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Exploring the Effects of the Collaborative and Cooperative Test-construction Strategies

Chun-Ping WU
Department of Education, National University of Tainan, Taiwan
*cpwu303@gmail.com

Abstract: Based on the positive impacts of the student-question-generation strategy, this study extended the question-generation activity to the test construction activity. The test-construction activity is even more complex than composing questions, and this activity may demand more of learners' mental efforts. This study adopted the concept of shared cognitive capacity, which is proposed by the cognitive load theory. Specifically, to avoid students being overloaded, collaborative and cooperative learning were integrated into the test-construction process. A pre-and-post experiment was conducted via online workshop for seven weeks. 79 subjects were randomly assigned to one of the interventions, collaborative test construction activity, cooperative test construction activity and individual test construction activity. A statistically significant difference in students' mastery of the newly learned contents among the three intervention groups was found; however, such an effect was not found in the variables of reported use of cognitive and metacognitive strategies. Implications for the practice and future research will be provided.

Keywords: Collaborative learning, cooperative learning, test-construction strategy

1. Introduction

The student-question-generation strategy (SGQ) prompts students to use their newly learned knowledge to design questions to assess their peers (Yu, Wu, & Hung, 2014). During the SGQ process, the question-authors create the core of the question by recalling what have learned and identifying important concepts and any concepts that may confuse other students. Second, the question-authors 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, they need to provide several possible solutions to the question.

The SGQ process may be beneficial to learning. First, the question-authors use their schema to interpret the newly learned contents, identify important concepts to be the core of questions. This process enables them to monitor their own learning and think of how to raise a question (Lee & Hutchison, 1998; van Blerkom & van Blerkom, 2004). Second, they need to evaluate their understanding of the learned contents and paraphrase their understanding into questions. This process enables them to use cognitive strategies, such as organization and elaboration (Craik, 2002). Third, the process of composing questions in texts or figures may enable them to deliberately interpret the knowledge in a meaningful way, which may help to schema construction (Bangert-Drowns, Hurley & Wilkinson, 2004; Lee & Hutchison, 1998). The question-authors may experience a micro problem-solving process while designing several possible solutions to the question (Yu, Liu, & Chan, 2005). To sum up, the SGQ may prompt students to use cognitive strategy during the question-posing process, thus contributing to deep learning. The positive impacts of SGQ on students' motivation, confidence, understanding of newly learned contents, and metacognition have been evidenced in numerous prior research studies (Abramovich & Cho, 2006; Berry & Chew, 2008; Chiu, Wu, & Cheng, 2013; Yu, 2005; Yu & Liu, 2005; Yu & Wu, 2012). However, most of the research focused on composing questions.

A good test needs to include a series of good questions, which evaluates students' understanding of *all* important concepts in the newly learned contents and judge whether students have achieved learning objectives. During the test-construction process, the question-authors need to understand learning objectives, identify the knowledge structure, and understand the relationships among the

concepts, which are essential in the process of designing the test structure. Then they move to question-authoring process and keep monitoring whether the questions they compose fit into the structure. The study of Yu and Su (2013) indicated that the strategy of student test-construction (SCT) enables students to review the learned content more comprehensively. The strategy could increase elementary students' science learning attitude and motivation (Yu & Su, 2015). Moreover, compared to the SGQ, the study of Yu and Wu (2016) evidenced that the test-items composed by the SCT group covered more and in-depth concepts and presented more concept connections than those by the group of students who only required to compose questions.

On one hand, the SCT may be more beneficial to learning; on the other hand, the SCT is more complex and may demand more of students' mental efforts, which may result in students being cognitively overloaded. When furtherly exploring the SCT process based on the cognitive load theory, the novice, with limited cognitive capacity to manage information simultaneously (Baddeley, 1992), may devote more intrinsic and extrinsic cognitive efforts to analyze the information relevant to the SCT task. When constructing a test for the newly learned knowledge, the SCT task itself may impose more intrinsic cognitive load on the novice (Sweller, 2010; Sweller, van Merriënboer, & Paas, 1998). Meanwhile, novice, without knowledge relevant to test construction or newly learned knowledge, may pay attention to the information that is irrelevant to the SCT task. This process may impose extrinsic cognitive loads on the students. The novice may be overloaded, thus, the potential benefits of the SCT may be reduced.

To sum up, numerous studies have evidenced the benefits of the SGQ strategy; however, few studies explored the potentials of SCT. Moreover, to avoid students being cognitively overloaded, this study, grounded on the concept of shared cognitive capacity, proposed by the cognitive load theory (Kirschner, Paas, & Kirschner, 2010). Specifically, the SCT tasks may impose high intrinsic cognitive load to individuals and result in cognitive overloaded, it may be a possible solution to have students work together on the task. According to the study of Kirschner, Paas, and Kirschner (2010), the collaborative learning efficiency was found because the collective memory effects occurred when students work together well on complex tasks. Several essentials to the collective memory effects include task complexity, students' willingness to work together and so on. Therefore, this study proposed to integrate the strategy of cooperative and collaborative learning into the SCT.

2. Research Purpose

Grounded on the concept of shared cognitive capacity, this study explored the potential of collaborative and cooperative SCT strategy on students' learning. Three research questions were proposed as follow:

1. Are there any differences found in the reported use of cognitive strategies among the collaborative SCT, cooperative SCT and the individual SCT groups?
2. Are there any differences found in the reported use of meta-cognitive strategies among the collaborative SCT, cooperative SCT and the individual SCT groups?
3. Are there any differences found in students' mastery of the newly learned contents among the collaborative SCT, cooperative SCT and the individual SCT groups?

3. Research Method

A pre-and-post experiment was conducted. Ninety participants participated in the online "educational psychology" workshop for seven weeks. All subjects were randomly assigned to one of the three intervention conditions, the collaborative SCT, the cooperative SCT and the individual SCT. Excluding those subjects who did not complete the post-tests, the data of seventy-nine subjects were analyzed. 58 of them are undergraduate students and 21 are graduate students.

3.1 The Online Test-construction System

The Collaborative SCT work-space (CSCT) is embedded in the web-based Knowledge Management and Question Authoring System (KMQAS) developed by the author. The KMQAS has the question-generation, the test-construction, and peer-assessment subsystems. Its quality was assured by two prior studies (Wu & Wu, 2017; Wu, Chen, & Wu, 2017). First, the user could use the test-construct function in the question posing and question-management processes. Second, the user could check their test item using the two-way specification table. Third, as shown in the figure1, the question- posing work area is located at the left side with the preview function at the right side. The "collaborative SCT work-space" button is always located at the bottom-right corner of the window. The users could click the button to open the space. Fourth, to minimize any possible interference brought by the SCT function, users are given the freedom to determine when to open the work space. Fifth, an exclamation mark is designed to notify users of any in-coming or unread messages.

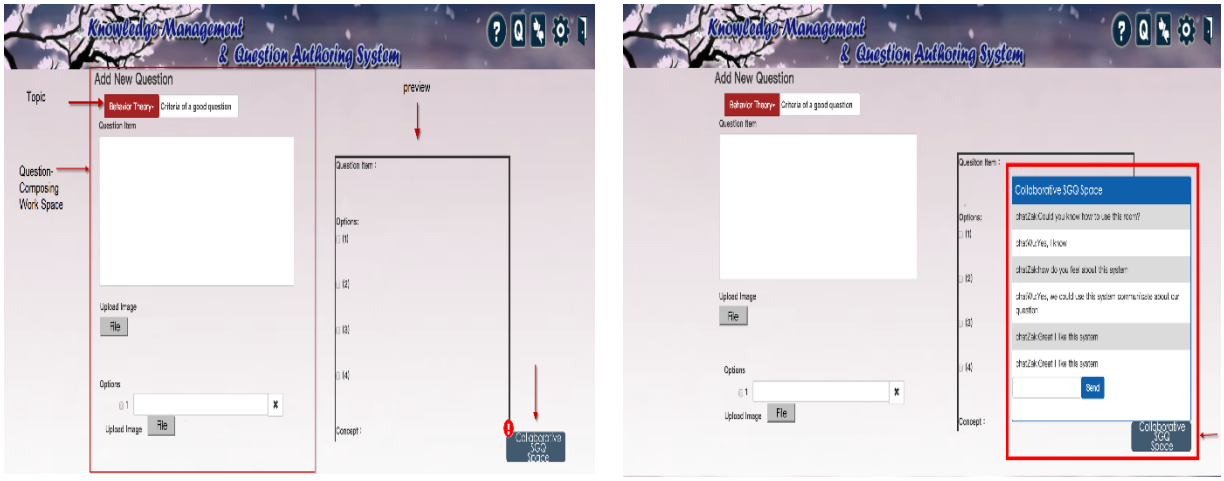

Figure 1. The Collaborative Function

Last, the users could provide or read feedback using the peer-assessment sub-system.

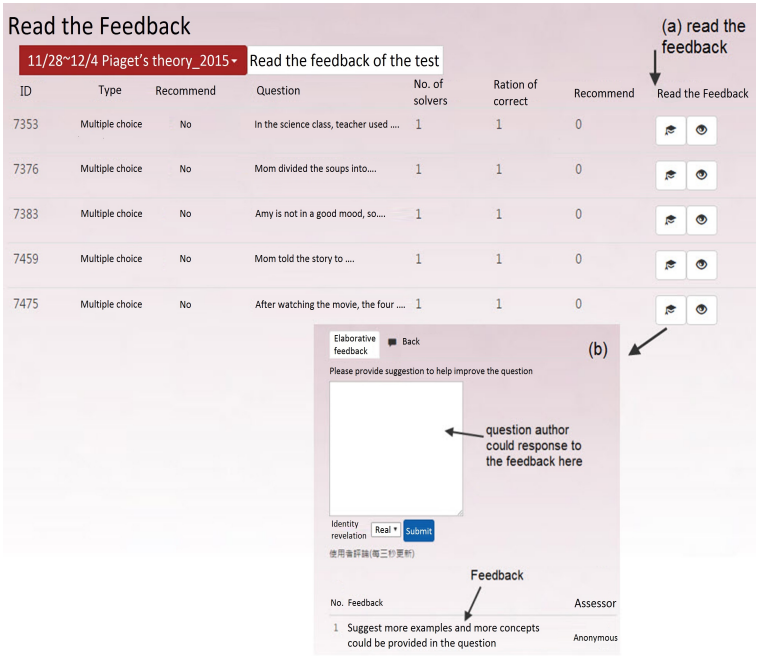

Figure 2. The Peer-assessment Sub-system.

3.2 The Independent Variable

The independent variable is the strategy of collaborative SCT. The three intervention conditions are: collaborative SCT, cooperative SCT and individual SCT. The subjects in the collaborative SCT

condition were paired to work on designing the structure of the test, composing and revising the test-items, and arranging the sequence of the test-items. The subjects in the cooperative SCT condition worked on the test construction tasks individually, but they were paired to provide feedback to their partner in each stage of the test construction (see figure 3). Last, the subjects in the individual SCT condition work on the test construction task individually.

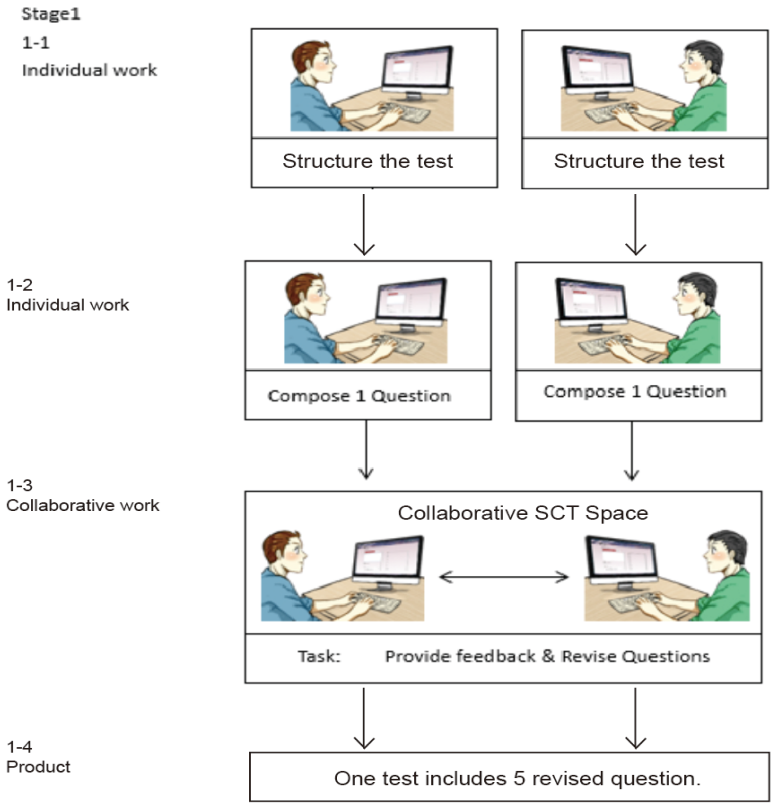

Figure 3. The Cooperative SCT process.

3.3 The Dependent Variables

The dependent variables are the reported use of cognitive strategies, the metacognitive strategies and the mastery of the newly learned contents. First, the reported use of cognitive strategy refers to the strategy students used to enhance effectiveness and efficiency of constructing the test. This study adopted the 16-item instrument created by Hung (2002), which includes three factors, the rehearsal strategy, the organization strategy and the elaboration strategy. The instrument adopted 6 point Likert scale. The higher the scores were, the more use of cognitive strategy students reported.

Second, the meta-cognitive strategy refers to the strategy individual uses to actively monitor their status and ensure their progress to the goal (Flavell, 1979). The strategy include plan, monitor and evaluation (Leutwyler, 2009; Schraw, Crippen, & Hartley, 2006; Schraw & Moshman, 1995). Schraw and Dennison (1994) developed Metacognitive Awareness Inventory (MAI) to measure adult's metacognition, using the 100-point scale. The second part of MAI, regulation of cognition, was adopted in this study. The higher the scores were, the more use of meta-cognitive strategy students reported.

Third, the newly learned contents referred to six educational psychology theories the participants learned in the online workshop, including the cognitive development theory, behaviorism, social learning theory, cognitive theory, scaffold, and motivation theories. Two equivalent tests were developed by the author to assess subjects' mastery of the theories. Each test included 45 items and were evaluated by two subject-matter experts. Then the tests were tested by 60 freshmen, who just completed the educational psychology course. After deleting items with poor discrimination, 42 items per test were used for the study.

3.4 The Research Design

The pre-and-post experiment was conducted in the online workshop for seven weeks. The first two weeks were conducted via a synchronous online workshop. In week1, a training session of the test-construction activity and the online system was delivered. The pre-tests were also implemented. In week2, the lesson of "the cognitive development theory" was delivered and the subjects were required to construct a test on the learned topic. In week3-6, all the learning activities were implemented via asynchronous online workshops. After learning the given theories, the subjects observed the outstanding tests constructed in prior week and read the feedback provided by the teacher. Then they were asked to construct a test on the learned topic. In week7, the post-tests were implemented.

4. Results

The descriptive statistics of three interventions were presented in Table 1 and 2.

Table 1. *The Descriptive Statistics of Reported Cognitive Strategies and Meta-Cognitive Strategies Use*

		Cognitive Strategies		Meta-Cognitive Strategies	
		Pre-test	Post-test	Pre-test	Post-test
	N	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Collaborative SCT	29	5.85(0.54)	5.67(0.69)	77.60(7.15)	75.91(9.81)
Cooperative SCT	29	5.50(0.93)	5.62(0.77)	75.65(10.32)	75.75(12.10)
Individual SCT	21	5.67(0.48)	5.59(0.87)	79.33(6.79)	77.36 (9.22)

Table 2. *The Descriptive Statistics of Mastery of Newly Learned Contents*

		Pre-test	Post-test
	N	Mean (SD)	Mean (SD)
Collaborative SCT	29	55.48 (8.7)	71.52 (10.90)
Cooperative SCT	29	59.14(9.55)	78.79 (9.45)
Individual SCT	21	55.76 (9.89)	68.23 (11.09)

The ANCOVA, using the using the pre-test of cognitive strategies as the covariate, was conducted. The Levene's test result indicated that the homogeneity assumption of ANVOCA was satisfied ($F = 1.10$, $p = .34$). No statistically significance was found in this variable among the three intervention groups ($F = .63$, $p = .54$).

The ANCOVA, using the using the pre-test of meta-cognitive strategies as the covariate, was conducted. The Levene's test result indicated that the homogeneity assumption of ANCOVA was satisfied ($F = 1.51$, $p = .23$). No statistically significance was found in this variable among the three intervention groups ($F = .52$ $p = .60$).

The ANCOVA, using the using the pre-test as the covariate, was conducted. The Levene's test result indicated that the homogeneity assumption of ANVOCA was satisfied ($F = 1.82$, $p = .17$). Statistically significant difference was found among the three intervention groups ($F = 5.62$, $p = .005$). The scores of collaborative SCT are statistically significantly different from those of cooperative SCT($p = .03$). The scores of cooperative SCT are statistically significantly different from those of individual SCT ($p = .002$).

5. Conclusion

The collaborative SCT demanded mental efforts to understanding the learned contents, constructing the tests and working with their partners. As found in this study, the cooperative group showed better mastery of the newly learned content than the other two groups. The cooperative SCT is similar to integrating peer-assessment into SCT. The result evidenced the value of peer-assessment. Furthermore, a possible explanation to the result may be that collaboration is even more demanding than cooperation in the online environment. The effect of shared collective cognitive capacity may be found only when

the work did not exceed students' cognitive capacity and the students knew how to work with their partners. Future research is suggested to explore the factors that may influence the collaborative SCT and extend this study into the face-to-face context.

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