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Facilitating and Bridging Out-Of-Class and In-Class Learning: An Interactive E-Book-Based Flipped Learning Approach for Math Courses

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ABSTRACT

Flipped learning is a well-recognized learning mode that reverses the traditional in-class instruction arrangement by delivering learning content outside of the classroom and engaging students in more activities in class. However, it remains a challenge for students to comprehend the learning material by themselves, particularly when learning abstract concepts such as in mathematics. In this study, an interactive e-book approach is proposed to support flipped learning. It facilitates and bridges out-of-class and in-class learning by providing support for interactive learning contents presented on mobile devices. To evaluate the effectiveness of the proposed approach, a quasi-experiment was conducted in an elementary school math course. The experimental group students learned with the interactive e-book approach in the flipped learning activity, while the control group students learned with the conventional video-based flipped learning approach. The experimental results indicated that the proposed approach not only promoted the students' self-efficacy for learning mathematics, but also improved their learning achievement; moreover, it was found that the approach benefited the lower self-efficacy more than the higher self-efficacy students. The learning record analysis further confirmed that the lower self-efficacy students spent more time reading the e-books before and in class than the higher self-efficacy students did.

Keywords

Interactive e-books, Flipped classroom, Flipped learning, Self-efficacy, Mobile technology

Introduction

In recent years, the positive effect of student-centered learning modes has been frequently discussed (Kong, 2015; McLaughlin et al., 2014). Several studies have revealed that this learning mode can improve students' learning achievement and increase the interaction among peers and teachers (Schultz, Duffield, Rasmussen, & Wageman, 2014). Currently, flipped learning is recognized as a learning mode that achieves the goal of student-centered learning, and engages students in meaningful peer-to-peer and peer-to-teacher interactions (Gaughan, 2014; Pierce & Fox, 2012). The learning mode of flipped learning involves students watching and reviewing the learning content before taking a class. The learning content students study was traditionally taught via direct instruction, but students can actually understand the knowledge themselves. Subsequently, by adopting this approach, there is more time for students and teachers to engage in individual and small group learning (i.e., project-based learning, problem-solving, or in-depth discussion) (Gilboy, Heinerichs, & Pazzaglia, 2015).

Some of the studies have already confirmed the advantages of implementing flipped learning in regular courses. For instance, Kong (2015) conducted three years of flipped learning to improve students' critical thinking in Humanities courses. In the flipped learning activities, the students had to preview the learning content on the pre-lesson learning platform, take part in group discussions in class, and then engage in extended learning after class. According to the intervention, it was found that the students' critical thinking abilities were improved, and they spent more time deducting, explaining, and evaluating the knowledge related to their learning. On the other hand, Al-Zahrani (2015) integrated the flipped learning mode into an e-learning course. The findings revealed that the flipped classroom enhanced the students' learning as well as stimulating their creativity when they were discussing or solving problems with their peers.

However, Al-Zahrani's (2015) research also indicated the challenges of flipped learning, including the provision of adequate learning guidance. For instance, in the out-of-class learning activities, some of the learning content was abstract conceptions or was difficult to comprehend, such as mathematics concepts (Kim, Kim, Khera, & Getman, 2014; Kuo, Hwang, & Lee, 2012). Without proper guidance, students might feel helpless and fail to acquire the knowledge they need for the upcoming in-class activities (Mason, Shuman, & Cook, 2013; McLaughlin et al., 2013). Several studies have addressed this issue by analyzing students' learning logs, and providing personalized supports via mobile devices (Ogata et al., 2015; Yin et al., 2015). Hwang, Lai and Wang (2015) further indicated the importance of bridging the out-of-class and in-class learning using mobile technology.

Therefore, in this study, an interactive e-book-based flipped learning approach is proposed. Several functions of this approach were included. For instance, the interactive e-book system consisted of all of the learning material the students have to learn outside the classroom. The students can directly make some annotations on the e-books, which they can then bring to class to share their ideas with their peers and teachers. Moreover, the system records the learning status and notes of all students. The teachers can monitor students' learning status before starting the in-class activities. To exam the effectiveness of the proposed approach, an experiment was conducted to evaluate the effectiveness in terms of students' learning achievement and self-efficacy. In addition, students' learning records in the interactive e-book-based flipped learning are also analyzed and discussed.

Literature review

Flipped classroom and flipped learning

The term "flipped classroom" refers to engaging students in gaining basic knowledge before class, and providing more activities, such as doing exercises or interacting with peers and the teacher in class (Pierce & Fox, 2012). It reverses the traditional arrangement of delivering basic knowledge in class to the time outside the classroom. Moreover, it replaces the time of in-class lecturing with peer-to-peer or peer-to-teacher interactions which can effectively solve students' learning problems and provide them with more opportunities to apply the knowledge (Bergmann & Sams, 2012; Davies, Dean, & Ball, 2013). Bergmann and Sams (2014) further defined the term "flipped learning" by emphasizing the importance of designing in-class learning activities to engage students in higher order thinking. It allows teachers to implement multiple learning strategies in their classroom, and creates a dynamic and interactive learning environment for students to apply knowledge and engage in project-based learning or inquiry learning (Bergmann & Sams, 2015).

The concept of the flipped classroom or flipped learning has been applied to various courses in recent years (Slomanson, 2014; Teo, Tan, Yan, Teo, & Yeo, 2014). For instance, Mason et al. (2013) applied the flipped classroom to a pharmaceutical course. In the study, the researchers divided the activities into two learning processes: out-of-class and in-class learning. In the out-of-class learning process, the students were asked to watch the video lecture before taking the class. In the in-class activities, the students had some group discussion and problem solving activities related to their learning contents. Mason et al. (2013) reported that the students who participated in the flipped classroom had more peer interaction in class. According to the qualitative analysis, it was found that they felt confident in learning, and experienced more engagement with the flipped classroom than with the traditional instruction. Teo et al. (2014) also conducted flipped learning in a chemistry course. There were three stages in the flipped classroom. The first was a home activity, in which the students had to watch videos and answer some related questions designed by the teacher. The second stage was the class activity. The teacher spent 15 minutes instructing the important concepts related to the students' home activity. After that, there was laboratory work which required the students to manipulate equipment, handle materials, and make observations of the science phenomena. In the last stage, the students had to finish their laboratory report at home. This result showed that they had better understanding of the chemical theories and were able to comprehend the complex practical procedures. Moreover, the findings implied that the flipped classroom learning mode can reduce the students' learning anxiety and improve their work efficiency (Teo et al., 2014).

However, previous studies have indicated the challenges of conducting an effective flipped classroom and flipped learning (Al-Zahrani, 2015; Gaughan, 2014). Several studies have asserted that teachers need to put a great deal of effort into providing adequate guidance for students to learn outside the classroom. With proper learning guidance, students can understand the real meaning of the learning content before class (Kim et al., 2014; Strayer, 2012). Moreover, they can concentrate on their self-directed learning process and achieve the expected goals of the flipped classroom, rather than being distracted by some useless information from irrelevant websites or platforms (Rahimi, van den Berg, & Veen, 2015).

The advancement of technologies and multimedia electronic materials (i.e., e-books, cloud computing services, handheld devices) has provided an opportunity to achieve the goals of the flipped classroom and flipped learning (Kong & Song, 2015; Hwang et al., 2015). E-books consist of various kinds of multimedia that engage students in learning with quality and well-organized content. In addition, via cloud computing services, students' learning logs can be recorded and analyzed, and hence learning support can be provided (Hwang et al., 2015; Sandberg, Maris, & Hoogendoorn, 2014).

E-books as a support for guiding students' learning

E-books represent a combination of the conventional figures in printed books and interactive computing technologies (Smeets & Bus, 2012). This kind of technology can be helpful for students who do not perform well with traditional textbooks (Maynard, 2010; Shamir & Shlafer, 2011; Yang, Hwang, Hung, & Tseng, 2013). In addition, some of the benefits of e-books have been identified: students can access digital content through e-books anytime and anywhere. E-books also offer a solution to the problem of the conventional dull instruction as they provide an opportunity for students to interact with the learning content (Jou, Tennyson, Wang, & Huang, 2016).

Previous studies have addressed several benefits of e-books integrated into education. For instance, Ihmeideh (2014) developed e-books to improve students' emergent literacy skills. The results indicated that the students' literacy skills were better than those of students who studied with regular printed books. In addition, the study further found that the students who learned with e-books significantly performed better in several emergent literacy aspects, such as print awareness and vocabulary. On the other hand, Huang and Liang (2015) discussed the relation of actual e-book reading behaviors and students' comprehension outcomes. The result indicated that the reading rate of the students can reflect their reading behaviors and is further associated with students' comprehension outcomes. This study further proved that the students' reading process with the e-books can be analyzed and interpreted, which is much more difficult when students are studying with printed books.

According to the literature, the flipped classroom has been recognized as an innovative learning mode which leads students to apply knowledge and achieve their learning objectives (Galway, Corbett, Takaro, Tairyan, & Frank, 2014). Some research has further indicated that the incorporation of e-books in students' learning can provide adequate guidance and improve their learning performance (Strayer, 2012). In addition, the students' learning behaviors can be easily recorded, which assists teachers and educators in understanding their learning in depth.

Therefore, in this study, an interactive e-book-based flipped learning approach is proposed for assisting students' learning outside of the classroom, and helping them bring their knowledge to their in-class discussion. Moreover, some research questions are investigated to evaluate the effectiveness of the proposed approach:

- Can the interactive e-book-based flipped learning approach improve the students' learning achievement in comparison with the conventional video-based flipped learning?
- Can the interactive e-book-based flipped learning approach improve the students' self-efficacy in comparison with the conventional video-based flipped learning?
- Are there differences between the learning frequency of the lower self-efficacy and higher self-efficacy students in learning with the interactive e-book-based flipped learning approach?

Interactive e-book environment for flipped learning

In this study, an interactive e-book-based flipped learning environment was developed with HamaStar SimMAGIC Designer and HamaStar SimMAGIC CLibrary. The structure of the proposed approach is composed of three components, namely cloud equipment, cloud resources, and cloud services, as shown in Figure 1. The cloud equipment consists of the system software, physical hardware, and network devices and environment. More specifically, the system software refers to the software which the teachers can use to develop their courses related to e-books, while the platform refers to where they can manage their online learning contents. Besides, the cloud resources provide the students with the learning material, the e-books, and related learning tasks. Those learning materials and resources on the cloud resources layer can be uploaded and managed by the teachers. Finally, the cloud services provide public or personal information to both teachers and students. The public information consists of the e-books that are available for every user, while the personal information represents the individuals' readings, their personal learning logs, and performance of the tasks. The information sharing service is also provided for the students or teachers to share their notes or tasks with a specific user. In the cloud services layer, the students can manage their readings and see their learning logs. In the meantime, the teachers can also monitor their students' learning logs and assign adaptive readings for a particular student.

Figure 2 shows the interface of interactive e-books. When the students log into the e-book system, they can search for the books they want to read or check the "assigned books" to access the e-books they are required to read. Once the e-books have been downloaded to the students' personal tablets, they can read them offline in "my bookcase."

Figure 1. Structure of the e-book library supporting the flipped learning

Figure 2. Interface of the e-book library

Figure 3. Interface of the e-books

As soon as the students select an e-book to read, it opens, as shown in Figure 3. A toolbar is hidden on the left side of the e-book, so the students can open it when they need it. A number of functions are included in the toolbar, such as bookmark, search, brush, text, take notes, share note, etc.

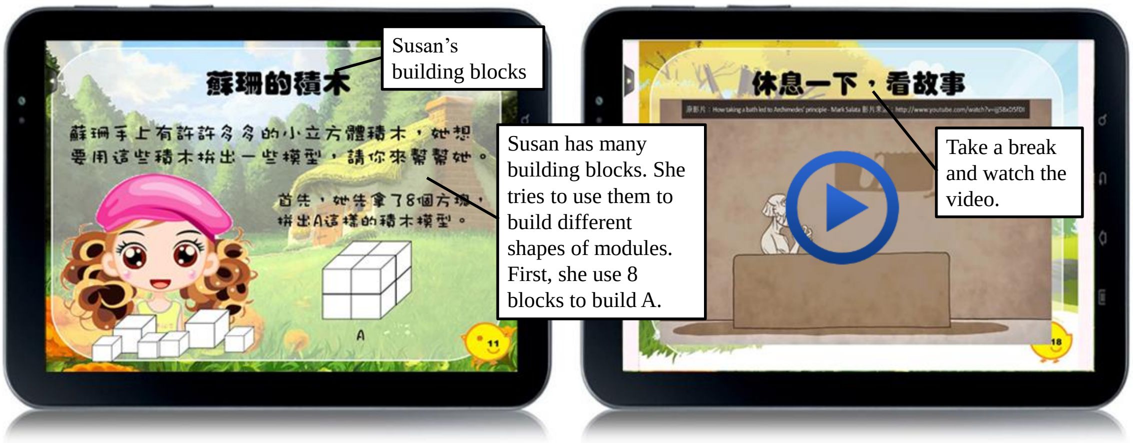

Figure 4. The e-book knowledge description and video watching functions

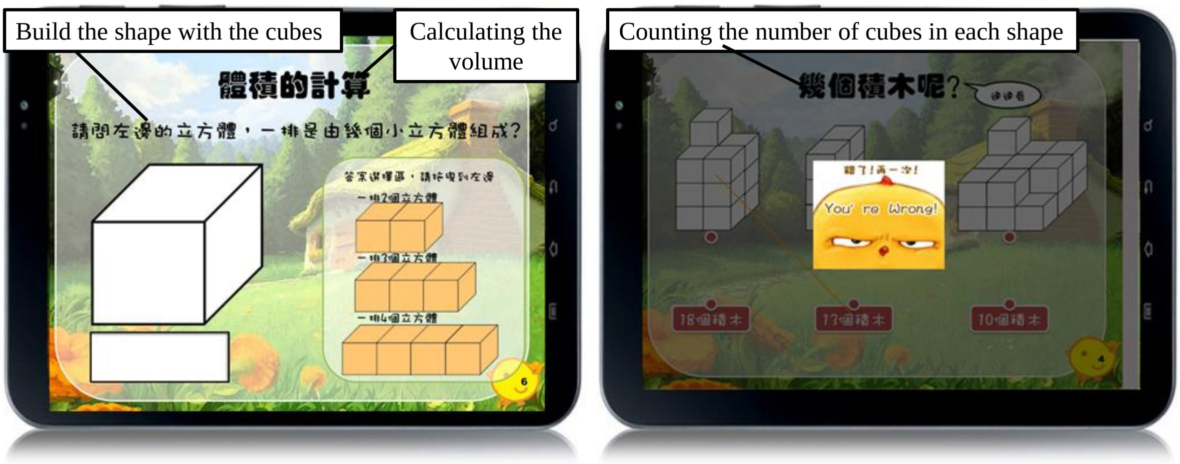

Figure 5. The interactive feedback provided to the students

Figure 4 shows the interface of the e-books and some knowledge descriptions and videos provided by the teachers in the e-books. The students can learn those learning materials wherever they are. Moreover, some of the learning tasks developed by the teachers were also embedded in the corresponding e-books. In other words, the students can learn the knowledge and solve the learning tasks on the same platform. Moreover, some interactive feedback is provided to the students when they fail the tasks, as shown in Figure 5.

Figure 6. Interface of sharing notes during the learning process

The students can not only read the learning content and complete the learning tasks, but can also take some notes during the learning process. For instance, they can use the brush to mark any concepts they have trouble understanding, and they can write some notes on the e-books. In the meantime, they can share their notes with their peers. More importantly, they are allowed to bring the e-books along with the notes they have taken to class so as to facilitate their learning in the forthcoming in-class activities. Figure 6 shows the interface which allows the students to read others' notes. The students can choose the function "read others' note" on the toolbar and select a specific student's notes. The system then downloads the selected student's e-book including his/her notes, so that the students can directly read the e-book and the notes made by others.

The e-book system also provides an additional function for teachers to realize the learning status of the students, so that proper in-class remedial instruction or activities can be provided accordingly. For example, the number of mistakes students make in solving each math question at home after learning with the e-book are recorded and summarized to help teachers determine whether additional instructions are needed in the class, as shown in Figure 7.

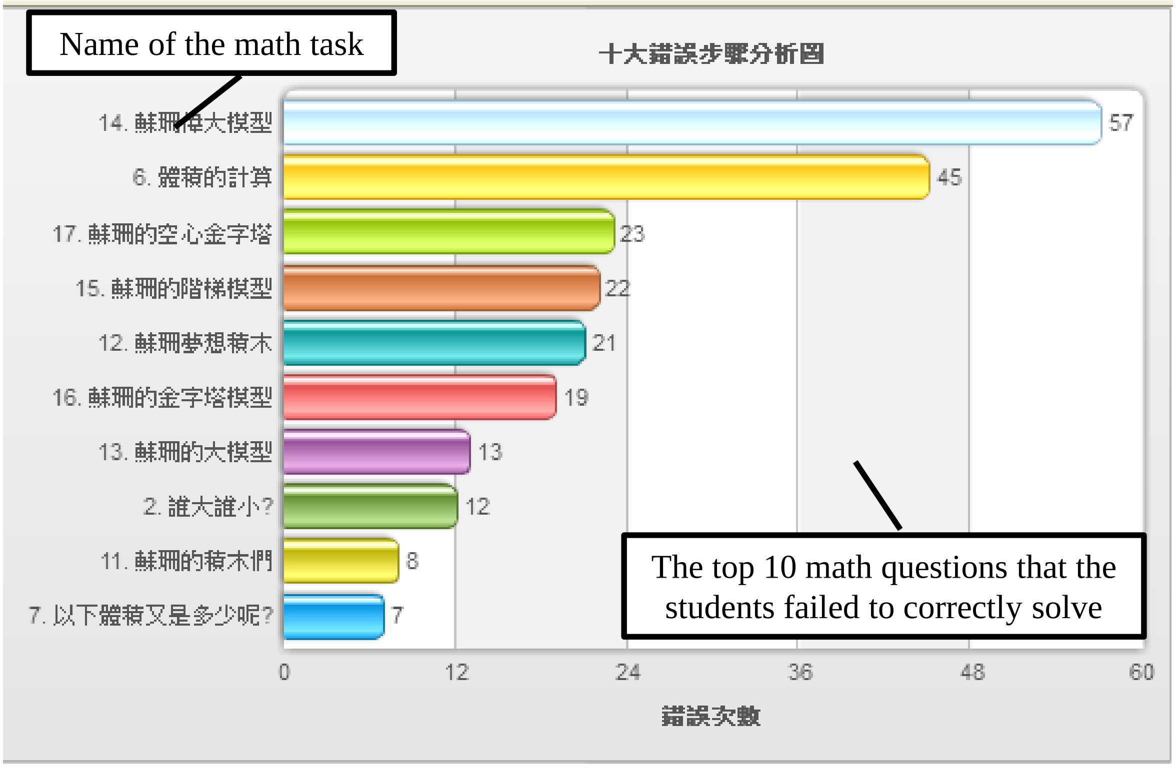

Figure 7. Summary of students' at-home learning status

Experimental design

To evaluate the effectiveness of the interactive e-book-based flipped learning approach, an experiment was conducted in an elementary school math course to investigate the effects of the approach on the students' learning achievement and self-efficacy. Moreover, the students' learning records were analyzed as well.

Participants

The participants of this study included two classes of fourth-grade students. One class was assigned to the experimental group and the other was the control group. The experimental group consisted of 24 students learning with the interactive e-book-based flipped learning; that is, the instructional videos, quizzes and learning guidance provided by the teacher were integrated into e-books. On the other hand, the control group students (n = 21) learned with the conventional video-based flipped learning approach. They learned with the instructional videos with printed learning sheets provided by the same teacher.

Instrument

The measurement instruments adopted in this study included the pre-test, post-test, and the questionnaire of self-efficacy.

The pre-test and post-test were developed by three experienced teachers. The pre-test aimed to evaluate whether the two groups of students had equivalent prior knowledge of the “Area and perimeter” concept of their math courses. It consisted of 5 multiple-choice items, 2 matching items, 7 fill-in-the-blank items, and 10 question-and-answer items, with a perfect score of 100. The post-test aimed to evaluate the students’ knowledge and competence of identifying various volumes and calculating complex volumes. It consisted of 10 multiple-choice items (50%), 5 matching items (25%), and 5 question-and-answer items (25%), and the perfect score of the post-test was 100.

On the other hand, the questionnaire of self-efficacy was modified from the measurement developed by Wang and Hwang (2012). It consisted of eight items with a five-point Likert scale. This questionnaire can be utilized for measuring the students’ expectations and confidence regarding learning the math course content well (e.g., “I believe that I can understand the most difficult part of this course”). The Cronbach’s alpha value of the questionnaire was 0.92, implying that the questionnaire is reliable.

Experimental procedure

Figure 8 shows the four-week experimental procedure. In the first week, the students in the two groups took the pre-test and completed the self-efficacy pre-questionnaire. Moreover, the teacher introduced the syllabus and the learning objectives. After that, the experimental group students learned with the interactive e-book in their out-of-class time, while the control group students learned with the conventional online videos with learning sheets provided by the teacher.

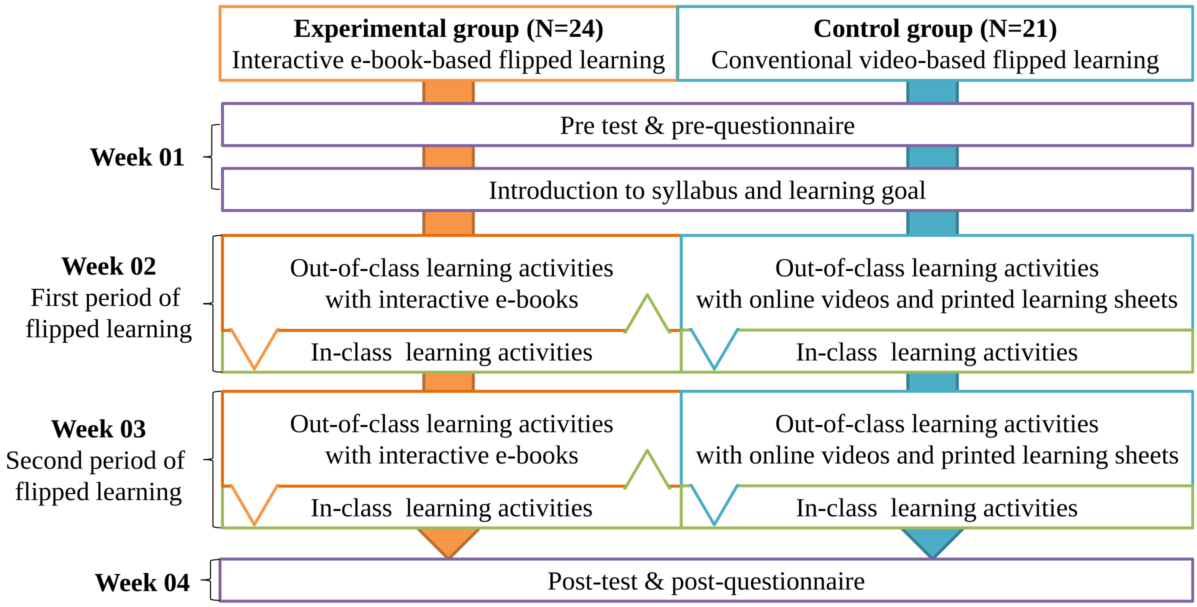

Figure 8. Diagram of the experiment design

Following the school curriculum arrangement, there were two 50-minute periods of in-class learning activities each week. In the in-class activities, the experimental group students brought their tablet computers with the annotated e-books, while the control group students brought their printed learning sheets with the notes they had taken. Both groups of students participated in the group discussion based on the same guideline provided by the teacher. In addition, they were asked to raise problems they had encountered in the out-of-class activities. Then, the teacher would encourage other classmates to solve the problems using electronic whiteboards, as shown in Figure 9. In the fourth week, the students took the post-test and the post-questionnaire of self-efficacy.

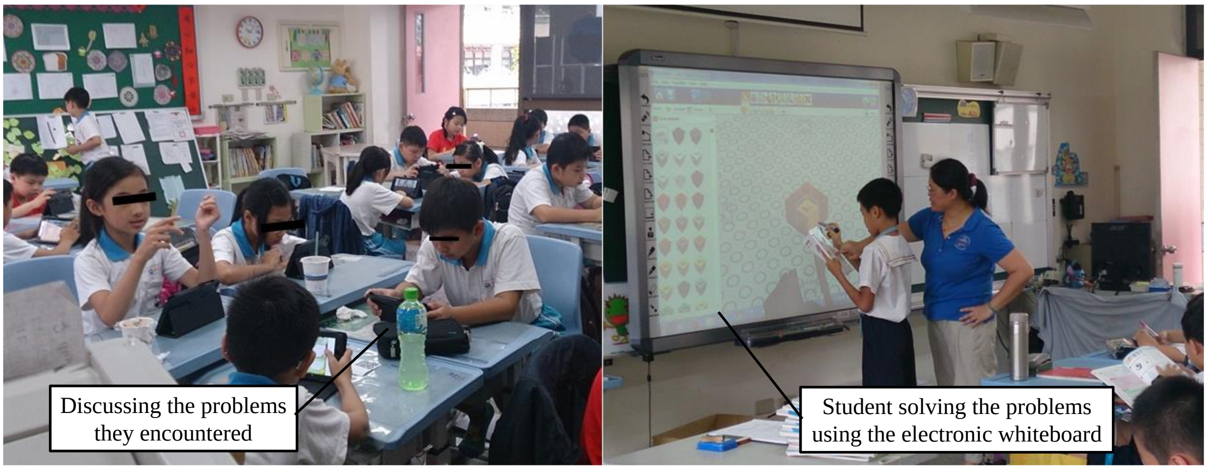

Figure 9. Scenario of the in-class activities

Results

In this study, an interactive e-book-based flipped learning approach was proposed to support students in a flipped learning context. In order to evaluate the effects of this approach, a quasi-experiment was conducted to investigate the effects of the proposed approach on students' learning achievement and self-efficacy. Moreover, the students' learning behavior regarding the e-books is further discussed.

Analysis of learning achievement

In order to examine the effects of the proposed approach, the students' learning achievement before and after the experiment was explored. The mean values and standard deviations of the pre-test scores were 82.69 and 9.67 for the experimental group students, and 80.57 and 17.79 for the control group students. The t-test shows that there was no significant difference between the two groups (t = 0.50, p > .05), indicating the equivalent prior knowledge of the two groups of students before engaging in the learning activity.

After the students finished the flipped learning activities, the post-test was conducted to evaluate the students' learning knowledge and capabilities of identifying various volumes and calculating those volumes. Table 1 shows the t-test result of the post-test scores of the two groups. The means and standard deviations were 80.92 and 5.69 for the experimental group students, and 74.76 and 10.31 for the control group students. The t-test result indicated that the post-test scores of the two groups were significantly different (t = 2.43, p < .05, Cohen'd = 0.74). Furthermore, the effect size (d) was 0.74, showing a medium to large effect (Cohen, 1988).

Table 1. The t-test result of the post-test scores of the two groups

Variable	Group	*N*	Mean	*SD*	*T*	*D*
Post-test	Experimental group	24	80.92	5.69	2.43^{*}	0.74
	Control group	21	74.76	10.31		

Note. $^{*}p < .05$.

On the other hand, the students' self-efficacy can be regarded as the criteria of their capabilities of organizing and executing the course and further achieving certain goals of learning, which has high correlation with their learning achievement (Bandura, 1977; Wang & Wu, 2008). Therefore, this study further explored the effects of this approach on the learning achievement of the students with different self-efficacy levels. A two-way ANOVA was further employed to evaluate the interaction between the different learning approaches (interactive e-book-based flipped learning and conventional video-based flipped learning) and different self-efficacy levels (higher and lower). The students were classified into high and low self-efficacy groups based on their self-efficacy ratings on the pre-questionnaire. The students in the top 50% were regarded as having higher self-efficacy, while the others had lower self-efficacy. The independent variables were the two learning approaches (i.e., interactive e-book-based flipped learning and conventional video-based flipped learning) and two levels (i.e., higher and lower) of self-efficacy, while the dependent variable was the students' learning achievement. The assumption of homogeneity of regression was not violated (F = 2.25, p > .05), suggesting that a common regression coefficient was appropriate for the two-way ANOVA.

Table 2 shows the two-way ANOVA results of the learning achievement. It was found that significant effects were observed for the learning approaches (F = 5.27, p < .05), self-efficacy (F = 6.08, p < .05), and the interaction between the learning approaches and self-efficacy (F = 4.81, p < .05) on the students' learning achievement. Furthermore, the effect sizes (η^2) were 0.11, 0.13, and 0.11 for each variable, representing a moderate effect size (Cohen, 1988).

Table 2. The two-way ANOVA result of the learning achievement

Variable	*SS*	*df*	MS	*F*	*P*	η^2
Learning approach	292.49	1	292.49	5.27	0.03	0.11
Self-efficacy	337.12	1	337.12	6.08	0.02	0.13
Learning approach*Self-efficacy	266.93	1	266.93	4.81	0.03	0.11
Error	2274.31	41	55.47			

A simple main-effect analysis was further employed to explore the effects of the self-efficacy levels on the learning achievement of the students who learned with different flipped learning approaches, as shown in Table 3. It was found that the students with different self-efficacy levels in the control group showed significantly different learning achievement (F = 10.66, p < .01, η^2 = 0.21). On the other hand, there was no significant difference between the students in the experimental group who had different levels of self-efficacy (F= 0.04, p > .05). These results indicate that the engagement of students' self-efficacy levels only played an important role when students were learning with the conventional video-based flipped learning. In other words, with the assistance of interactive e-books, fewer effects of the students' learning efficacy on their achievement would occur.

Table 3. Simple main-effect analysis results of self-efficacy levels on students' learning achievement

Variable		*SS*	*df*	MS	*F*	*p*	η^2
Interactive e-book-based flipped learning (experimental group)	Between groups	2.08	1	2.08	0.04	0.85	
	Within groups	2274.31	41	55.47			
	Total	2276.39	42				
Conventional video-based flipped learning (control group)	Between groups	591.25	1	591.25	10.66	0.002	0.21
	Within groups	2274.31	41	55.47			
	Total	2864.56	42				

Table 4 shows the simple main-effect analysis results of the effects of the learning approaches on the learning achievement of the students with different self-efficacy levels. It was found that the lower self-efficacy students showed significantly different learning achievements when learning with different approaches (F = 9.24, p < .01, η^2 = 0.18), while there was no significant difference between higher self-efficacy students with different learning approaches (F = 0.01, p > .05). According to the results, it is implied that the interactive e-book-based flipped learning approach could benefit the students who engaged in lower self-efficacy more than those with higher self-efficacy.

Table 4. Simple main-effect analysis results of learning approach on students' learning achievements

Variable		*SS*	*df*	MS	*F*	*p*	η^2
Higher self-efficacy	Between groups	0.32	1	0.32	0.01	0.94	
	Within groups	2274.31	41	55.47			
	Total	2274.63	42				
Lower self-efficacy	Between groups	512.53	1	512.53	9.24	0.004	0.18
	Within groups	2274.31	41	55.47			
	Total	2786.84	42				

Figure 10 shows the interaction between the different flipped learning approaches and the self-efficacy levels on the students' learning achievements. It was clearly found that the students who learned with the interactive e-book-based flipped learning performed significantly better than those who learned with the conventional flipped classroom approach. Moreover, while learning with the conventional video-based flipped learning, the students who had higher self-efficacy showed significantly higher achievement than those with lower self-efficacy. These results imply that students' self-efficacy plays an important role when they are learning in the conventional video-based flipped learning context. Their self-efficacy performance has a certain positive impact on their learning achievement. On the other hand, there was no difference found in the students' learning achievement in the different self-efficacy levels in the experimental group, indicating that the interactive e-book-based flipped learning approach can support students' learning and improve their learning achievement, regardless of whether the students have higher- or lower-level self-efficacy.

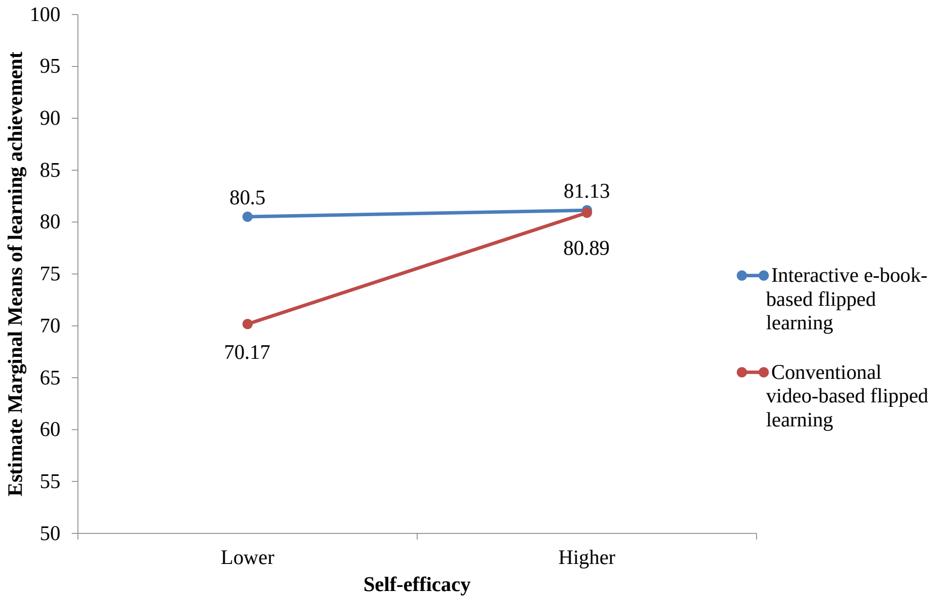

Figure 10. Interaction between self-efficacy levels and learning approaches

Analysis of self-efficacy

In order to evaluate the effects of the interactive e-book-based flipped learning on students' self-efficacy beliefs, in this study, the students' self-efficacy before and after the experiment was collected. Furthermore, a one-way ANCOVA examination of the students' self-efficacy in the experimental group and the control group was adopted. The assumption of homogeneity of regression was not violated ($F = 2.11$, $p > .05$), showing a common regression coefficient for one-way ANCOVA. Table 5 shows the results of self-efficacy for the two groups. The adjusted means of the values were 3.98 in the experimental group and 3.60 in the control group. The standard errors of the two groups were 0.12 and 0.13, respectively. According to the ANCOVA result, it was found that the self-efficacy of the experimental group was significantly higher than that of the control group ($F = 4.57$, $p < .05$, $\eta^2 = 0.10$). This result implies that the interactive e-book-based flipped learning approach can stimulate the students to have stronger beliefs in learning than the conventional flipped classroom.

Table 5. The one-way ANCOVA of the students' self-efficacy

Group	*N*	Mean	*SD*	Adjusted Mean	Adjusted SD	*F*	η2
Experimental group	24	4.00	0.66	3.98	0.12	4.57^{*}	0.10
Control group	21	3.58	0.51	3.60	0.13		

Note. $^{*}p < .05$.

Analysis of the e-book learning records

In order to understand the students' learning behaviors in the interactive e-book-based flipped learning, this study further analyzed the experimental group students' learning records in the interactive e-books. The interactive e-book system automatically recorded the students' reading frequency and reading time of each interactive e-book. This study, therefore, classified the students' learning records based on their ratings of self-efficacy on the pre-questionnaire (higher self-efficacy and lower self-efficacy). The values of the students' self-efficacy higher than the mean value (3.81) were regarded as higher self-efficacy, while the others were considered as lower self-efficacy. Moreover, we separately discuss the students' learning frequency in the first period of the flipped classroom (unit 1 e-book reading) and the second period (unit 2 e-book reading). Figure 11 shows the learning records of the students in the different self-efficacy levels for each e-book, where Si represents student identification.

According to the learning records, the students with higher self-efficacy spent 19.57 minutes on average reading the unit 1 e-book, while the students with lower self-efficacy spent 18.05 minutes on average. On the other hand, 72% of the higher self-efficacy students read the unit 1 e-book more than two times, while 75% of the lower self-efficacy students read the unit 1 e-book more than two times.

Compared to the unit 1 reading, the students with higher self-efficacy spent 17.80 minutes on average reading unit 2. Just over half of the higher self-efficacy students (55.56%) read the unit 2 e-book more than two times, which was significantly less than their reading of the unit 1 e-book. The lower self-efficacy students, on the other hand, spent 21.05 minutes on average reading the unit 2 e-book, and more than 62.50% of the lower self-efficacy students read the unit 2 e-book more than two times.

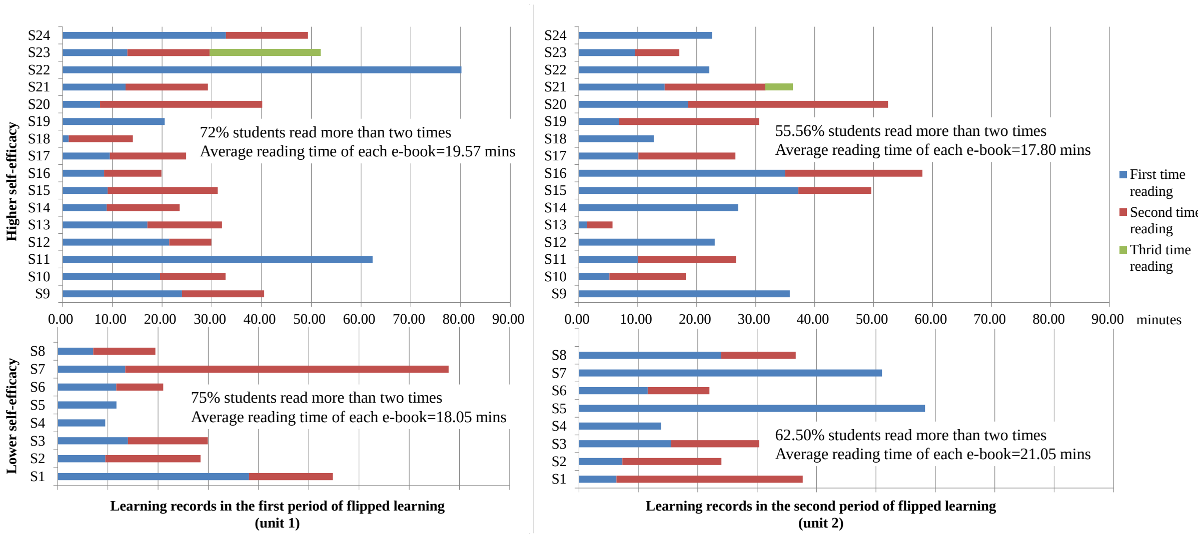

Figure 11. Learning frequency of the e-books of the students in different self-efficacy levels

According to the learning records, some conclusions can be drawn. First, no matter whether the students had higher or lower self-efficacy, far fewer students read the unit 2 e-book more than two times compared with the unit 1 e-book. Second, the average reading time of the two e-books slightly decreased for the higher self-efficacy students, while it slightly increased for the lower self-efficacy students. Third, the proportion of the lower self-efficacy students who read the unit 2 e-book more than two times was higher than the proportion of higher self-efficacy students who did.

Discussion and conclusions

In recent years, the implementation of flipped learning has been frequently discussed. Some of the research has proved the advantages of flipping the classroom, and its benefits for the students' learning performance (Hung, 2015; Wanner & Palmer, 2015). However, several studies have indicated the importance of providing multimedia and proper learning guidance for supporting and bridging the in-class and out-of-class activities (Al-Zahrani, 2015; Strayer, 2012). In order to achieve this purpose, in this study, an interactive e-book-based flipped learning approach was proposed for students to learn abstract mathematical conceptions. In this learning mode, students can read multimedia materials and preview the learning content in the interactive e-book system, and make their own annotations on the e-books. In the in-class activities, the students can bring all the learning content and annotations they have made to class, and have in-depth discussions with their teachers or classmates. An experiment was conducted in an elementary school to examine the proposed learning approach. The experimental group used the interactive e-book-based flipped learning approach, while the control group learned with the conventional video-based flipped learning approach. The experimental results showed that the proposed approach significantly benefited the students' learning achievement and self-efficacy.

This finding proved that the interactive e-book system can benefit students in a flipped learning context, and encourages students to construct knowledge by themselves. This result is consistent with previous studies which found that the provision of e-books in learning can improve students' learning achievement and increase their confidence in learning (Huang, Liang, Su, & Chen, 2012). Moreover, the findings of this study suggest the need to provide proper guidance and support for bridging out-of-class and in-class learning (Hung, 2015; McLaughlin et al., 2013).

According to the results of simple main-effect of self-efficacy levels on students' learning achievement, it was found that the interactive e-book-based flipped learning improved the students' learning achievement regardless of whether they had higher- or lower-level self-efficacy. In the conventional video-based flipped learning, it was found that the higher self-efficacy students outperformed the lower self-efficacy students. These results indicate that students' self-efficacy in math learning plays an important role in flipped learning, and teachers need to pay more attention to those students with lower self-efficacy when conducting conventional flipped learning.

On the other hand, the simple main-effect of learning approach on students' learning achievement revealed a significant difference for lower self-efficacy students who learned with the different learning approaches, but this difference was not found for the higher self-efficacy students. In the social cognitive theory, Bandura (1986) described the reciprocity of learners' behaviors, personal factors and environments, and indicated that environmental factors would determine students' learning behaviors and influence their efficacy beliefs (van Dinther, Dochy, & Segers, 2011). In the current study, the environmental intervention of the interactive e-books approach also confirmed this theory. Since the students who had higher self-efficacy already had higher cognitive engagement in learning, it was certain that the higher self-efficacy students were able to adopt better strategies for learning (Tsai, Ho, Liang, & Lin, 2011). On the contrary, students who have lower self-efficacy usually engage in self-devaluation, and are depressed or may withdraw from learning (Bandura, 2009). However, in this study, it was interesting to find that the learning achievement of the lower self-efficacy students was as good as that of the higher self-efficacy students when learning with the interactive e-book-based flipped learning. The e-book logs further showed that the lower self-efficacy students' learning frequency for unit 1 and unit 2 was stable. Moreover, they spent more time learning unit 2. These results reveal that the interactive e-book-based flipped learning approach stimulated the lower self-efficacy students to spend more time reading.

The effectiveness of the proposed approach could be due to the fact that it successfully served as guidance to support and bridge the students' learning outside and within the classroom; this was indicated by Hwang et al. (2015) who argued that "seamless flipped learning" could benefit students by improving their learning performance. In the current study, the annotation function and cloud services in the interactive e-book environment allowed the students to bring all of the learning content, the annotations they made, and the questions they raised during the out-of-class and in-class activities with them. Therefore, they could seamlessly and continuously review, construct, and practice their learning knowledge across the learning contexts.

In sum, the main contribution of this study is to show the effectiveness of "seamless flipped learning," which refers to the use of mobile technology to bridge the out-of-class and in-class learning by providing learning supports in the class based on the students' out-of-class learning status, as well as allowing them to bring what they have learned at home to the in-class activities. In the future, note-recommendation and advanced visualization functions can be implemented in the e-book system based on learning log analysis to better assist students and teachers, as indicated by several researchers (Aljohani & Davis, 2012; Mouri & Ogata, 2015).

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References

Aljohani, N. R., & Davis, H. C. (2012). Significance of learning analytics in enhancing the mobile and pervasive learning environments. In *Sixth International Conference on Next Generation Mobile Applications, Services and Technologies (NGMAST)* (pp. 70-74). doi:10.1109/NGMAST.2012.49

Al-Zahrani, A. M. (2015). From passive to active: The Impact of the flipped classroom through social learning platforms on higher education students' creative thinking. *British Journal of Educational Technology, 46*(6), 1133-1148.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Bandura, A. (1986). *Social foundations of thought and action: A Social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (2009). Cultivate self-efficacy for personal and organizational effectiveness. In E. A. Locke (Ed.), *Handbook of principles of organization behavior* (2nd ed., pp. 179-200). New York, NY: Wiley.

Bergmann, J., & Sams, A. (2012). *Flip your classroom: Reach every student in every class every day*. Washington, DC: International Society for Technology in Education.

Bergmann, J., & Sams, A. (2014). *Flipped learning: Gateway to student engagement*. Washington, DC: International Society for Technology in Education.

Bergmann, J., & Sams, A. (2015). *Flipped learning for math instruction (The Flipped learning series)*. Washington, DC: International Society for Technology in Education.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). New Jersey, NJ: Lawrence Erlbaum Associates.

Davies, R. S., Dean, D. L., & Ball, N. (2013). Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course. *Educational Technology Research and Development, 61*(4), 563-580.

Galway, L. P., Corbett, K. K., Takaro, T. K., Tairyan, K., & Frank, E. (2014). A Novel integration of online and flipped classroom instructional models in public health higher education. *BMC medical education, 14*(1), 1.

Gaughan, J. E. (2014). The Flipped classroom in world history. *The History Teacher, 47*(2), 221-244.

Gilboy, M. B., Heinerichs, S., & Pazzaglia, G. (2015). Enhancing student engagement using the flipped classroom. *Journal of Nutrition Education and Behavior, 47*(1), 109-114.

Huang, Y. M., & Liang, T. H. (2015). A Technique for tracking the reading rate to identify the e-book reading behaviors and comprehension outcomes of elementary school students. *British Journal of Educational Technology, 46*(4), 864-876.

Huang, Y. M., Liang, T. H., Su, Y. N., & Chen, N. S. (2012). Empowering personalized learning with an interactive e-book learning system for elementary school students. *Educational Technology Research and Development, 60*(4), 703-722.

Hung, H. T. (2015). Flipping the classroom for English language learners to foster active learning. *Computer Assisted Language Learning, 28*(1), 81-96.

Hwang, G. J., Lai, C. L., & Wang, S. Y. (2015). Seamless flipped learning: A Mobile technology-enhanced flipped classroom with effective learning strategies. *Journal of Computers in Education, 2*(4), 449-473.

Ihmeideh, F. M. (2014). The Effect of electronic books on enhancing emergent literacy skills of pre-school children. *Computers & Education, 79*, 40-48.

Jou, M., Tennyson, R. D., Wang, J., & Huang, S. Y. (2016). A Study on the usability of E-books and APP in engineering courses: A Case study on mechanical drawing. *Computers & Education, 92*, 181-193.

Kim, M. K., Kim, S. M., Khera, O., & Getman, J. (2014). The Experience of three flipped classrooms in an urban university: An Exploration of design principles. *The Internet and Higher Education, 22*, 37-50.

Kong, S. C. (2015). An Experience of a three-year study on the development of critical thinking skills in flipped secondary classrooms with pedagogical and technological support. *Computers & Education, 89*, 16-31.

Kong, S. C., & Song, Y. J. (2015). An Experience of personalized learning hub initiative embedding BYOD for reflective engagement in higher education. *Computers & Education, 88*, 227-240.

Kuo, F. R., Hwang, G. J., & Lee, C. C. (2012). A Hybrid approach to promoting students' web-based problem-solving competence and learning attitude. *Computers & Education, 58*(1), 351-364.

Mason, G. S., Shuman, T. R., & Cook, K. E. (2013). Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course. *IEEE Transactions on Education, 56*(4), 430-435.

Maynard, S. (2010). The Impact of e-books on young children's reading habits. *Publishing Research Quarterly, 26*(4), 236-248.

McLaughlin, J. E., Griffin, L. M., Esserman, D. A., Davidson, C. A., Glatt, D. M., Roth, M. T., Gharkholonarehe, N., & Mumper, R. J. (2013). Pharmacy student engagement, performance, and perception in a flipped satellite classroom. *American Journal of Pharmaceutical Education, 77*(9), 196.

McLaughlin, J. E., Roth, M. T., Glatt, D. M., Gharkholonarehe, N., Davidson, C. A., Griffin, L. M., Esserman, D. A., & Mumper, R. J. (2014). The Flipped Classroom: A Course Redesign to Foster Learning and Engagement in a Health Professions School. *Academic Medicine, 89*(2), 236-243.

Mouri, K., & Ogata, H. (2015). Ubiquitous learning analytics in the real-world language learning. *Smart Learning Environments, 2*(1), 1-18.

Ogata, H., Yin, C., Oi, M., Okubo, F., Shimada, A., Kojima, K., & Yamada, M. (2015). E-Book-based learning analytics in university education. In H. Ogata et al. (Eds.), *Proceedings of 23rd International Conference on Computer in Education* (pp. 401-406). Hangzhou, China: Asia-Pacific Society for Computers in Education

Pierce, R., & Fox, J. (2012). Vodcasts and active-learning exercises in a "flipped classroom" model of a renal pharmacotherapy Module. *American Journal of Pharmaceutical Education, 76*(10), 196.

Rahimi, E., van den Berg, J., & Veen, W. (2015). Facilitating student-driven constructing of learning environments using Web 2.0 personal learning environments. *Computers & Education, 81*, 235-246.

Sandberg, J., Maris, M., & Hoogendoorn, P. (2014). The Added value of a gaming context and intelligent adaptation for a mobile learning application for vocabulary learning. *Computers & Education, 76*, 119-130.

Schultz, D., Duffield, S., Rasmussen, S. C., & Wageman, J. (2014). Effects of the flipped classroom model on student performance for advanced placement high school chemistry students. *Journal of Chemical Education, 91*(9), 1334-1339.

Shamir, A., & Shlafer, I. (2011). E-books effectiveness in promoting phonological awareness and concept about print: A Comparison between children at risk for learning disabilities and typically developing kindergarteners. *Computers & Education, 57*(3), 1989-1997.

Slomanson, W. R. (2014). Blended learning: A Flipped classroom experiment. *Journal of Legal Education, 64*(1), 93-102.

Smeets, D. J. H., & Bus, A. G. (2012). Interactive electronic storybooks for kindergartners to promote vocabulary growth. *Journal of Experimental Child Psychology, 112*(1), 36-55.

Strayer, J. F. (2012). How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learning Environments Research, 15*(2), 171-193.

Teo, T. W., Tan, K. C. D., Yan, Y. K., Teo, Y. C., & Yeo, L. W. (2014). How flip teaching supports undergraduate chemistry laboratory learning. *Chemistry Education Research and Practice, 15*(4), 550-567.

Tsai, C. C., Ho, H. N. J., Liang, J. C., & Lin, H. M. (2011). Scientific epistemic beliefs, conceptions of learning science and self-efficacy of learning science among high school students. *Learning and Instruction, 21*(6), 757-769.

van Dinther, M., Dochy, F., & Segers, M. (2011). Factors affecting students' self-efficacy in higher education. *Educational Research Review, 6*(2), 95-108.

Wang, S. L., & Hwang, G. J. (2012). The Role of collective efficacy, cognitive quality, and task cohesion in computer-supported collaborative learning (CSCL). *Computers & Education, 58*(2), 679-687.

Wang, S. L., & Wu, P. Y. (2008). The Role of feedback and self-efficacy on web-based learning: The Social cognitive perspective. *Computers & Education, 51*(4), 1589-1598.

Wanner, T., & Palmer, E. (2015). Personalising learning: Exploring student and teacher perceptions about flexible learning and assessment in a flipped university course. *Computers & Education, 88*, 354-369.

Yang, C. C., Hwang, G. J., Hung, C. M., & Tseng, S. S. (2013). An Evaluation of the learning effectiveness of concept map-based science book reading via mobile devices. *Educational Technology & Society, 16*(3), 167-178.

Yin, C., Okubo, F., Shimada, A., Hirokawa, S., Ogata, H., & Oi, M. (2015). Identifying and analyzing the learning behaviors of students using e-books. In *Proceedings of the 23rd International Conference on Computers in Education* (pp. 118-120). Hangzhou, China: Asia-Pacific Society for Computers in Education.