Computers & Education 85 (2015) 149–159

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

An interactive peer-assessment criteria development approach to improving students' art design performance using handheld devices

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A R T I C L E I N F O

Article history:
Received 2 October 2014
Received in revised form
17 December 2014
Accepted 22 February 2015
Available online 2 March 2015

Keywords:
Teaching/learning strategies
Elementary education
Cooperative/collaborative learning
Interactive learning environments

A B S T R A C T

Engaging students in higher order thinking such as evaluation and analysis has been recognized as being an important strategy for helping them develop knowledge and skills, in particular, in creativeness-oriented learning activities such as artwork design. In this paper, an interactive peer-assessment criteria development approach is proposed to help students develop assessment criteria, learn from viewing peers' work, and make reflections in artwork design activities using mobile devices. To evaluate the effectiveness of the proposed approach, an experiment was conducted in an elementary school art course. A total of 103 students participating in the experiment were assigned to an experimental group and a control group. The students in the experimental group learned with the proposed approach, while those in the control group learned with the conventional peer assessment approach. From the experimental results, it was found that the proposed approach significantly improved the students' learning achievement, learning motivation and meta-cognitive awareness, suggesting the effectiveness of engaging students in assessment criteria development in an interactive manner.

1. Introduction

Scholars have for decades emphasized the importance of conducting higher order thinking activities in school settings (Lin, Yeh, Hung, & Chang, 2013; Piirto, 2011; Yang & Cheng, 2010). In creativeness-oriented courses such as art and design courses, fostering students' knowledge of the criteria for evaluating artwork has been identified as the key to improvement in their knowledge and development of their artwork skills (Bonsignore, Quinn, Druin, & Bederson, 2013; Groenendijk, Janssen, Rijlaarsdam, & van den Bergh, 2013; Halverson et al., 2014). Among various learning strategies, peer assessment has been considered as effective for helping students understand teachers' assessment criteria and make reflections during the learning process (Auttawutikul, Wiwitkunkasem, & Smith, 2014; Lin, Hong, Wang, & Lee, 2011). In the past decade, several studies have reported the effectiveness of conducting peer assessment activities in school settings (Tsai & Liang, 2009; Wen & Tsai, 2008). For instance, Nicolaidou (2013) conducted a one-year peer assessment activity that engaged students in developing their own e-portfolios, examining peers' portfolios, and providing feedback to peers, while Hwang, Hung, and Chen (2014) conducted a peer assessment activity for game development in a natural science course.

On the other hand, scholars have pointed out several problems of applying the peer assessment approach. For example, students might not be able to fully understand the meaning of the peer assessment or of the rubrics provided by the teacher. They could also feel frustrated when facing complex review tasks (Hovardas, Tsivitanidou, & Zacharia, 2014). Moreover, some students might ignore the assessment criteria and the feedback from their peers (Cho & MacArthur, 2010; Tsivitanidou, Zacharia, Hovardas, & Nicolaou, 2012). Furthermore, some limitations of conventional peer assessment have also been identified. For example, it lacks effective approaches to engage students in developing, examining and modifying the scoring rubric during the evaluation process; that is, students merely follow the criteria provided by the teacher without thinking why they have been adopted (Ng, 2014; Tsai & Liang, 2009).

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http://dx.doi.org/10.1016/j.compedu.2015.02.011
0360-1315/

Therefore, to foster students' evaluation ability in art or design courses, it is important to involve them in assessment criteria development. In this study, an interactive peer-assessment criteria development approach is proposed. A learning system has been implemented based on the proposed approach to enable students to develop assessment criteria, share artworks, review peers' work, and make reflections based on peers' comments using mobile devices. An experiment has been conducted to evaluate the performance of the approach in terms of learning achievement, motivation, meta-cognitive awareness and cognitive load.

2. Literature review

2.1. Peer assessment

Peer assessment has been noted as a potential learning strategy for engaging students in knowledge construction and skill development via comprehending teachers' assessment criteria, learning from viewing peers' work, and making reflections (Boud, Cohen, & Sampson, 1999; Carlson & Berry, 2008; Matsuno, 2009; Tseng & Tsai, 2010). Topping (1998) defined peer assessment as a learning strategy whereby students evaluate or comment on the value or the quality of the work or the learning outcomes of their peers who learned with the same learning content.

The objectives of conducting peer assessment activities are to improve the students' learning outcomes, stimulate their higher order thinking (e.g., meta-cognitive awareness), and increase their autonomy (McMahon, 2010; Xiao & Lucking, 2008). For example, several studies have reported that peer assessment activities are effective in terms of enhancing students' autonomous learning ability (Chen, 2010; Yang, Badger, & Yu, 2006). Moreover, the effect of engaging students in the role of a reviewer on their reflections has been pointed out (Prins, Sluijsmans, Kirschner, & Srijbos, 2005; Xiao & Lucking, 2008). On the other hand, the benefit of receiving feedback from peers in improving students' learning outcomes has also been reported (Miller, Topping, & Thurston, 2010; Tsuei, 2012). For instance, Nicolaidou (2013) found that students' feedback could gradually become more comprehensive and correct by inspecting peers' comments in the learning process. Other researchers have also found that assessment training can result in a significant decrease in the discrepancy between student and instructor ratings of example projects; that is, the students' meta-cognitive awareness might be improved (Liu & Li, 2014).

Several studies have further emphasized the advantages of involving students in peer-assessment activities, including stimulating the self-reflection and higher order thinking of students (Dkeidek, Mamlok-Naaman, & Hofstein, 2011; Prins et al., 2005; Yu, Liu, & Chan, 2005). In addition, other benefits of engaging students in peer-assessment, such as promoting their learning performance (Maas et al., 2014; Xiao & Lucking, 2008), learning motivation (Jenkins, 2004; Llado et al., 2014), and facilitating their self-reflection and communication abilities (Brader, Luke, Klenowski, Connolly, & Behzadpour, 2014) have been reported. For example, Yu (2011) stated that involving students in peer-assessment activities could not only engage them in making reflections, but could also improve their higher order thinking and communication abilities.

On the other hand, researchers have pointed out the problems of the conventional peer-assessment approach. One of the problems is that students might have difficulty fully comprehending the assessment criteria provided by the teacher (Juwah, 2003; Tsivitanidou et al., 2012). Therefore, Juwah (2003) suggested that researchers and educators might consider involving students in determining the assessment criteria. However, to the best of our knowledge, despite the recommendations, none of these previous studies have involved students in developing their own peer-assessment criteria; instead, they merely asked the students to assess their peers' work based on the criteria provided by the teachers (Segrist & Schoonaert, 2006; Yu & Wu, 2013). Another problem encountered in most peer-assessment activities is that teachers are usually unable to provide instant comments or feedback owing to the lack of effective tools or strategies (Denton, Madden, Roberts, & Rowe, 2008; Wu, Hwang, Milrad, Ke, & Huang, 2012). Students are likely to feel frustrated and lose interest during the learning process if their learning difficulties cannot be resolved immediately (Chen & Huang, 2010; Hwang, Wu, & Ke, 2011).

Therefore, the aim of this study is to overcome these problems by proposing an interactive peer-assessment criteria development approach, and implementing a learning support system based on the approach to improve students' learning outcomes.

2.2. Mobile technology-enhanced learning

Mobile technology has been regarded as a potential medium for engaging students in learning in the classroom or in the field (Hwang, Tsai, & Yang, 2008; Hwang, Tsai, Chu, Kinshuk, & Chen, 2012). The popular handheld devices, such as smartphones and tablet computers, not only enable students to access learning materials without being limited by time or space, but also provide teachers with opportunities to develop learning activities from new perspectives (Chen, 2010; Hwang et al., 2011; Looi et al., 2010).

Moreover, many researchers have reported the benefits of using mobile technologies in school settings, such as the provision of personalized learning objectives and schedules (Chen & Li, 2009; Sandberg, Maris, & Hoogendoorn, 2014; Sung, Hwang, Liu, & Chiu, 2014), the access to learning facilities (Hyewon, MiYoung, & Minjeong, 2014), and the provision of learning support (Chang, Lan, Chang, & Sung, 2010) anywhere and at any time.

The presence of mobile technologies has brought criteria development to a new stage (Ogata, Saito, Paredes, San Martin, & Yano, 2008; Yang & Lin, 2010). With the help of mobile technologies, students are able to observe real artwork developed by their peers, acquire new knowledge via access to online resources, share their artwork and opinions, reorganize their knowledge, create assessment criteria, and make reflections on their own work (Chen & Huang, 2010; Jones, Ramanau, Cross, & Healing, 2010). Moreover, the facilities of providing personalized feedback can help students identify their shortcomings in the criteria they develop as well as realize their possible misunderstandings of the learning objectives provided by the teacher (Corbalan, Paas, & Cuypers, 2010; Jordan, 2012; Yu & Wu, 2013). The knowledge sharing and instant interaction facilities provided by mobile and wireless communication technologies further enable students to receive immediate feedback from teachers and peers (Chu, 2014; Lin, Wu, Hung, Hwang, & Yeh, 2009; Shih, Chuang, & Hwang, 2010).

Therefore, in this study, an interactive peer-assessment criteria development approach is proposed for developing mobile learning systems for the poster design unit of an elementary school art course. Moreover, several research questions are investigated to evaluate the effectiveness of the proposed approach:

(1) Can the peer-assessment criteria development approach improve the students' learning achievements?
(2) Can the peer-assessment criteria development approach improve the students' learning motivations?
(3) Can the peer-assessment criteria development approach improve the students' meta-cognitive awareness?
(4) Does the peer-assessment criteria development approach increase the students' cognitive load?

3. Mobile learning system based on a formative criteria development approach

To engage students in higher order thinking, a mobile learning system is developed for supporting interactive peer-assessment criteria development. The system consists of a student poster gallery, a criteria setting system, a peer assessment system, a student profile, and an expert criteria database, as shown in Fig. 1. The student poster gallery provides all students' posters for peers' reference. The criteria setting system consists of a rate poster unit, a criteria setting unit, and an observing platform that displays others' criteria. The peer assessment system enables students to evaluate the posters developed by their peers. The expert criteria database stores the criteria developed by experts (i.e., teachers).

Fig. 2 shows the procedure for guiding students to develop peer-assessment criteria and to evaluate peers' work using the mobile learning system. After students log into the learning system, they can observe all the groups' posters in the gallery. When they start to set the criteria, a three-step criteria setting procedure is provided: rate the poster, develop the criteria, and view others' criteria. During the process in which the students develop the criteria, the system compares their criteria with those of the expert, and then gives feedback. After the students finish writing all their criteria, they evaluate other groups' posters based on the criteria they designed themselves.

Fig. 3 shows the student interface of the mobile learning system. After students log into the system, the task list is provided so that they can observe other groups' posters, set criteria and evaluate others' posters.

There is a three-step criteria setting procedure provided; the first step is shown as Fig. 4. In this process, students need to rank the ten posters made by other groups and themselves. In this stage, students are engaged in comparing the overall quality of each poster and rating the posters based on their strengths and weaknesses.

Fig. 5 shows the second step in which the students set their own criteria. There are four dimensions students need to develop criteria for in this learning activity: words, space, color and theme. In Fig. 5, in the first dimension, words, students need to develop the criteria relating to the text used on the poster. After the students read the description of the task, they need to input the criteria which they think are important in the word dimension when designing the poster (e.g., the heading should be big; there should be some decoration in the heading.). After finishing their criteria setting, the system compares the students' criteria with those provided by the teacher and presents the degree of similarity (i.e., high, medium, and low) between the corresponding criteria as well as the comments from the teacher. Thus, the students can read the teacher's comments and revise their criteria accordingly.

Fig. 6 shows the last step, view others' criteria, of the criteria setting, in which students can view other groups' criteria, and observe the difference between their own criteria and those of others. In this procedure, students can choose to revise their criteria via the previous interface.

After students finish setting their criteria, they utilize their criteria to evaluate other groups' posters, as shown in Fig. 7. The system records and lists students' criteria in the evaluation platform, with a score range of 1–3, where 1 is the lowest and 3 is the highest. Students need to evaluate all others' posters in this learning procedure. The total score of each group is calculated by the system, and then shown in the student poster gallery, as in Fig. 8.

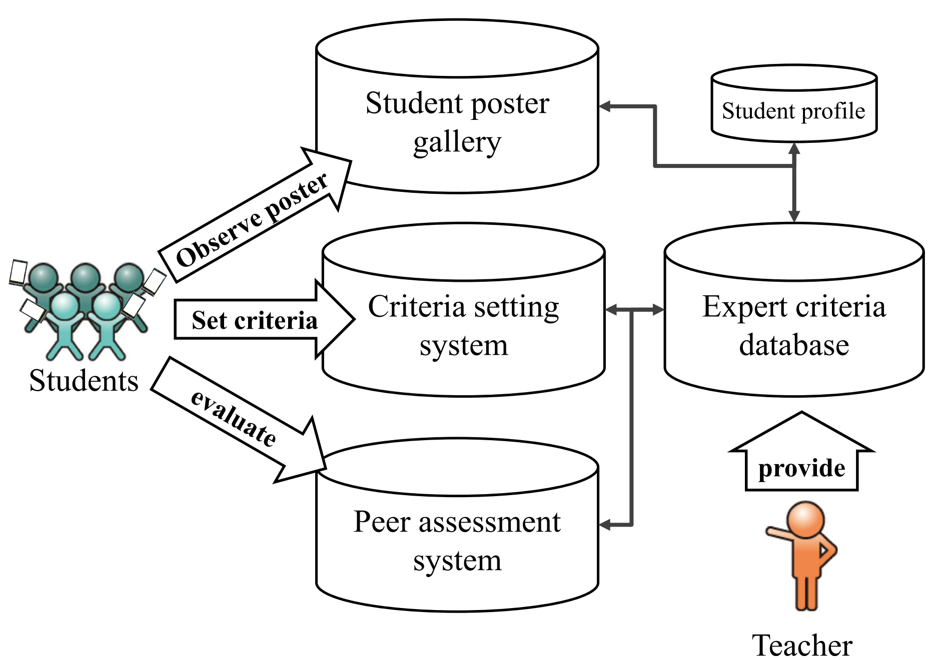

Fig. 1. Structure of the mobile learning system.

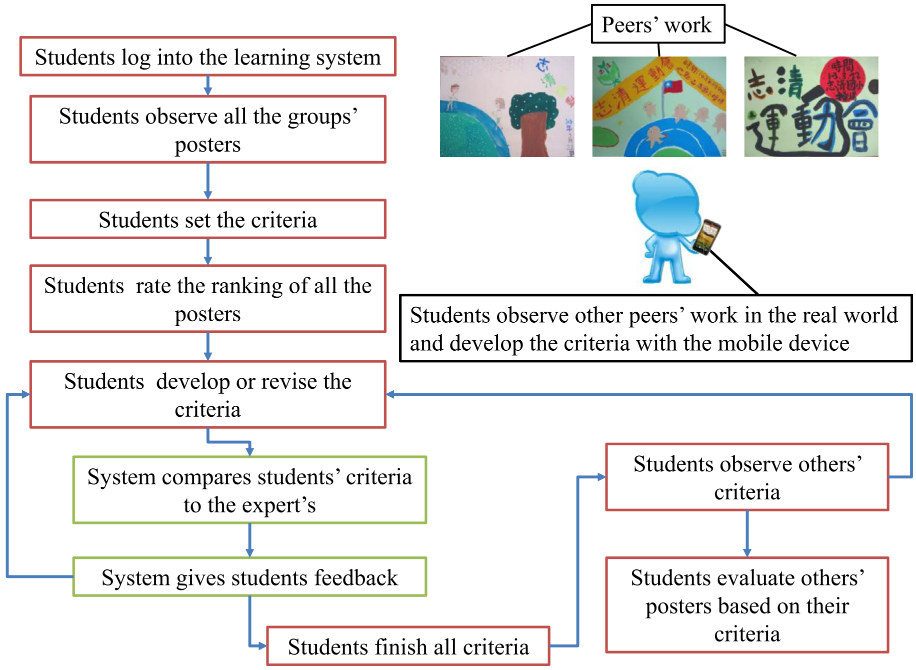

Fig. 2. Flow of the interactive peer-assessment criteria development approach.

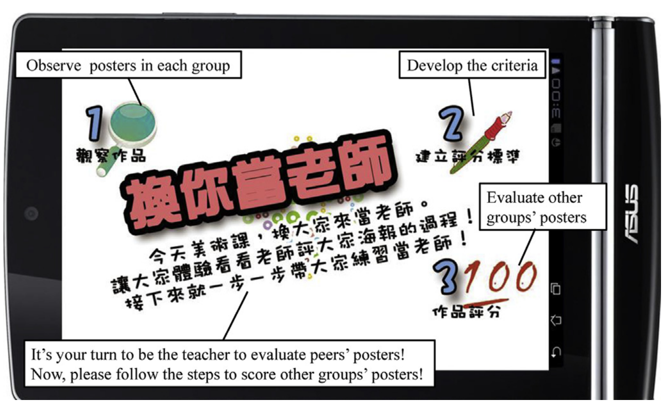

Fig. 3. The homepage of the mobile learning system.

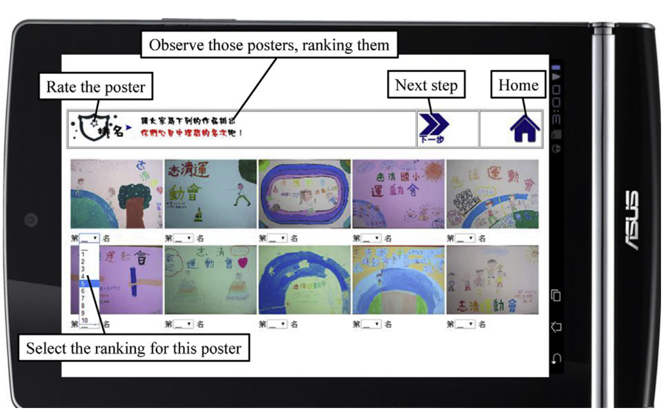

Fig. 4. The first step, rate the poster, of criteria setting.

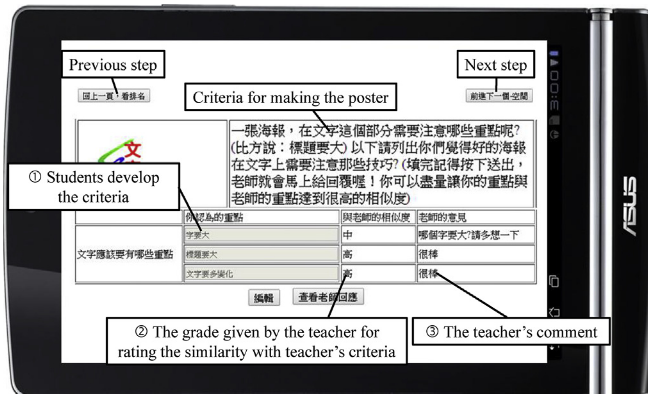

Fig. 5. The second step, developing the criteria, of criteria setting.

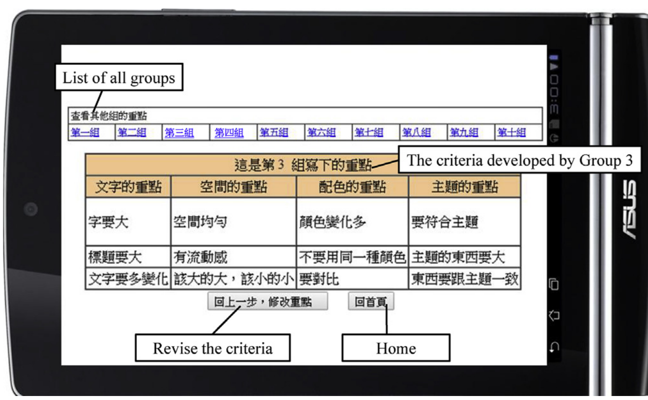

Fig. 6. The third step, view others' criteria, of criteria setting.

4. Experiment design

To evaluate the performance of the interactive peer-assessment criteria development approach to helping students set criteria and perform peer assessment, an empirical experiment was conducted in an art course of an elementary school in northern Taiwan. Several measuring tools were used to assess the students' learning achievement, learning motivation, meta-cognitive awareness and cognitive load.

4.1. Participants

In order to control the possible factors that might influence students' learning performance as well as reflect the teaching reality of the schools in Taiwan, in this study, the participants were selected based on the following criteria: the learning activity was part of the formal curriculum of the school and the students were taught by the same teacher. Therefore, the participants of this study included four classes of fifth graders of an elementary school. Two classes were randomly assigned to be the experimental group and the other two were the control

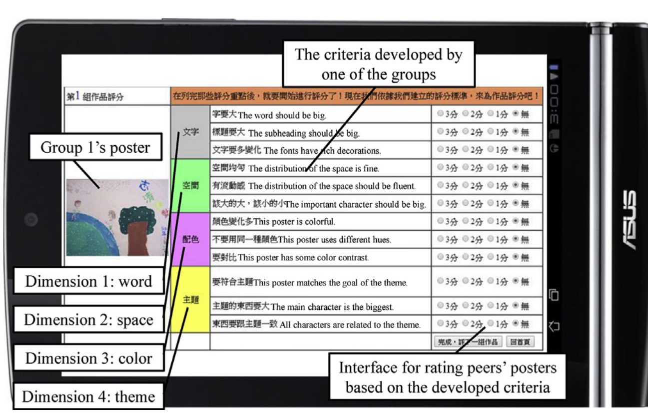

Fig. 7. The interface of peer assessment.

Fig. 8. The interface of students' poster gallery.

group. All of the students had the basic skills of designing posters, and were grouped into the teams they usually worked in. Each group consisted of 2–3 students. The experimental group, including 51 students, learned with the interactive peer-assessment criteria development approach. On the other hand, the control group, with 52 students, learned with the conventional peer assessment strategy. During the learning activity and the data analysis process, all of the students' personal information, including their names, were hidden by using a serial number as identification.

4.2. Rubrics for evaluating posters

To ensure the reliability of the evaluating criteria in this study, two researchers and a school teacher who had more than 10 years' experience of teaching art courses collaboratively defined the rubrics for evaluating the posters, as shown in Table 1. The rubrics were used not only to guide the students in the control group to develop their artwork, but also to serve as a reference for helping the experimental group students develop their own rubrics.

4.3. Experimental procedure

The learning procedure is shown in Fig. 9. At the beginning of the learning activity, the students took the printed pre-questionnaires of learning motivation and meta-cognitive awareness. After completing the pre-questionnaires, the students designed a poster based on the topic specified by the teacher as the pre-test. During the peer assessment activity, the students in both the experimental group and the control group were equipped with a tablet computer to interact with the learning system, which enabled them to share posters, provide comments and receive comments from peers. The only difference between the two groups was the learning approach.

The students in the experimental group learned with the interactive peer-assessment criteria development approach; that is, they participated in the 80-min peer-assessment criteria development process via the learning system. Following that, a 60-min peer-assessment activity was conducted. During this activity, they evaluated other groups' posters and received feedback from their peers for improving their posters.

On the other hand, the control group learned with the conventional peer assessment strategy. At the beginning of the activity, an 80-min assessment criteria instruction was given by the teacher who presented several demonstration posters to help the students understand the evaluation method and criteria. Following that, the students participated in a 60-min peer-assessment activity, in which they evaluated peers' posters via the learning system and received feedback from their peers for refining their posters.

After the learning activity, all of the students completed the questionnaires of learning motivation, meta-cognitive awareness and cognitive load. Moreover, they were asked to design another poster in 120 min as the post-test.

Table 1
The four dimensions of the criteria for poster design.

Dimension	Rating		
	3	2	1
Word	The size of the heading is large and striking. The size of the content is middle type. The text has rich decoration.	The size of the heading is not large enough. The size of the content looks the same as the heading. The text has some decoration.	The size of the heading is too small. The size of the content is too big. The text has no decoration.
Space	The distribution of the space is fine. The font size of the main content is proper.	The distribution of the space is not good enough. The font size of the main content is not big enough.	The distribution of the space is messy. The font size of the main content is too small.
Color	This poster is colorful. The adopted colors make the main content striking.	This poster only contains 2–3 colors. The adopted colors do not make the main content striking.	This poster is boring. The adopted colors make the poster messy.
Theme	All of the poster content is consistent with the theme. The heading is highly related to the theme.	Part of the poster content is related to the theme. The heading is partially relevant to the theme.	All of the content, including its heading, is not relevant to the theme.

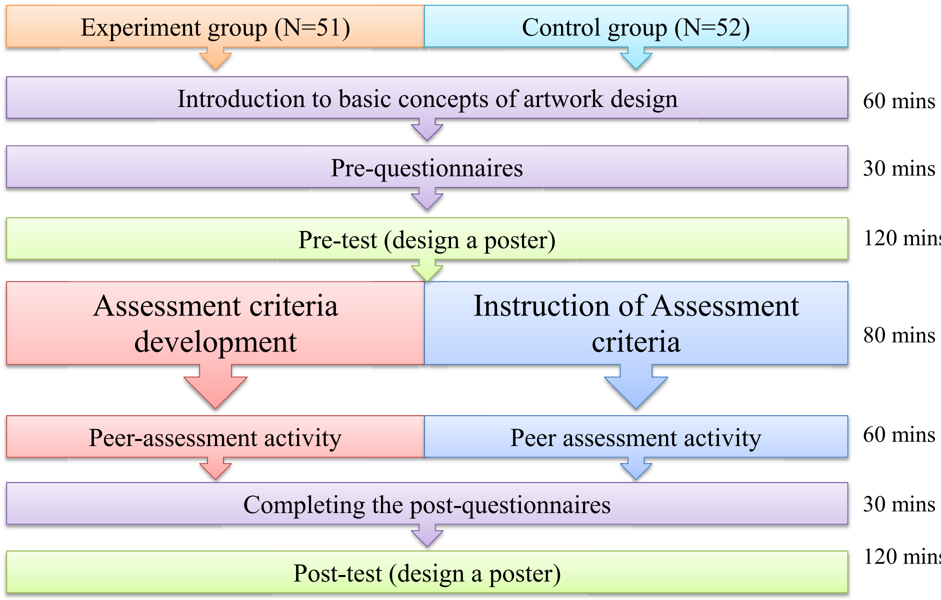

Fig. 9. Diagram of the experiment design.

4.4. Instruments

The measuring tools of this study included the pre-test, post-test, and the questionnaires of learning motivation, meta-cognitive awareness and cognitive load.

In order to evaluate the students' poster designing ability, the pre-test and the post-test required the students to design a poster with their group members. Two experienced art teachers scored the students' posters according to the criteria of poster design which consisted of four evaluating dimensions, "words" (25%), "space" (25%), "color" (25%), and "theme" (25%), with a perfect score of 100. The Cronbach's alpha value of the pre-test was .86, and it was .92 for the post-test, showing a high inter-rater reliability of the test scores.

The questionnaire of learning motivation was modified from the measure developed by Hwang, Yang, and Wang (2013). It consisted of seven items (e.g., "I think learning art is interesting and valuable" and "It is worth learning those things about art") based on a five-point rating scheme. The Cronbach's alpha value of the questionnaire was 0.85.

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

The cognitive load instrument was developed by Hwang et al. (2013) based on the cognitive load measures proposed by Paas, Renkle, and Sweller (2003) and Sweller, van Merrienboer, and Paas (1998). It consists of eight items based on a seven-point Likert rating scheme. The total Cronbach's alpha value of the questionnaire was 0.96.

5. Experimental results

5.1. Analysis of learning achievement

The mean values and standard deviations of the pre-test score were 58.82 and 9.06 for the experimental group, and 58.85 and 10.76 for the control group. The *t*-test result shows that there was no significant difference between the two groups ($t = -.01$, $p > .05$), meaning that the two groups of students had equivalent prior design skills before the learning activity.

After the learning activity, the second poster design as the post-test was conducted to evaluate the students' design skills. Table 2 shows the *t*-test result of the post-test scores of the two groups. The means and standard deviations were 83.06 and 5.31 for the experimental group, and 70.31 and 5.33 for the control group. According to the *t*-test result, there was a significant difference between the two groups ($t = 10.09$, $p < .001$). Furthermore, the Cohen's *d* value of the test results was 2.39. Usually a test result is said to have a large effect size if its Cohen's *d* value is greater than .80 (Cohen, 1988). This result indicates that the finding has a good effect size.

5.2. Learning motivation

The means and standard deviations of the learning motivation pre-questionnaire ratings were 4.00 and 0.59 for the experimental group, and 4.19 and 0.62 for the control group. The *t*-test result shows no significant difference between the pre-questionnaire ratings of the two groups ($t = -1.56$, $p > .05$), showing that the two groups of students had equivalent learning motivation before participating in the learning activity.

Table 3 shows the ANCOVA result of the learning motivation on the post-questionnaire of the two groups. The adjusted means and standard error of the ratings were 4.32 and .09 for the experimental group, and 4.01 and 0.90 for the control group. It is found that the post-questionnaire ratings of the two groups are significantly different ($F = 5.72$, $p < .05$). As the adjusted mean of the experimental group (4.32)

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

Group	N	Mean	S.D.	*t*	*d*
Experimental group	51	83.06	5.31	10.09***	2.39
Control group	52	70.31	5.33		

***$p < .001$.

Table 3
ANCOVA result of the learning motivation post-questionnaire scores of the two groups.

Group	N	Mean	S.D.	Adjusted mean	Std. Error.	*F*
Experimental group	51	4.28	.69	4.32	.09	5.72*
Control group	52	4.08	.79	4.01	.09	

*$p < .05$.

was significantly higher than that of the control group (4.01), it is concluded that the interactive peer-assessment criteria setting strategy had a significant impact on improving the students' learning motivation regarding the art course.

5.3. Meta-cognitive awareness

During the assessment criteria development process, the students were engaged in such higher order thinking activities as identifying the objectives to be accomplished, proposing criteria for fulfilling the objectives, evaluating the criteria proposed by the teacher and their peers, exchanging ideas with others, and making reflections and judgments for revising the criteria. Those activities are highly relevant to meta-cognitive awareness, which refers to what individuals know about the cognitive process and status of themselves and others (Mokhtari & Reichard, 2002). Meta-cognitive awareness helps learners develop and monitor their learning plans as well as enabling them to realize their learning strengths and weaknesses (Schraw & Dennison, 1994).

In this study, the means and standard deviations of the meta-cognitive awareness pre-questionnaire ratings were 3.93 and 0.67 for the experimental group, and 4.05 and 0.66 for the control group. The *t*-test result shows no significant difference between the pre-questionnaire ratings of the two groups ($t = -.89$, $p > .05$), showing that the two groups of students had equivalent meta-cognitive awareness before participating in the learning activity.

Table 4 shows the ANCOVA result of the meta-cognitive awareness post-questionnaire ratings of the two groups. The adjusted means and standard errors of the ratings were 4.14 and .08 for the experimental group, and 3.82 and 0.8 for the control group. It is found that the post-questionnaire ratings of the two groups are significantly different ($F = 7.97$, $p < .01$), suggesting that the interactive peer-assessment criteria setting strategy had a significant impact on improving the students' meta-cognitive awareness in the art course.

5.4. Cognitive load

As it was a new experience for the students to learn with the interactive peer-assessment criteria development approach in the art course, it is interesting to know whether this new approach would increase their cognitive load during the learning process. Table 5 shows the *t*-test result, suggesting that no significant difference was found between the cognitive load ratings of the two groups ($t = -.94$, $p < .05$); that is, the interactive peer-assessment criteria development approach did not increase the students' cognitive load.

6. Discussion and conclusions

In this study, an interactive criteria development approach was proposed for helping students develop knowledge and skills in creativeness-oriented learning activities. An experiment was conducted in the poster design activity of an elementary school art course to evaluate the performance of the proposed approach. The experimental results show that the proposed approach significantly improved the students' learning achievement, learning motivation and meta-cognitive awareness.

In terms of learning achievement, several studies that conducted technology-enhanced constructivist learning activities have reported the potential of engaging students in constructing knowledge themselves (Longfellow, May, Burke, & Marks-Maran, 2008) as well as improving their higher order skills, such as creativity (Auttawutikul et al., 2014; Tsai & Liang, 2009) and reflection (Juwah, 2003; Su & Beaumont, 2010). Researchers have also indicated that learning tasks that engage students in developing course-related content can benefit them in terms of having positive learning performance, stimulating them to have active interaction with peers, and helping them realize their learning problems during such a constructivist learning process (Halverson et al., 2014; Hardy et al. 2014; Jordan, 2012; Yang, 2010). In the present study, the experimental group students created their assessment criteria with the interactive criteria development approach, which involved them in the learning process of developing new criteria, comparing their criteria with those of their peers, making reflections and revisions based on the teacher's comments, and applying the criteria to practical cases. Such a learning process not only

Table 4
ANCOVA result of the meta-cognitive awareness post-questionnaire scores of the two groups.

Group	N	Mean	S.D.	Adjusted mean	Std. Error.	*F*
Experimental group	51	4.12	.67	4.14	.08	7.97**
Control group	52	3.87	.81	3.82	.08	

**$p < .01$.

Table 5
t-Test result of the cognitive load post-questionnaire scores of the two groups.

Group	N	Mean	S.D.	*t*
Experimental group	51	2.45	1.00	−.94
Control group	52	2.65	1.20	

situated them in higher order thinking, but also enabled them to fully comprehend the assessment criteria proposed by the teacher and their peers. This could be the reason why the students showed better learning achievements in their final artwork than the other group.

In terms of learning motivation, although the two groups of students were both asked to evaluate other groups' posters, their learning motivations differed. From the experimental results, it is apparent that the students in the experimental group could develop their own criteria and evaluate other groups' posters based on their criteria. Through this kind of learning activity, the students had the opportunity to play an important role in the learning process; that is, they were allowed to propose their own perspectives and strengthen their confidence via developing and applying their own criteria to the evaluation of peers' work (Pintrich, 2003; Schunk, Pintrich, & Meece, 2008; Wang & Wu, 2008). Therefore, the students' learning motivation, which was related to their self-worth, was aroused (Hyun, 2005; Zhang et al., 2010).

As for meta-cognitive awareness, some researchers have pointed out that engaging students in developing works (e.g., educational games, concept maps) as well as constructing knowledge by themselves could provide them with more opportunities for self-reflection and deeper thinking in their learning (Akinoglu, 2013; Donnelly, 2010; Hwang et al., 2014). Differing from the control group students in the current study, who only evaluated other groups' posters, the students in the experimental group needed to face the challenges from their peers and teacher to make reflections during the assessment criteria development and revision process. Such a process of developing, comparing, reflecting on and revising assessment criteria could situate them in higher order thinking and help them see things from different perspectives (Sutopo & Waldrip, 2014; Yang, Gamble, Hung, & Lin, 2014); that is, they were more aware of the objectives to be accomplished, the criteria to be fulfilled, and how to meet the criteria. This finding also supports the point indicated by scholars that learners with better meta-cognitive awareness are likely to show better performance in identifying the key points of the learning tasks, finding the required strategies and sources, planning the procedure and time for completing the tasks, and checking whether the criteria of the tasks are fulfilled; therefore, they tend to learn more strategically and effectively (Chu, Hwang, & Tsai, 2010; Mokhtari & Reichard, 2002). Moreover, from the students' learning outcomes and their feedback on the cognitive load measure, it was found that the proposed approach could help the students learn better without increasing either their mental load or their mental effort. That is, the students did not feel overly stressed even though they needed to face the challenges from the teacher and their peers during the assessment criteria development process. Consequently, it is evident that the interactive peer-assessment criteria development approach is an effective strategy for engaging students in higher order thinking.

To sum up, the major contribution of this study is to propose and implement an interactive assessment criteria development approach that has not been considered before. The proposed approach realizes the future work addressed by several previous studies (Juwah, 2003; Yu & Wu, 2013); that is, it is important to increase students' participation and engagement during the learning process, and involving them in the assessment criteria process could be a good strategy. The research findings of this study also accomplish the expectations of several researchers (Jonassen, Carr, & Yueh, 1998; Peng, Su, Chou, & Tsai, 2009), namely that involving students in constructing knowledge on their own can help them to demonstrate high quality learning performance. Furthermore, the provision of individual feedback in the criteria developing process can help the students design fit-for-purpose work after learning (Nicolaidou, 2013).

On the other hand, it should be noted that the present study has some limitations. First, the experiment was conducted with fifth graders taking an art course; therefore, the findings might not be able to be generalized to subjects of other ages or to those taking other courses without conducting further experiments. Second, during the assessment criteria development process, teachers need to provide feedback to individual students via the learning system, which might increase their workload to some extent. Although a friendly interface has been provided to assist teachers in comparing students' rubrics with the objective rubric, such a feedback-providing approach could overload the teachers if the number of students is large. Therefore, it is worth developing semi-automatic or even fully automatic mechanisms to provide feedback for improving students' rubrics in future studies. In addition, since the proposed assessment criteria development approach is effective in terms of assisting students in improving their learning performance for poster design, it is worth investigating students' learning behaviors and the quality of their self-generated criteria in the future.

Acknowledgments

This study is supported in part by the National Science Council of the Republic of China under contract numbers NSC 99-2511-S-011-011-MY3 and NSC 100-2631-S-011-003. The authors would like to thank Dr. J.C. Yang for his assistance in developing the learning system.

Appendix. Questionnaire items

Learning motivation

(1) I think learning art is interesting and valuable.
(2) I would like to learn more and observe more in the art course.
(3) It is worth learning those things about art.
(4) It is important for me to learn the art course well.
(5) It is important to know the art knowledge related to our lives.
(6) I will actively search for more information and learn about art.
(7) It is important for everyone to take the art course.

Meta-cognitive awareness

(1) I ask myself periodically if I am meeting my goals.
(2) I ask myself if I have considered all options when solving a problem.
(3) I periodically review to help me understand important relationships.
(4) I find myself pausing regularly to check my comprehension.
(5) I ask myself questions about how well I am doing while I am learning something new.
(6) I ask myself if there was an easier way to do things after I finish a task.
(7) I summarize what I've learned after I finish.
(8) I ask myself how well I accomplish my goals once I'm finished.
(9) I ask myself if I have considered all options after I solve a problem.
(10) I ask myself if I learned as much as I could have once I finish a task.

Cognitive load

(1) The learning content in this learning activity was difficult for me.
(2) I had to put a lot of effort into solving the learning tasks in this learning activity.
(3) It was troublesome for me to solve the learning tasks in this learning activity.
(4) I felt frustrated solving the learning tasks in this learning activity.
(5) I did not have enough time to solve the learning tasks in this learning activity.
(6) During the learning activity, the way of instruction or learning content presentation caused me a lot of mental effort.
(7) I need to put lots of effort into completing the learning tasks or achieving the learning objectives in this learning activity.
(8) The instructional way in the learning activity was difficult to follow and understand.

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