The Design of Instructional Scaffolds to Facilitate Online Project-Based Learning

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Abstract: The study designed scaffolds to facilitate online project-based learning. The question-generation, worked examples and peer-assessment were adopted and transformed into the scaffolds. The integration of the scaffolds into the project process was exemplified in a distance course, entitle as *instructional design*. Thirty college students participated in the study for 18 weeks. The Moodle as well as the Adobe-connect learning system were adopted to engage learners with the contents, scaffolds and team collaboration. Data analysis found that the scaffolds facilitated participants' engagement with the learning contents and team interaction. Empirical significance of the study as well as suggestions for instructional implementation and future study are provided.

Keywords: Online project-based learning, Worked examples, Scaffolds, Peer-assessment

1. Introduction

Creating instructional products with virtual teams to effectively engage learners in active knowledge creation by maximizing the merits of advanced interactive learning technology is very complex (Perez & Emery, 1995). Instructional designers' cognitive abilities to integrate multiple domains of knowledge and collaboration skills to bring together the diverse expertise of each team member at the distant are highly demanded. The online project-based learning strategy is frequently adopted to engage student designers in deliberately practicing the above-mentioned process (Tynjala, 1998).

However, the inherent openness of project-based learning environment might introduce even more complex cognitive tasks which might increase student designers' cognitive loads. Without systematic guidance to facilitate learners in constructing essential knowledge bases, student designers often fail to execute relevant domain knowledge in analyzing the project scenarios. Moreover, they are often not able to efficiently manage project progress and exchange ideas among virtual team members, which might further result in the incompleteness of project tasks. Therefore, design appropriate scaffolds to provide support on a conceptual level and virtual team interaction are essential.

This study aims to design the scaffolds for implementing project-based learning in the distance course of instructional design. More specifically, the design of the worked example, question generation strategy and peer-assessment as the scaffolds is proposed. Students' engagement in the learning process and interaction among peers are investigated.

2. Literature Review

Project- based learning, which is rooted in the idea of learning by doing, enables student designers to practice solving diverse design problems, synthesize theories and skills, and further construct their knowledgebase (Tynjala, 1998). Its effect is influenced by three design elements: (1) The relevancy of the project scenario with the real-world design problems: The more the project simulates the real-world problem, the more complex of the project scenario will be. The complexity of the project brings student designers more challenge; meanwhile, it might also enhance their curiosity and intrinsic goal orientation (Bednar, Cunningham, Duffy, & Perry, 1992; Cobb, 1994; Karagiorgi, & Symeou, 2005). (2)Systematic guidance: The project usually presents learners with ill-structured design problems, requiring multiple thinking dimensions, which in turns result in student learners heavy cognitive loads. Without adequate and timely guidance, learns might easily give up their projects especially while working with peers at the distant on the virtual project. Moreover, student designers, lacking of the experience in working on ill-structure problems, tend to think of the design problem from single perspective and over-emphasize on the project product instead of the project process. (3) Team facilitation: Student designers' abilities to construct their cognitive structures are enhanced by social interaction with peers, which includes asking questions, explaining their reasoning for the design ideas, listening to peers' ideas and reconciling differences between their ideas and the ideas of others (O'Donnell & King, 1999). However, collaboration levels in the virtual projects are difficult to control, which leads to the lack of clarity of individual responsibilities and leadership and low intensity of interaction among the virtual group members. Therefore, a sound design of scaffolds is essential to engage student designers in reasoning through the problem from multiple perspectives, provide challenge and encourage more creative design ideas (Tynjala, 1998) and facilitate them in working on virtual projects.

Two essential types of scaffolds to facilitate online project-based learning are conceptual scaffolds and interaction scaffolds. The support of the conceptual scaffold using the worked example could effectively reduce a novice designer's cognitive load in analyzing and solving a new ill-structured problem (Sweller, 1998; Sweller, 2005; Turner, Meyer, Cox, Logan, DiCintio, & Thomas, 1998; van Merriënboer, Kirschner, & Kester, 2003). However, the reduction of the extraneous cognitive loads does not necessarily initiate their devoting more working memory to exploring the complex structures represented in the worked examples and the underlying principles and knowledge associated with the given problem. In other words, an effective worked example should engage student designers in executing working memory to simulate expert thinking process and reason through the solution path. Moreover, the cognitive load brought by the project tasks will change according to a designer's expertise. A designer, who is able to transfer the learned knowledge and skills into schema, could efficiently focus on the design/solution path and underlying knowledge structures presented in the worked example. Too much guidance might bring them extra cognitive load (Kalyuga, Ayres, Chandler, & Sweller, 2003; Kalyuga & Sweller, 2004), Therefore, the conceptual support should gradually fade out with student designers' development of the expertise.

Scaffolding effects of question-generation and peer-assessment strategies can be reasoned based on social learning and constructivism (Yu, & Liu, 2005; van Gennip, Segers & Tillema, 2009). On one hand, the effects of these two strategies in enhancing learners' comprehension of the contents are evidenced in many empirical studies. On the other hand, the high cognitive abilities demanded by the collaborative question-generation task might contribute to high density of the interaction within virtual teams and encourage them to share and construct knowledge. Moreover, the peer-assessment process enables student designers to observe peers' products, compare their own design solutions with those designed by others, which might lead to modification of their products and their own cognitive structures.

Several research gaps after in-depth literature review were identified: First, the linkage between the worked examples and novice instructional designers' engagement in the activity of constructing their knowledge base in the distant learning environment remains less known. Second, the scaffolding effects of question-generation and peer-assessment strategies on cognitive abilities can be reasoned based on social learning and constructivism; however, their effects on the team interaction require more empirical evidence. Last, but the most importantly, reflection is importance in developing instructional designers' competency. Majority of the research emphasizes on the role of "self" in the reflection process (Bilinski, 2002; Johns, 1995; Schmidt, 2004). However, argued from the collective intelligence perspective, that peer assessment and dialogue could enhance more deliberate and collaborative reflection is reasonably anticipated (Sluijsmans, Moerkerke, van Merriënboer, & Dochy, 2001; Sluijsmans, Brand-Gruwel, & van

Merriënboer, 2002). Therefore sound design of these scaffolds emphasizing on peer collaboration in the distant course is worthy of more efforts.

3. Research Method

3.1 Research Design

Thirty college students, who registered in the distant course, entitle as *instructional design*, participated in the study for 18 consecutive weeks. The asynchronous features of the Moodle learning system and the synchronous features of the Adobe-Connect were adopted in this study to engage learners with the learning activities, contents, scaffolds etc. To ensure that participants possessed the fundamental skills of using the communication technologies embedded in the learning systems, a training session on integrating the technologies for project communication and the follow-up question-generation and peer assessment with hands-on activity was arranged.

For the duration of the study, students attended face-to-face sessions at the first two weeks to get familiar with the learning path of the overall course, their peers and the learning technologies. The learners were randomly assigned to six teams. In the following 16 weeks, the class moved on to an asynchronous format. During the weekly online learning activity, students watched the video explaining the learning contents individually, followed by a team mission to be completed. Each member within the team took turns on leading the team to accomplish the team mission. In addition to the weekly team mission, each team was required to an instructional product as their course project. At the last class, they moved on to individually assess the instructional product developed by other teams.

The design blueprint of the scaffolds was developed and implemented. Two data sources are collected to explore the impact of the scaffolds. First, the frequency of participants' accessing the systems was used to evidence levels of their engagement with the course content and the scaffolds. Second, the number and quality of the posting within each team were presented and analyzed weekly.

4. Results and Conclusions

4.1 Design of the Scaffolds

Two types of scaffolds to facilitate online project-based learning were designed and exemplified in Table 1. The purposes and implementation of the scaffolds associated with the four stages of online project-based learning were described.

Table 1. Design blueprint of the scaffolds

Learning stage	Aim	Scaffold	Levels
1.Project initiation	Associate the course progress with the project process	Learning Map	Individual
	Introduce the project	Project Descriptor	Group
2-1.Knowledge building	Ensure the knowledge base for the project	Question-Generation	Individual
2-2.Team Building	Enhance team interaction	Question-Assessing	Group
3-1.Problem Analysis	Exemplify the analysis process	Worked Examples	Group
3-2.Research /Development	Exemplify the research/development process	Worked Examples	Group
4.Solution Evaluation	Seek feedback	In-field testing	Group

	Enhance evaluation ability	Peer-assessment	Individual

1. Project initiation stage: Learning maps were designed to match the project tasks and requirement with the weekly learning contents. This scaffold does not only enable individual learner to link learning contents with the learning outcomes but also scaffold learners to plan their learning path. The second scaffold introduced is the project descriptor. This study created an animation to present different project scenarios and the e-tutor within the animation guided the learners to explore the information inherent in the scenario. Teams were asked to reach consensus in selecting one scenario as their term project based on their exploration of the scenarios.
2. Knowledge and team building stage: The scaffold of question-generation was implemented to ensure individual's comprehension of the course contents by asking each learner to generate one multiple-choice question. The weekly leaders of the teams have to facilitate their team discussion to modify the generated questions.
3. Problem analysis, research and development stage: The scaffold of worked example with e-tutor exemplified experts' reasoning process and guided learners to think of multiple perspectives and synthesize the required domain knowledge.
4. Solution evaluation stage: Each team conducted a field-testing of their design products and revised before in-class peer review. During the peer review process, each individual evaluated the assigned product according to the given criteria and provided written recommendation. After the peer-assessment, the team members were required to read and interpret the comments and write a reflection on product improvement.

Learners' engagement with the learning content is evidenced in 798 times of visiting the content weekly. More specifically, the frequencies of each learner interacting with the contents during the period of introducing the scaffolds of learning maps, project descriptors, question-generation and worked-examples are 26.6, 10.4, 13.2, and 10.53, respectively.

Table 2. The frequency of learners' interacting with course contents weekly

	Learning Maps	Project Descriptor	Question-Generation	Worked-Example
Weekly hits	798	312	396	316
Weekly hits per learner	26.6	10.4	13.2	10.53

Team interaction is revealed in 743 postings supplied by the learners and the 959 times of visiting the posting during 18 weeks. More specifically, the weekly conversations within teams occurring during the period of introducing question-generation scaffolds range from 8 to 39 iterations while the team conversations occurring during the period of introducing the worked example scaffold range from 1 to 25 iterations (Please see Table 3).

Table3. The weekly conversations within the team weekly

	No. of subjects	Question-Generation	Worked-Example	Peer-Assessment
Team1	6	20	7	12
Team2	4	12	2	11
Team3	4	28	8	14
Team4	5	8	1	18
Team5	5	12	2	11
Team6	6	39	25	12
Total	30	119	45	78

In addition to the number of postings, the team interaction should also account for the frequency of reading the postings, which can represent inherent cognitive interaction within the team. Table 4 presents the weekly frequency of reading the postings within teams during the period of introducing question-generation scaffolds, ranging from128 to 536 times. More interestingly, the weekly frequency of reading the comments provided by their peers during the peer-assessment activity ranges from92 to 217.

Table4. The weekly frequency of reading Postings and replied postings within the team

	No. of subjects	Question-Generation	Worked-Example	Peer-Assessment
Team1	6	300	86	217
Team2	4	233	243	114
Team3	4	298	82	181
Team4	5	128	21	192
Team5	5	150	33	92
Team6	6	536	348	185
Total	30	1644	613	981

4.2 Conclusion

The study designed scaffolds to engage student designers in conducting instructional projects with virtual teams. First, the results imply that the designed scaffolds could facilitate student designers' engagement with constructing their knowledge base in the distant learning environment. Second, the scaffolding effects of question-generation and peer-assessment strategies on the team interaction are also evidenced.

The findings have important empirical significance as well as implications for research on online project-based learning. First, the study substantiated the effect of question-generation on learners' mastery of the content Second, the worked-example scaffold which simulates experts' reasoning process, facilitates students in synthesizing knowledge associated with solving the given problem, which is the key factor to the success of project-based learning. Finally, the team interaction was enhanced by the scaffolds. In-depth and systematic analysis of the conversations between interacting parties and learners perceptions toward group dynamic via interaction process analysis is recommended for future study.

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