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Creating Interactive E-Books through Learning by Design: The Impacts of Guided Peer-Feedback on Students' Learning Achievements and Project Outcomes in Science Courses

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ABSTRACT

With the rapid progress of technology, the popularity of tablet computers and the development of e-book applications have brought the use of e-books as a learning tool under the spotlight. In the meantime, the aim of school education lies not only in providing students with knowledge but also in encouraging them to construct knowledge actively. Consequently, in this study, an approach of integrating the guided peer-feedback strategy into e-book design was proposed. An experiment was conducted on an elementary school natural science course to explore its effectiveness in comparison with the conventional e-book development activity. It was expected that the guided peer-feedback approach could engage students in knowledge organizing and in-depth thinking while stimulating more innovative ideas. To assess the impacts of this approach, a quasi-experimental design method was adopted. The students were divided into two groups: the experimental group, in which the students learned with the guided peer-feedback strategy together with the e-book development approach, and the control group, in which the students learned with the conventional e-book development approach. The experimental results indicated that the integrated guided peer-feedback and e-book development strategy had significant impacts on the students' learning achievements and e-book project outcomes while reducing their cognitive load and increasing their innovative thinking tendency in the design process.

Keywords

Mobile learning, Electronic books, Mobile technology, Peer feedback, Project-based learning

Introduction

As educational settings and strategies have become more diverse, technology-based teaching has gradually become one of the trends in education (Chu, 2014). The popularity of tablet computers and the development of digital reading technologies such as multimedia and interactive facilities have brought the use of e-books as a learning tool under the spotlight (Jenny et al., 2015; Huang & Liang, 2015). Meanwhile, "developing e-books" has become a popular project-based learning activity in schools (Colombo & Landoni, 2013). Scholars have indicated that this approach of learning by design has great potential for fostering students' innovative thinking and learning achievement if appropriate learning support is provided (Huynh & Ghimire, 2015; Hwang, Hung, & Chen, 2013). In the meantime, researchers have stated the necessity of adopting learning guiding strategies in such project-based activities to enhance students' learning performance and project quality (Tseng & Tsai, 2007).

Among various learning strategies, learning by design is a well-recognized one, based on constructivism, in which students need to think about what the important parts of the learning content are through the design process, and how to present the key concepts fully to others (Harel, 1991; Jonassen & Carr, 2000). In comparison with conventional instruction, the mode of learning by design allows students to participate more actively and construct their own knowledge step by step for meaningful learning (Minovic, Milovanovic, Evic, Minovic, & Evic, 2011).

In addition, engaging students in peer-feedback is also one of the learning strategies that have positive impacts on students' learning motivation, attitudes and achievement (Lai & Hwang, 2015; Tseng & Tsai, 2007; Hwang, Hung, & Chen, 2013). It refers to the learning activities that engage students with similar backgrounds in assessing the learning outcomes of peers by playing the role of an instructor, including sharing knowledge and giving feedback or suggestions. Via peer interactions and feedback, students not only have more innovative ideas, but also learn to make reflections through viewing peers' work.

Most previous studies related to peer feedback were conducted for older age groups (e.g., college or high school students), who were asked to complete artworks, videos or system development projects, such as websites, computer programs or digital games (Ali, Heffernan, Lambe, & Coombes, 2014; Hsia, Huang, & Hwang, 2016; Tseng & Tsai, 2007). In addition to learning achievement, these studies mainly measured students' learning

motivation, attitudes or the correlations between these variables. Few studies have been conducted to investigate younger students' innovative thinking and project outcomes as well as their learning achievement and cognitive load, not to mention adopting interactive e-books (i.e., e-book with interactive features) as the target of learning-by-design and peer-feedback activities. Therefore, in this study, an approach of integrating the guided peer-feedback strategy into e-book design was proposed for younger groups. To evaluate the effectiveness of this approach, an experiment was performed on an elementary school science course to investigate the following research questions:

- Can the guided peer feedback-based e-book development approach improve students' learning achievements in comparison with the conventional e-book development approach?
- Can the guided peer feedback-based e-book development approach improve students' project outcomes in comparison with the conventional e-book development approach?
- Can the guided peer feedback-based e-book development approach promote students' innovative thinking tendency in comparison with the conventional e-book development approach?
- Can the guided peer feedback-based e-book development approach reduce students' cognitive load in comparison with the conventional e-book development approach?
- What are the correlations between the students' learning achievements, e-book development outcomes, and innovative thinking tendency?

Literature review

Learning by design

The concept of learning by design derives from "Constructionism," a concept proposed by educators which emphasizes that students take part in gradually constructing their own knowledge by themselves (Papert, 2000). Students need to consider which information is important and how to present it (Jonassen & Carr, 2000). They will attend courses more actively since they have to gather more information to design their output (Perkins, 1986), which at the same time makes learning more meaningful (Bruckman & Resnick, 1995). Scholars have pointed out that the instruction of learning by design could bring students abundant opportunities to learn (Baytak & Land, 2011). That is, via constructing knowledge in the process of integrating and designing, students can be more impressed by the learning mode (Bruckman & Resnick, 1995; Papert, 2000; Minovic, Milovanovic, Evic, Minovic, & Evic, 2011). In addition, it could arouse the potential of students if presented with a well-designed teaching strategy (Chen, Wei, Wu, & Uden, 2009).

The popularity of technology guides the trend of digital information, the benefits of which have been applied in the education and learning field. Differing from traditional books presented in paper form, electronic books integrate digital information with multimedia (Barker, 1992). Most early studies regarded e-books as the learning medium of instruction (Korat & Shamir, 2008; Moody, 2010; Shamir, Korat, & Shlafer, 2011). For example, Worm (2013) let students learn with e-book teaching material on respiratory physiology and pulmonology, resulting in better learning performance. Thus, it can be seen that the support material provided by e-books provides better learning results (Choi, 2007; Moody, 2010).

On the other hand, researchers have pointed out that by making good use of the multimedia characteristic of e-books, the effect of viewing them as a design tool for students to learn could be a good educational issue for discussion. Jonassen et al. (1995) argued that production of multimedia works is the best knowledge construction activity. Students will construct their own knowledge after integrating a variety of information, instead of always listening to explanations and copying; this is a way of learning that makes students not only pay more attention to their learning but also surpasses their originally equipped ability to reflect and learn via the process of repetitive testing and verifying. Therefore, in recent years, several researchers have indicated the advantages of situating students in the context of learning by design. For example, Minovic et al. (2011) chose game design as a learning tool for a computer networks course, the results of which showed promoted learning effects as well as more creatively developed story works.

The teaching mode of learning by design brings students new learning experiences (Kolodner et al., 2003). Students can design without constraint after integrating what they have learned in learning by design activities. In addition, they can establish their ideas and implement their program of work or material through manipulating it themselves. In this way, students can maintain their interest and motivation to learn while the outcomes are also enhanced since the process of exploration brings about the reinforcement of knowledge and desire to move on to higher learning levels (Papert, 2000). However, researchers have pointed out that it is not only necessary to take strategic and flexible design into consideration, but it is also essential to provide students with suitable

learning support to avoid unnecessary disturbance (Warren, Dondlinger, & Barab, 2008). Consequently, an important issue is how to provide appropriate guidance which would enable students to take care of the development of both creation and academic knowledge in the process of learning by doing (Kafa & Peppler, 2011).

Guided peer-feedback

Among various learning strategies, guiding students to play the role of a "teacher" or "reviewer" has been identified by scholars as an appropriate strategy for enhancing students' learning performance and critical thinking ability, and further promoting the interaction between teachers and students (Spandorfer et al., 2014; Tseng & Tsai, 2007; Merrill & Gibert, 2008). It is a learning setting in which students are guided to play the role of "instructors" or "reviewers" based on the criteria established by the teacher (Topping, 1998). In addition to scoring peers' work, students also provide comments to peers during the peer-feedback process. On the other hand, they accept the recommendations of others, producing the interaction of sharing, querying and discussing with each other. Thereby, they could make reflections and self-assessment considering the conflict caused by the various opinions of their peers (Boud, Cohen, & Sampson, 1999).

There have been many studies concerning peer-feedback in recent years. For example, El-Mowafy (2014) conducted an experiment in a university geography on-the-spot investigation course, and found that the students learned the knowledge content in more detail and strived harder to achieve the learning objectives after the peer-feedback activity. In addition to the objective of improving students' learning achievement, researchers have further integrated the use of the peer-feedback strategy into tooth extraction competency (Ali, Heffernan, Lambe, & Coombes, 2014), dance performance (Hsia, Huang, & Hwang, 2016) and environmental issues (Hwang, Hung, & Chen, 2013), the result of which indicated that the learning mode could be a potential strategy to reinforce and enrich the learning experience of students, while also cultivating positive attitudes and self-efficacy toward learning.

The purpose of guided peer-feedback is to provide guidance to promote the students' vision of viewing work and comprehension of knowledge. The evaluation criteria for assessment are thus quite important. For example, to help students prove that they have enough ability to succeed rather than reducing their confidence, the evaluation items need to be appropriate; that is, the content of each item should match the students' ability (Chen et al., 2009; van den Berg & Cillessen, 2013). In addition, it is important to consider the time needed for students to make reflections and improve their work or performance (Jenkins, 2004). On the other hand, students need to understand the evaluation criteria so that they have a firm basis on which to score or give comments. Not only should the distance between students and teachers be shortened to enhance their confidence in accomplishing the goals set by the teacher, but the interaction among peers should also be improved (Tsivitanidou, Zacharia, & Hovardas, 2011). In the meantime, the teacher could encourage students to appreciate different opinions to avoid influencing the peer-feedback results. That is, students would make reflections via the process of viewing the strong and weak points of their work as pointed out by their peers or giving advice to others, making the learning more flexible as well as helping them develop more active attitudes (Chen, 2010).

Method

In this study, a quasi-experimental design method was adopted. The independent variables were the learning modes, that is, the integration of the guided peer-feedback into the e-book design, and the conventional e-book design, while the dependent variables were the results of the students' learning achievement, innovative thinking tendency and cognitive load. The experiment was conducted for the "knowing plants and the ecology" unit of the elementary school natural science course. The objectives of the course unit are to teach students to identify the features of the representative plants on school campus and the relationships between the features and growing environments of the plants. It should be noted that training the review ability of students was not the main purpose of this study; instead, we aimed to guide students to better organize what they have learned while developing the e-book and make in-depth thinking during the peer-feedback process. It was expected that via interpreting learning contents and realizing the relationships between the learning contents, the students' learning achievements could be improved. Therefore, the guided peer feedback-based e-book development approach played the role of a knowledge construction tool, as indicated by Jonassen et al. (1995).

Participants and procedures

The participants were 72 students from two classes of fifth graders in an elementary school in southern Taiwan. One of the classes was selected as the experimental group (n = 36). The other class was assigned to be the control group (n = 36). The experimental group learned with the guided peer-feedback-based e-book design approach and the control group with the conventional e-book development approach. Moreover, to avoid unnecessary experimental error, both groups of students learned the same course content, used the same software to design their e-book, and were taught by the same instructor who had more than twenty-year experience in teaching the course.

In this study, we chose the e-book design software, ShineCue, developed by the Hama-Star Technology Company in Taiwan. This software was chosen because it is easy to learn and effortless to create an e-book, so the students did not need to spend much time learning how to operate it. Several e-book development functions, such as "insert photos," "insert videos," "insert hyperlinks," "insert text," "link to other objects" and "jump to other pages" were provided in this tool; thus, the students were able to put more effort into organizing their knowledge and further integrating it with multimedia into an e-book, as shown in Figure 1.

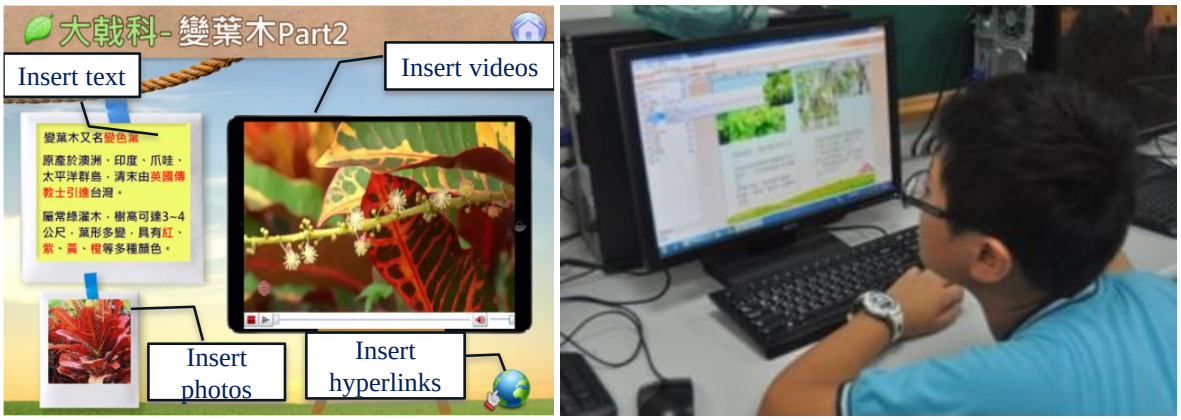

Figure 1. Learning scenarios of the e-book design activity

Taking the learning topic from the science curriculum, we picked out 16 kinds of plants for the students to study by surfing the Internet for relevant information in order to complete the e-book design. In the first two weeks of the learning activity, both groups of students received the basic knowledge of natural science, instruction in using the e-book software, and they completed the pre-questionnaire, all in a total of 80 minutes. In the following six weeks, the students in both groups were asked to use the same tool to design their personal e-books for 40 minutes per week. In the third week, the teacher gave the orientation to help the students understand the evaluation criteria of the e-book design.

During weeks 4-8, all students freely designed and developed their e-books using the provided software in the computer classroom. In weeks 5 and 7, the students in the experimental group evaluated the performance of their peers by playing the role of instructor based on the evaluation criteria; on the other hand, the control group students received feedback from their teacher. All of them could revise their e-book design based on the comments or recommendations in order to perfect it.

Finally, the students took the post-test and scales of innovative thinking tendency and cognitive load after the e-book design activity, which took 30 minutes.

Evaluation criteria for assessing the e-books

As mentioned previously, in addition to designing their own e-books, the experimental group students were randomly assigned to evaluate the e-books designed by peers. Consequently, assessment criteria were developed by the researcher and the teacher who had more than ten years' experience of teaching, referring to the similar research by Hwang, Hung, and Chen (2013). Besides, the criteria were also advised by an experienced e-learning expert for expert validity. There are six evaluative dimensions, presented with a three-point scheme, from 0 to 2, where "0" represents that the e-book design needs major revisions, "1" represents that it needs minor revisions and "2" represents that the e-book design is almost perfect. Apart from scoring, the student could also write some compliments or suggestions. The purpose of the evaluation activity is to stimulate the behavior of sharing or

reflecting via the process rather than the final total score of each student. To balance the students' focuses on the completeness and correctness of the learning content as well as the innovation of the e-book design, the assessment rubrics consisted of two dimensions: Content and Design, each of which contains three assessment items. The "content" dimension consisted of three items, that is, Structure (whether the content of the e-book is coherent and easy to read), Completeness (whether the complete learning objectives required by the teacher were included) and Accuracy (whether the contents of the e-book were presented correctly, including the concepts and the relationships between the concepts). The "Design" dimension consisted of three items, that is, Appearance (whether the interface of the e-book is nice to look at, such as font size, color and mockup), Innovation (whether the e-book design has some innovative or creative ideas) and Interaction (whether the interactive function in the e-book-design software is used appropriately, such as video, drag or question setting). Detailed criteria of the assessment rubrics are given in Table 1.

Table 1. Assessment rubrics for e-book design

Dimension	Items	0	1	2
Content	Structure	More than two thirds content of the e-book isn't coherent or comprehensible.	Some part of (1/3 ~2/3) the e-book isn't coherent or comprehensible.	The e-book is well-structured; the content is coherent and comprehensible.
	Accuracy	More than three pages in the e-book are incorrect (typos, wrong concepts or descriptions)	One or two pages in the e-book are incorrect.	The content in the e-book is all correct.
	Completeness	More than three points or concepts that are important are not presented in the e-book.	One or two points or concepts that are important are not presented in the e-book.	All important points and concepts are presented in the e-book.
Design	Appearance	The layout of the e-book is not reader-friendly.	Some part of (1/3 ~2/3) the layout of the e-book is not reader-friendly.	The layout of the e-book is reader-friendly.
	Innovation	The content of the e-book is boring.	There are one or two interesting and innovative ideas in the e-book.	The content of the e-book is creative and includes more than three innovative ideas.
	Interaction	Most learning content in the e-book is presented in an interactive way (e.g., pop quizzes, word matching and dragging interaction).	Only some (1/3~2/3) learning content in the e-book is presented in an interactive way.	All of the learning content in the e-book is presented in an interactive way (e.g., pop quizzes, word matching, dragging interaction). It can improve learning motivation.

Figure 2 shows an illustrative example of an e-book with a high score in the "Content" dimension. It can be seen that the e-book is developed with a proper layout, abundant materials (photos from diverse perspectives), and accurate descriptions of the learning content. Figure 3 shows another example of an e-book with a high score in the "Design" dimension. In this e-book, a map is provided to replace the outline of the content. The map not only shows the physical locations of the corresponding learning targets, but also provides direct links to the relevant e-book pages.

Figure 2. Illustrative example of a student's e-book with a good score in the "Content" dimension

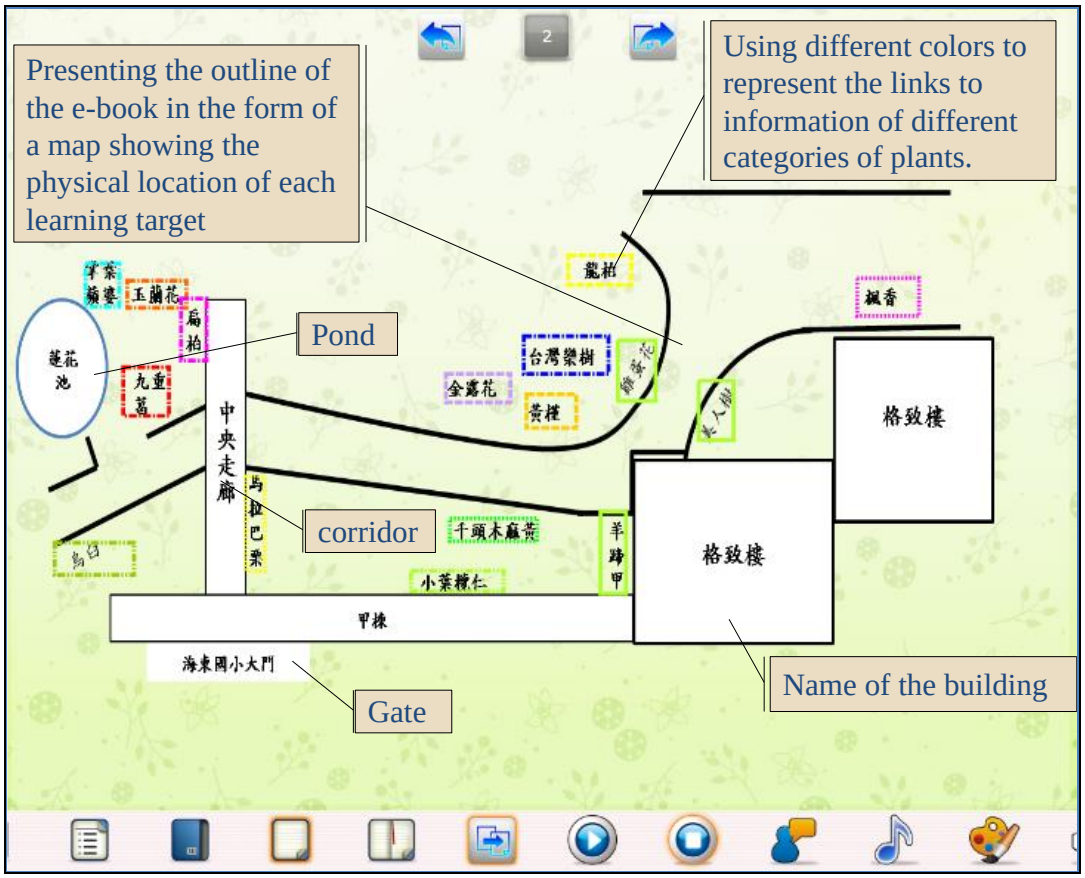

Figure 3. Illustrative example of a student's e-book with a good score in the "Design" dimension

Measuring tools

The measures employed in the present study included the tests of knowledge and work performance, and the questionnaires of innovative thinking tendency and cognitive load.

The pre-test and post-test were developed by two teachers who had more than 10 years' experience of teaching the science curriculum. On the one hand, the objective of the pre-test was to assess whether the two groups of students had equivalent basic knowledge before participating in the learning activity, and included yes-or-no items, multiple-choice items, matching questions and short answer questions with a total score of 100. On the other hand, the post-test aimed to evaluate the students' knowledge of the 16 kinds of plants, consisting of basic multiple-choice, advanced multiple-choice matching questions and short answer questions, with a total score of 100.

Apart from this, we also collected the performance of the students' e-book design work. The researchers and educational experts graded the students' e-book work separately based on the six evaluation criteria we developed, consisting of the design dimension (kappa = 0.82) and content dimension (kappa = 0.92).

Following this, the questionnaire of innovative thinking tendency was modified from the measure developed by Lin and Wang (1994). It consisted of six items (e.g., "I like to ask some questions that no one have ever thought of before" and "I like to imagine about something that I want to know or want to do") on a five-point Likert scale. The Cronbach's alpha value of the questionnaire was 0.8. The reason why we wanted to measure this was because innovative thinking tendency is highly related to learning by design (Breivik, 2005). In developing an interactive e-book, the students were encouraged to design the layout of the content as well as the interactive features in innovative ways.

Moreover, the questionnaire of cognitive load was modified by Hwang, Yang and Wang (2013) for elementary school students based on the measures developed by Paas (1992) and Sweller, van Merriënboer and Paas (1998). It consists of 8 items in two dimensions, including mental load (e.g., "The learning content of the activity is difficult for me") and mental efforts (e.g., "I need to put lots of efforts to follow the instructional way of the teacher during the learning activity"). Mental load is related to the complexity of the learning content that students need to handle, while mental efforts is related to the learning approaches or strategies used in the learning activities. The Cronbach's alpha values of the mental load and mental effort dimensions were 0.86 and 0.85, respectively.

Results

Learning achievement

After examining the heterogeneity of the pre-test scores of the two groups, ANCOVA was used to compare their post-test scores. Table 2 illustrates the ANCOVA results of the post-test scores using the pre-test as a covariate in which the adjusted mean values of the post-test scores were 69.29 for the experimental group, and 58.6 for the control group. It was found that the students in the experimental group had significantly better achievements than those in the control group ($F = 14.82$, $p < .001$), implying that the teaching strategy of guided peer-feedback had a positive impact on the students' learning performance.

Table 2. Descriptive data and ANCOVA of the post-test results

Group	*N*	Mean	*SD*	*F*
Experimental group	36	69.29	1.95	14.82^{***}
Control group	36	58.60	1.95	

Note. $^{***}p < .001$.

E-book design project outcomes

In terms of the project outcomes, two teachers who had more than 10-year experience in teaching the course scored the students' e-books separately based on the six evaluation items. The consistence of their scores for the content dimension (kappa = 0.92) and the design dimension (kappa = 0.82) showed high inter-rater reliability.

As shown in Table 3, the means and SDs of the work performance scores in the content dimension were 11.58 and 3.18 for the experimental group, and 9.50 and 3.05 for the control group. The *t*-test result ($t = 2.84$, $p < .001$) shows that there was a significant difference between the two groups. For the design dimension, the scores were 11.00 and 8.40 for the experimental group, and 9.50 and 3.05 for the control group. The *t*-test result ($t = 6.51$, $p < .001$) shows there was also a significant difference between the two groups for this dimension. Consequently, we can conclude that the integration of guided peer-feedback into the course had significantly positive effects on the students' project outcomes. The reason seems to be that the students performed better when the learning shifted from the teacher-centered to the student-centered mode, requiring them to not only construct knowledge actively through the creating process, but also to modify their personal productions based on the comments of their peers after the scoring activity.

Table 3. t-test result of the ratings on the students' e-books of the two groups

Dimension	Group	*N*	Mean	*SD*	*t*
Content	Experimental group	36	11.58	3.18	2.84***
	Control group	36	9.50	3.05	
Design	Experimental group	36	11.00	1.57	6.51***
	Control group	36	8.40	1.80	

Note. ***$p < .001$.

Innovative thinking tendency

In terms of students' innovative thinking tendency, the *t*-test results of the pre-questionnaire showed no significant difference between the two groups ($t = 1.20$, $p > .05$) before the learning activity. After the activity, the students completed the innovative thinking tendency post-questionnaire. As shown in Table 4, the *t*-test results showed that the students in the experimental group had significantly higher innovative thinking tendency than those in the control group ($t = 2.21$, $p < .05$). Therefore, it is concluded that the integration of the guided peer-feedback strategy into the e-book design had a positive impact on the students' innovative thinking tendency in comparison with the conventional learning mode.

Table 4. t-test result of the innovative thinking tendency post-questionnaire of the two groups

Group	*N*	Mean	*SD*	*t*
Experimental group	36	3.93	0.83	2.21*
Control group	36	3.55	0.61	

Note. *$p < .05$.

Cognitive load

As given in Table 5, the means and standard deviations of the cognitive load ratings were 3.18 and 1.11 for the experimental group, and 3.92 and 0.99 for the control group. According to the results ($t = -2.98$, $p < .01$), there was a significant difference between the two groups, implying that the e-book design activity with the guided peer-feedback was able to reduce the cognitive load of the students in the learning process. Moreover, there was a significant difference between the two groups of students in terms of cognitive load ($t = -2.54$, $p < .05$) and mental efforts ($t = -2.90$, $p < .01$). These finding confirmed that the guided peer-feedback approach was an effective strategy for helping the students comprehend the course content and complete the learning task.

Table 5. t-test result of the cognitive load of the two groups.

Dimension	Group	*N*	Mean	*SD*	*t*
Cognitive load	Experimental group	36	3.18	1.11	-2.98**
	Control group	36	3.92	0.99	
Mental load	Experimental group	36	2.98	1.10	-2.54*
	Control group	36	3.65	1.13	
Mental efforts	Experimental group	36	3.51	1.36	-2.90**
	Control group	36	4.36	1.13	

Note. *$p < .05$; **$p < .01$.

Correlation coefficients between the different variables

This section discusses the correlation coefficients between the different variables in order to examine the relationships between them, including learning achievement, ratings for the "content" and "design" dimensions of the e-books, and innovative thinking tendency.

The statistical results are shown in Table 6. It was found that the students' learning achievement and innovative thinking tendency had a positive correlation ($r = 0.26$, $p < .05$), implying that the students who were engaged in the learning activity more enthusiastically benefited greatly in terms of learning achievement as well as innovative thinking tendency. In other words, it is important to take both the content and the design aspects into consideration when designing assessment rubrics.

In addition, the e-book design consisted of both content and design dimensions, with the statistical results revealing that the students' work in the "content" dimension of the teacher assessment and in the "design" dimension of the teacher assessment had a positive correlation ($r = .38$, $p < .01$), implying that the organization of information is related to the quality of the students' e-book design work.

Besides, we further found that the students' work in the "design" dimension of teacher assessment and innovative thinking tendency after the learning activity also had a positive correlation ($r = .23$, $p < .05$), representing that the scores of the students' project work were quite closely correlated to their innovative thinking tendency after the learning activity. To sum up, the students not only had higher innovative thinking tendency, but also had better creative performance in real e-book design according to the guidance of the peer-feedback strategy.

Table 6. Pearson correlation for the different variables

	Learning achievement	Ratings for the "content" dimension	Ratings for the "design" dimension	Innovative thinking tendency
Learning achievement	-	.31**	.40**	.26*
Ratings for the "content" dimension		-	.38**	.17
Ratings for the "design" dimension			-	.23*
Innovative thinking tendency				-

Note. $^{*}p < .05$; $^{**}p < .01$.

Discussion and conclusions

In this study, an approach of integrating the guided peer-feedback strategy into e-book design has been proposed and applied to a learning activity in an elementary school natural science course. From the experimental results, it was found that the students learning with the guided peer-feedback-based e-book development strategy showed better learning achievements, project outcomes and innovative thinking tendency, while having lower cognitive load than those learning with the conventional e-book development strategy.

The good performances on the students' learning achievements and project outcomes can be attributed to the features of integrating guided peer-feedback in to the learning by design activity that engages students in reviewing peers' work, providing feedback to peers and making reflections on their own work as well as organizing the learning content and trying innovative thinking during the e-book development process. In the peer-feedback stage, the students would be able to appreciate the different opinions of their peers and make reflections as well as sharing knowledge and giving comments to peers during the peer-feedback process. As indicated by the researchers, playing the role of a reviewer is important to students since they have chance to see peers' and their own work from the teacher's viewpoints and make in-depth reflections, which is usually omitted in conventional learning by design activities in which teachers directly give comments and scores to individual students (Topping, 1998; Fallows & Chandramohan, 2001). The e-book design activity engaged the students in organizing what they have learned, while the peer-feedback strategy engaged them in reconsidering the developed content and the e-book structure in depth, which enabled them to better comprehend the concepts in the learning content and the relationships between the concepts.

In the term of the innovative thinking tendency, when playing the role of a reviewer, the students needed to learn and know the evaluation principles in depth before providing comments to peers' work, implying that they could have the opportunity to see thinking from different viewpoints (i.e., the teachers' viewpoints). Moreover, they

also had the opportunity to see different design concepts implemented by peers. As indicated by researchers, receiving different or even conflicting concepts or comments could stimulate more innovative ideas (Gibbs, 2006; Planas Lladó et al., 2014). The findings in this study might provide another evidence for this point.

Regarding cognitive load, researchers have indicated that there might be a negative impact on learning effect when cognitive load is excessive during the learning (Paas & van Merriënboer, 1994). In the present study, it was found that the peer-feedback strategy was able to reduce the cognitive load of the students when designing the e-books. That is, this learning approach could help the students better organize the required information that they had learned as well as understand the learning content and tasks. During the peer-feedback stage, the students scored peers' work and provided feedback to them after having in-depth comprehension to the evaluation criteria, which enabled them to have a clearer concept of the learning task as well as better knowledge of organizing the content. This is likely to be the reason why their mental efforts were reduced. On the other hand, mental load is related to the relative difficulty of the learning materials to individual students. Although both groups of students were arranged to learn the same subject content and participated in the same learning activity, the students in the experimental group revealed that learning the content was not so difficult to them after the learning activity. It is inferred that the experimental group students had better comprehension of the learning content and the relationships between the concepts to be learned, and hence they showed lower cognitive load than the control group. This finding is consistent with the students' learning achievements.

In the near future, in addition to examining the potential of peer-feedback in fostering students' critical thinking ability, it would be worthwhile to investigate the effects of peer-feedback-based e-book development activities on students' critical thinking and reflection levels. Moreover, it would also be worth analyzing and exploring the learning behaviors of students if the e-book design and the peer-feedback process could be recorded. In that case, we could better understand students' behavior under different teaching treatments based on the recorded data, such as what kind of learning mode would have a positive impact on students' learning performance, or the relationship between learning behavior, and so on. Finally, the participants in this study were restricted to elementary school students; this strategy could, however, be adopted by learners of all ages. Consequently, it would pay to employ the guided peer-feedback strategy with different age groups in order to gain a more diversified perspective.

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References

Ali, K., Heffernan, E., Lambe, P., & Coombes, L. (2014). Use of peer assessment in tooth extraction competency. *European Journal of Dental Education*, *18*(1), 44-50.

Barker, P. (1992). Electronic books and libraries of the future. *The Electronic Library, 10*(3), 139-149.

Baytak, A., & Land, S. M. (2011). An Investigation of the artifacts and process of constructing computers games about environmental science in a fifth grade classroom. *Educational Technology Research and Development, 59*(6), 765-782.

Boud, D., Cohen, R., & Sampson, J. (1999). Peer learning and assessment. *Assessment & Evaluation in Higher Education, 24*(4), 413-426.

Breivik, P. S. (2005). 21st century learning and information literacy. *Change: The Magazine of Higher Learning, 37*(2), 21-27.

Bruckman, A., & Resnick, M. (1995). The Mediamoo project constructionism and professional community. *Convergence: The International Journal of Research into New Media Technologies*, *1*(1), 94-109.

Chen, C. H. (2010). The Implementation and evaluation of a mobile self- and peer-feedback system. *Computers & Education, 55*(1), 229–236.

Chen, N. S., Wei, C. W., Wu, K. T., & Uden, L. (2009). Effects of high level prompts and peer assessment on online learners' reflection levels. *Computers & Education, 52*, 283–291.

Choi, W. (2007). A Study on developing of an e-book as a supplemental learning material based on elearning theory. *The Journal of Studies in Learning, 22*(3), 273-288.

Chu, H. C. (2014). Potential negative effects of mobile learning on students' learning achievement and cognitive load - A Format assessment perspective. *Educational Technology & Society, 17*(1), 332-344.

Colombo, L., & Landoni, M. (2013). Low-tech and high-tech prototyping for eBook co-design with children. In *Proceedings of the 12th International Conference on Interaction Design and Children* (pp. 289-292). New York, NY: ACM.

El-Mowafy, A. (2014). Using peer assessment of fieldwork to enhance students' practical training. *Assessment & Evaluation in Higher Education, 39*(2), 223-241.

Fallows, S., & Chandramohan, B. (2001). Multiple approaches to assessment: Reflections on use of tutor, peer and self-assessment. *Teaching in Higher Education, 6*(2), 229-246.

Gibbs, G. (2006). How assessment frames student learning. In C. Bryan & K. Clegg (Eds.), *Innovative assessment in higher education* (pp. 23-36). London, UK: Routledge.

Harel, I. (1991). *Children designers: Interdisciplinary constructions for learning and knowing mathematics in a computer-rich school*. Westport, CT: Ablex Publishing.

Hsia, L. H., Huang, I., & Hwang, G. J. (2016). Effects of different online peer-feedback approaches on students' performance skills, motivation and self-efficacy in a dance course. *Computers & Education, 96*, 55-71.

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.

Huynh, M. Q., & Ghimire, P. (2015). Learning by doing: How to develop a cross-platform web app. *Journal of Information Technology Education: Innovations in Practice, 14*, 145-169.

Hwang, G. J., Hung, C. M., & Chen, N. S. (2013). Improving learning achievements, motivations and problem-solving skills through a peer assessment-based game development approach. *Educational Technology Research and Development, 62*(2), 129-145.

Hwang, G. J., Yang, L. H., & Wang, S. Y. (2013). A Concept map-embedded educational computer game for improving students' learning performance in natural science courses. *Computers & Education, 69*, 121-130.

Jenkins, M. (2004). Unfulfilled promise: Formative assessment using computer-aided assessment. *Learning and Teaching in Higher Education, 1*(1), 67-80.

Jenny, B., Darbyshire, J. E., Arnold, N. D., Marston, B. E., McGie, D. A., Ogren, K. L, Preppernau, C. A. Schuetz, S. R., Speece, J. R., & Watson, J. E. (2015). E-book atlases for tablet computers: The Atlas of the Columbia River Basin. *Journal of Maps, 11*(4), 664-673.

Jonassen, D. H., & Carr, C. S. (2000). Mindtools: Affording multiple knowledge representations for learning. In S. P. Lajoie (Ed.), *Computers as Cognitive Tools, Vol. 2: No more walls* (pp. 165-196). Mahwah, NJ: Lawrence Erlbaum Associates.

Jonassen, D., Davidson, M., Collins, M., Campbell, J., & Haag, B. B. (1995). Constructivism and computer-mediated communication in distance education. *American journal of distance education, 9*(2), 7-26.

Kafai, Y. B., & Peppler, K. A. (2011). Youth, technology, and DIY developing participatory competencies in creative media production. *Review of Research in Education, 35*(1), 89-119.

Kolodner, J. L., Camp, P. J., Crismond, D., Fasse, B., Gray, J., Holbrook, J., Puntambekar, S., & Ryan, M. (2003). Problem-based learning meets case-based reasoning in the middle-school science classroom: Putting learning by design (tm) into practice. *The Journal of the Learning Sciences, 12*(4), 495-547.

Korat, O., & Shamir, A. (2008). The Educational electronic book as a tool for supporting children's emergent literacy in low versus middle SES groups. *Computers & Education, 50*(1), 110-124.

Lai, C. L., & Hwang, G. J. (2015). An Interactive peer-feedback criteria development approach to improving students' art design performance using handheld devices. *Computers & Education, 85*, 149-159.

Lin, H. T., & Wang, M. J. (1994). *威廉斯創造力測驗指導手冊* [Creativity assessment packet]. Taipei, Taiwan: Psychological Publishing.

Merrill, M. D., & Gibert, C. G. (2008). Effective peer interaction in problem-centered instructional strategy. *Distance Education, 29*(2), 199-207.

Minovic, M., Milovanovic, M., Evic, I. K., Minovic, J., & Evic, D. a. S. (2011). Game design as a learning tool for the course of computer networks. *International Journal of Engineering Education, 27*(3), 498-508.

Moody, A. K. (2010). Using electronic books in the classroom to enhance emergent literacy skills in young children. *Journal of Literacy and Technology, 11*(4), 22-52.

Paas, F. G. W. C., & van Merriënboer, J. J. G. (1994). Variability of worked examples and transfer of geometrical problem-solving skills: A Cognitive-load approach. *Journal of Educational Psychology, 86*(1), 122-133.

Papert, S. (2000). What's the big idea? Toward a pedagogy of idea power. *IBM Systems Journal, 39*(3), 720-729.

Perkins, A. (1986). *Knowledge as design.* Mahwah, NJ: Lawrence Erlbaum Associates.

Planas Lladó, A., Soley, L. F., Fraguell Sansbelló, R. M., Pujolras, G. A., Planella, J. P., Roura-Pascual, N., Martinez, J. J. S. & Moreno, L. M. (2014). Student perceptions of peer assessment: An Interdisciplinary study. *Assessment & Evaluation in Higher Education, 39*(5), 592-610.

Shamir, A., Korat, O., & Shlafer, I. (2011). The Effect of activity with e-book on vocabulary and story comprehension: A Comparison between kindergarteners at risk of learning disabilities and typically developing kindergarteners. *European Journal of Special Needs Education*, *26*(3), 311-322.

Spandorfer, J., Puklus, T., Rose, V., Vahedi, M., Collins, L., Giordano, C., Schmidt, R., & Braster, C. (2014). Peer assessment among first year medical students in anatomy. *Anatomical sciences education, 7*(2), 144-152.

Sweller, J., Van Merrienboer, J. J., & Paas, F. G. (1998). Cognitive architecture and instructional design. *Educational psychology review, 10*(3), 251-296.

Topping, K. (1998). Peer assessment between students in colleges and universities. *Review of Educational Research, 68*(3), 249–276.

Tseng, S. C., & Tsai, C. C. (2007). On-line peer assessment and the role of the peer feedback: A Study of high school computer course. *Computers & Education, 49*(4), 1161-1174.

Tsivitanidou, O. E., Zacharia, Z. C., & Hovardas, T. (2011). Investigating secondary school students' unmediated peer assessment skills. *Learning and Instruction, 21*(4), 506–519.

van den Berg, Y. H., & Cillessen, A. H. (2013). Computerized sociometric and peer assessment- An Empirical and practical evaluation. *International Journal of Behavioral Development, 37*(1), 68-76.

Warren, S. J., Dondlinger, M. J., & Barab, S. A. (2008). A MUVE towards PBL writing: Effects of a digital learning environment designed to improve elementary student writing. *Journal of Research on Technology in Education*, *41*(1), 113-140.

Worm, B. S. (2013). Learning from simple e-books, online cases or classroom teaching when acquiring complex knowledge. A Randomized controlled trial in respiratory physiology and pulmonology. *PLOS one*, *8*(9), e73336. doi:10.1371/journal.pone.0073336