting that the interactive e-book approach had a significant impact on improving the students' meta-cognitive awareness in the math course.

Table 2. *t*-test result of the meta-cognitive awareness of the two groups

Group	N	Mean	S.D.	*t*
Experimental group	24	3.83	0.64	0.99*
Control group	21	3.38	0.80	

* p<.05

6. Discussion and Conclusion

In order to improve the students' learning performance in the context of the flipped classroom, this study conducted the interactive e-books approach in the flipped learning into students' regular math courses. In order to examine the performance of this study, a quasi-experimental design is adopted and one class is assigned to the experimental group and the other class to the control group. The students in the experimental group learn with this learning approach; while students in the control group learn with the conventional technology-enhanced learning mode. Moreover, some achievement exams were adopted in this study for analyzing students learning performance before and after this experiment.

According to the result, the students' learning achievement in the experimental group has significantly higher than the students in the control group. This result was consisted with Smeets and Bus (2012) that the interactive e-books can promote students learning performance. Moreover, it was consisted with Kong's research (2014) that technology-enhanced flipped classroom can improve the quality of flipped classroom. In sum, it is expected that the future learning mode can be developed in accordance with this learning approach.

On the other hand, the experimental results also show that the proposed approach significantly improved the students' meta-cognitive awareness. It is consisted with some researchers, who have pointed out that engaging students in constructing knowledge by themselves could provide them with more opportunities for self-reflection and deeper thinking in their learning (Akinoglu, 2013; Hwang, Hung, & Chen, 2014).

To sum up, the major contribution of this study is to propose and implement an interactive e-book approach in flipped classroom. In future studies, it is worth recommend that providing more personal and adaptive learning approach to fulfill students' learning in the flipped classroom.

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