Development of a Web-Based Learning System to Engage Students in Question Generation Activities

Chun-Ping Wu and Shu-Ling Wu

***Abstract*—The strategy of student generated question engages students in deeply interacting with the newly learned contents, examining their learning outcomes, and practicing asking questions and generating answers. Grounded on the potential of this strategy, this study aims to develop a web-based system to engage students in question generation activities. A single group pre-and-posttest experimental design was adopted to further explore its effects on students' learning gains. Sixty one college students participated in the study for four weeks. The findings show that students learning is significantly enhanced by the SGQ strategy. Furthermore, students' perquisite knowledge is significantly correlated with the quality of the questions students generated. Last, students who generated questions of better quality are found to perform better in the post-knowledge assessment. Suggestions for instructional practice and future studies are provided. .**

***Index Terms*—Student generated question strategy, a web-based learning system, learning gain**

I. Introduction

Asking a good question is critical in the learning process. Students, who well use their knowledge to observe and interpret the newly learned contents, usually ask a good question worthy of further exploration. Therefore, in addition to encouraging students to ask questions, educators need to facilitate students in connecting their existing knowledge with new knowledge, which may enhance students' ability to ask a good question.

The strategy of Student-generated question (SGQ) assigns the evaluation task to the students, which students play the role of a teacher and create an assessment tool to evaluate students' mastery of the newly learned content. During the process, students need to identify important concepts as the core of their questions, design the question items, provide a better/correct answer, and constantly revise their questions. Such a process does not only engage students in searching for questions and answers, but also provide an opportunity for students to deliberately practicing asking a good question. The positive effects of the strategy on students' self-reported motivation and cognitive strategies use were evidenced in prior studies [1]-[4]. More research studies in exploring its effects on students' knowledge gains using objective measures are needed.

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This study aims to develop a web-based question generation system, which allows students to compose and revise questions, observe their peers' questions and receive instant feedback from their peers. Furthermore, a user experience testing was conducted to ensure the quality of the system. Last, but most importantly, an empirical experiment was conducted to explore the effects of the SGQ strategy.

II. Literature Review

The literature regarding the SGQ strategy and cognitive load theory will be review and discussed.

A. SGQ Strategy

The SGQ strategy is defined as students using their newly learned knowledge to compose a series of questions to assess their peers. First, students need to create the core of the question, by recalling what have learned and identifying important concepts and concepts which their peers might be confused about. Second, they need to construct the question stems by deeply examining the meaning the concepts, and the relationships among different concepts. Then they translate their understanding into the question wording. Third, when designing the answers, they experience a micro problem-solving process [5]. Specifically, they need to offer several possible solutions to the question they raise, carefully examining and testing the solutions to ensure the best/correct answer is obtained. The above process facilitates students in recalling, analyzing, organizing and synthesizing the learning content [6], evaluating self-understanding of the concepts[7], elaborating understanding of the learned content into the content of questions, which helps to schema construction [8] [9]. The positive impacts of the SGQ strategy on learning motivation, higher order thinking, cognitive and metacognitive strategies use were empirically validated in prior studies [1]-[4].

B. The Cognitive Load Theory and SGQ System Development

Students without prior experience in question, generation, usually feel the activity novelty, challenging but difficult [10]. According to the cognitive load theory, students have to devote cognitive efforts to the question generation tasks. For those students without experience in question generation or pre-requisite knowledge regarding the newly learned contents, the question generation tasks will impose them a lot of intrinsic cognitive load [11]-[13]. At the same time, the explanation of the task requirements and the way students are asked to present their products (i.e. questions) will also impose their extraneous cognitive loads. If the intrinsic and extraneous cognitive load exceed students' limited cognitive

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capacity [14], the potential learning effects brought by the SGQ strategy will not occur. Therefore, it is essential to develop an online SGQ environment, which does not only reduce any possible extraneous cognitive load, but also allow students to create and revise question easily and enhance the quality of their questions via peer feedback activities.

To sum up, the SGQ strategy engages students in deeply interacting with the learned contents. Therefore it is reasonably to propose the following hypotheses:

Hypothesis1: Students' pre-requisite knowledge regarding the newly learned content will be correlated with the quality of the questions students generate.

Hypothesis2: Students' mastery of the newly learned content will be enhanced by being engaged in the SGQ activity.

Hypothesis3: Students' mastery of the newly learned content will be correlated with the quality of the questions students generate.

III. Research Method

This study consists two stages: First, the web-based SGQ system was designed and developed by the research team. Ten college students with experience in question-generation were invited as the participants for the user experience (UX) testing. Second, the single group pretest-and-posttest experimental design was adopted. Sixty-one students, include 47 undergraduate and 14 graduate students were recruited to participate in the four-week experiment. The contents chosen are one test-construction theory and three educational psychology theories while the multiple choice question is selected as the type of question students have to compose.

A. Variables and Instruments

User experience (UX) is defined as question-authors' behavior and feeling, which is adopted to evaluate usability and ease of use the web-based SGQ system. The 10 invited question-authors were asked to conduct a series of question-generation tasks within the system. The users' action, operation path and time to conduct each sub-task were recorded by the Morae to evaluate whether the system accommodate users' intuitive operation. After that, each question-author is asked to rate the quality of "the question-posing function", "the question-management function", "navigation and interface" and "the visual appeal". The system was revised based on the user experience testing results before conducting the second stage of the study.

The quality of the questions students generate were evaluated by six dimensions: fluency, flexibility, elaboration, originality, cognitive level and importance [15]. Fluency (0~6) refers to the correctness of the wording and clarity of the meaning. Flexibility (0~2) refers to consisting several concepts and self-derived examples. Elaboration (0~2) refers to creating scenarios for the questions. Originality (0~2) refers to using creative way to design or present the question. Cognitive level (0~4) refers to the cognitive demanded for composing this question. Importance (0~2) evaluates whether the question assess important concepts. Two raters were recruited to rate each question using the six indicators. The scores received from the raters were averaged per question per week throughout the activity.

The pre-requisite knowledge was assessed by 24 multiple choice questions, which evaluated participants' knowledge about the previously mentioned four theories before being engaged in the SGQ activity. The difficulty of the items range from 0.3 to 0.7.

Students' mastery of the four theories after the experiment was assessed by another 24 multiple choice questions.

B. Experiment Procedures

Sixty-one students participated in the four-week workshop. At the beginning of the study, the pre-requisite assessment was administered. The training on the question generation task and the web SGQ system were introduced. Participants were asked to practice composing one question within the system. The workshop instructor selected four questions and facilitated participants in discussing how to improve the selected questions. During the experiments, per weekly, the workshop instructor delivered 2.5 hour lecture on one theory and the participants were asked to compose four questions after the lecture within 30 minutes.

IV. Results

A. The Web-Based SGQ System

This study developed the web-based SGQ system which was named as Knowledge Management and Question Authoring System. The system was revised based on the user experience testing results. Two subsystems (question-generation and peer-assessment) were embedded in the system.

The question-generation sub-system includes three functions:

1) Question-posing function

As shown in Fig. 1, the left side of the interface allows users to type in question stems and four options, set up correct answers, and select cognitive levels and concepts. To facilitate users in recalling the concepts, the system allows the instructor to present the concepts in the format of "concept-map". Then the user could click the button of "concept-map" and read the groups of concepts (see Fig. 2). S/he may select the concepts to be the core of the question by simply clicking the concepts in the concept-map. The concepts being selected will be automatically inserted into the question-posing interface.

The right side of the interface allows users to preview the questions they construct before submitting to the system.

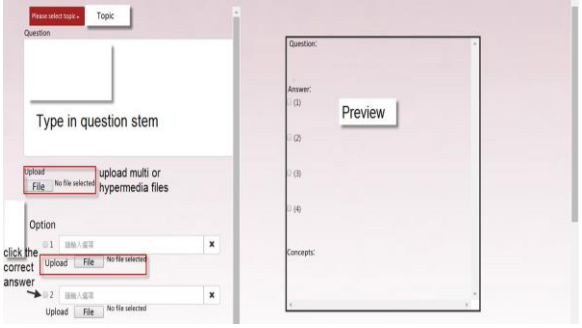

Fig. 1. Question-posing interface.

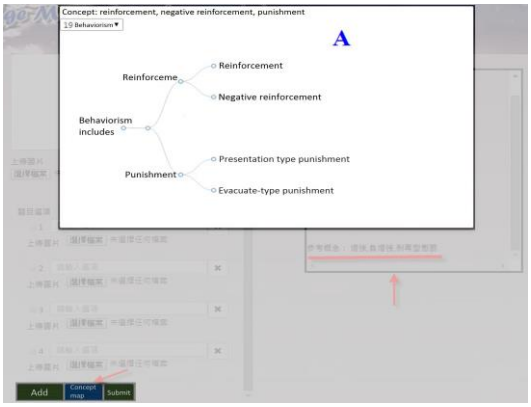

Fig. 2. Concept map function in the question-posing interface.

2) Question management function

The question management function (see Fig. 3) allows users to manage the questions and edit the questions. Additionally, users could export the questions into the pdf format.

Fig. 3. Question-management interface.

3) Feedback-review function

The feedback review function allows users to read the feedback given by the instructor or the peers. When users click the button "a" (see Fig. 4), the feedback given by the peers will appear in the area of "b". The question author could read the feedback and respond to the feedback as well.

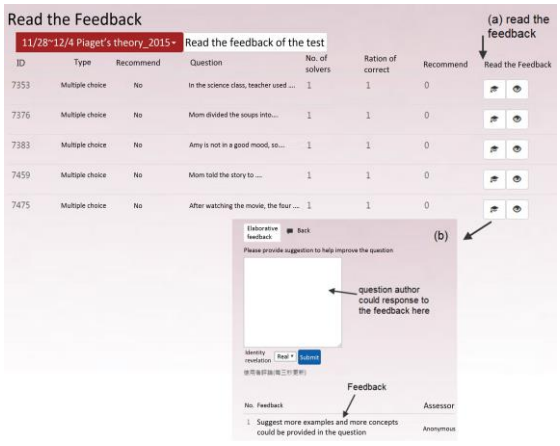

Fig. 4. Feedback review interface.

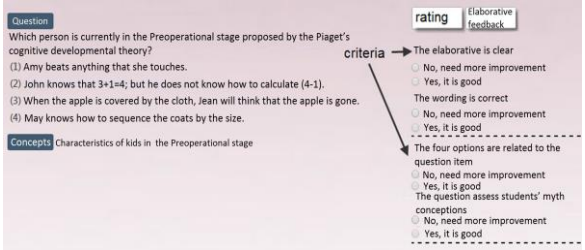

Fig. 5. Question-rating function in the peer-assessment interface.

The peer-assessment sub-system, although not being used in the second stage of this study, was created for the users to observe and review the questions composed by their peers. They learn to rate the peers' questions according to the given criteria (see Fig. 5) and then provide elaborative suggestions to help their peers to improve the questions (see Fig. 6).

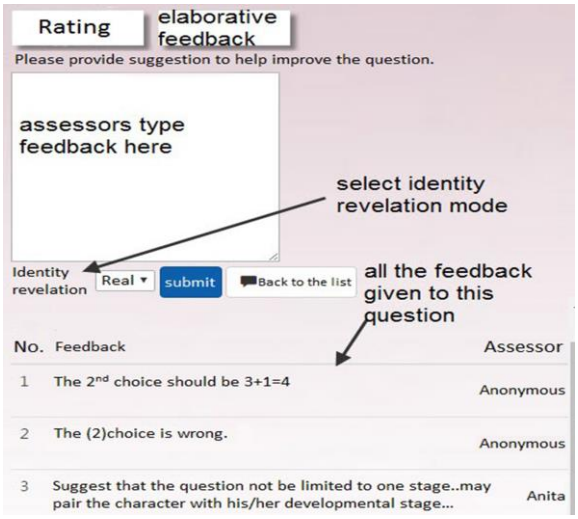

Fig. 6. Elaborative feedback function in the peer-assessment interface.

B. The Students' Pre-requisite Knowledge Is Correlated with the Quality of the Questions Students Generate

The students' scores gained in the four pre-requisite knowledge tests are presented in Table I. Moreover, as shown in Table II, the quality of students' questions ranges from 12.73 to 15.25.

TABLE I: THE PRE-REQUISITE KNOWLEDGE

Topic	Topic 1	Topic 2	Topic 3	Topic 4	Sum
Mean	10.49	31.15	13.44	9.05	64.13
SD	3.59	6.41	4.32	5.51	14.29
Perfect score	16	40	20	20	96

TABLE II: THE QUALITY OF STUDENTS' QUESTIONS

Topic	Topic 1	Topic 2	Topic 3	Topic 4
Mean	12.73	15.25	13.03	14.33
SD	3.93	2.40	3.03	1.70
Perfect score	18	18	18	18

TABLE III: THE POST-TEST SCORES

Topic	Topic 1	Topic 2	Topic 3	Topic 4	Sum
Mean	10.42	35.48	14.95	11.67	72.53
SD	3.81	5.73	3.57	5.90	12.45
Perfect score	16	40	20	20	96
T (post vs. pretest)	-0.12	4.74	2.4	4.68	5.94
P-value	.90	.00	.02	.00	.00

The correlation result show that the students' pre-requisite knowledge is significantly correlated with the quality of the questions students generated (r = .23, p < 0.01). In other words, students with better pre-requisite knowledge tended to generate questions of better quality.

C. Students' Mastery of the Newly Learned Content Is Enhanced by Being Engaged in the SGQ Activity

The students' scores gained in the four post-tests are presented in Table III. The pair-t test result show that students' mastery of the newly learned contents is significantly higher than the knowledge at the beginning of the study (t = 5.94, p < 0.01). In other words, students' mastery of the theories is enhanced by being engaged in the SGQ activities.

D. Students' Mastery of the Newly Learned Content Is Correlated with the Quality of the Questions Students Generated

The correlation result show that the students' performance in the post tests is significantly correlated with the quality of the questions students generated (r = .25, p < 0.01). In other words, students who generated questions of better quality tended to gain higher scores in the post-tests.

V. Conclusion

A web-based SGQ system was developed in this study to engage students in the activity of composing questions. The empirical findings substantiated the educational benefits of the SGQ strategy on enhancing students' learning outcomes. Additionally, the finding contributed to understanding that students' pre-requisite knowledge may affect students' engagement in the SGQ activity. Instructors are suggested to adopt this creative strategy rather than traditional drill-and-practice activities to enhance students' interaction with the knowledge. Those students without well pre-requisite knowledge may need more attention from the instructor. To avoid students being overloaded by the SGQ and peer-assessment activities, this study did not adopt peer-assessment. As found in the finding, students learning was enhanced, which could be reasonably infer that the cognitive efforts demanded by the SGQ did not exceed students' cognitive capacity. Therefore, future studies are recommended to further explore the coupling effects of these two strategies.

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