

An Experimental Study on the Effects of an Online Student-Constructed Tests Learning Activity

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Abstract: While the learning potential of student-constructed tests for the promotion of knowledge integration and elaboration has been suggested, its learning effects warrant further empirical examination. Three fifth-grade classes (N=76) participated in this study for nine consecutive weeks. A one-group pre-post experimental research design was used, and an online student-constructed tests learning system was adopted to support elementary students' science learning. The results from the paired *t*-tests found significant increase in students' attitudes toward science and science learning motivation as a result of the incorporated activity. Yet, no significant differences were found in students' use of cognitive and metacognitive strategies after the activity. Based on the collected data, suggestions for instructional implementations are provided.

Keywords: Experimental study, learning effects, online learning system, primary school settings

1. Introduction

The learning benefits of student-generated questions (hereafter name SQG) have been well established empirically. In general, empirical evidence accumulated since the 1960s provides a solid basis for its effects on enhancing understanding, academic achievement, motivation, question-generation abilities, the use of cognitive and metacognitive strategies, problem-solving abilities and attitudes toward the subject matter studied (Brown and Walter, 2005; Chin, Brown and Bruce, 2002; Dori and Herscovitz, 1999; English, 1997; Perez, 1985; Rosenshine, Meister and Chapman, 1996; Yu and Liu, 2008).

Recently, researchers have experimented the idea of engaging students in constructing a test and found promising evidence for its potential. Specifically, data on students' perceptions found that students' preference to and perceptions of student-constructed tests (SCT) and teacher-constructed tests (TCT) were statistically significant at $p < .01$ with a considerable proportion of students preferring SCT as the approach for assessing their learning and regarding SCT as a better approach for promoting learning (Yu, 2013). Descriptive data analyzed further highlighted the potential of SCT for the promotion of knowledge integration (Yu and Su, 2013a) and knowledge elaboration (Yu and Su, 2013b).

Constructing "tests" is different from constructing questions, and it would direct attention to additional criteria. Since a more holistic view of the study content may be obtained (Yu and Su, 2013a), and cognitive processes of different nature and intensity may be mobilized, the learning effects of SCT was the focus of this study. To provide comprehensive information about the observed phenomena in educational context, the learning effects on both cognitive and affective (specifically, the use of cognitive and metacognitive strategies, attitudes toward science and science learning motivation) are examined in this study.

2. Methods

2.1 Participants and instructional content

Students from three intact fifth-grade classes (N=76) taught by the same science teacher were briefed about the purpose of the introduced online learning activity (i.e., support of their science learning; the promotion of higher-order thinking skills, including self-monitoring comprehension level when attending lectures, grasping the main ideas of the study content; evaluating self- and peers' learning by constructing a set of questions of appropriate scope and difficulty) and invited to participate. All students at the participating schools started taking computer classes when they were at the 3rd grade and so had basic computer skills needed to carry out the activity.

Two science units were covered during the study. The first unit is about “how heat affects matter” with three lessons that cover topics including the changes of matter after heating, heat transfer, and insulation. The second unit is on “air and burning” with three lessons. Topics covered include the characteristics of oxygen and carbon dioxide, their uses in daily life and their relationship to burning matter; three elements of combustion; and fire extinguishing and the fire prevention.

2.2 Implementation procedures

The implementation procedure is delineated in Figure 1. A pilot study involving one fifth-grade class in the participating school (N=28) was conducted to ensure that the planned procedures and time allocation for various activities were appropriate prior to the actual study. Data on participants' cognitive and metacognitive strategy use, attitudes toward science and science learning motivation was collected prior to the commencement of this study.

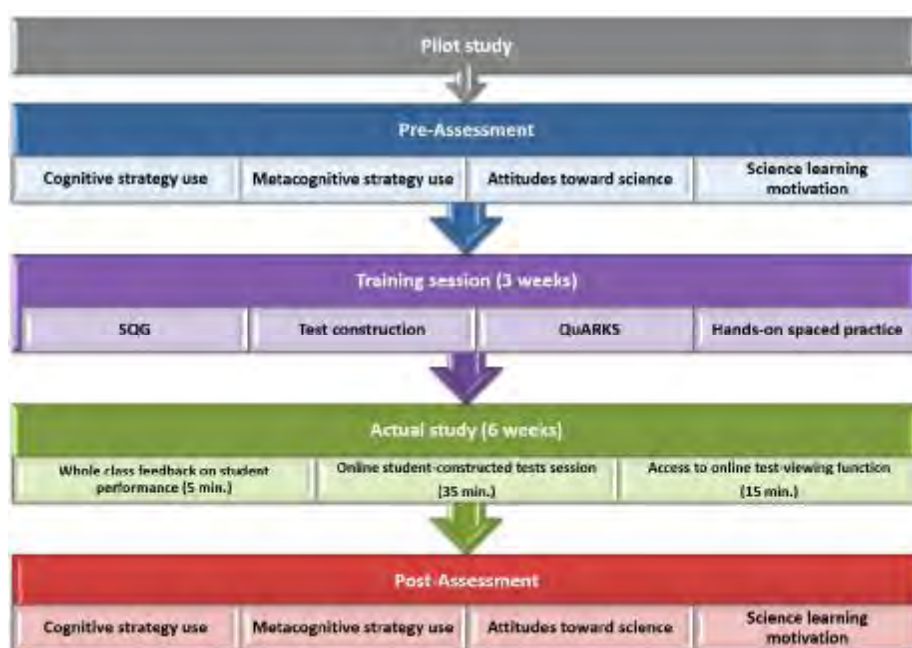


Figure 1. *Experimental procedures of this study*

This study took place right after the school-wide first-term exam. For this study, three of the most frequently encountered question types in primary schools in Taiwan were chosen for the learning activity—true/false, matching and multiple-choice questions. For the duration of the study (i.e., nine consecutive weeks in total), as a routine, participating students would head to the computer lab after attending three 40-minute instructional sessions on science in their respective class. To equip participants with essential knowledge and skills associated with the engaged tasks, three sessions were reserved for training prior to the study. During the training session, quality criteria frequently associated with SQG and SCT and basic principles for item writing for each of the chosen question types were introduced and explained. In addition, the operational procedures for the adopted system were demonstrated, followed up by students' hands-on spaced practice activities.

For each of the following six weeks, at the beginning, whole-class feedback on student performance at the previous SCT activity was arranged with reference to SCT criteria (e.g., covering

all main topics, appropriateness of test difficulty level in general, appropriateness of coverage and representation of all main topics). Afterwards, students were directed to construct a test around the science content covered in the prior three instructional sessions by composing a minimum of five question items consisting of at least two out of the three chosen question types. A post-session questionnaire were disseminated to participants for individual completion after the study.

2.3 The Online SCT Learning System

An online learning system supporting associated activities of the study was adopted. Students in this study had access to test-construction and test-view functions of the adopted system.

To construct a test, students first design the overall structure of a test in terms of the number and scoring scheme of each question type. Second, students generate questions out of any of the three question types of their choice. After satisfying a number of questions have been generated, students then view and select individual questions to be included in the test at work. Finally, students can determine and re-arrange the relative sequence of questions both within and among question types before submission.

To promote learning by permitting students to learn from observing peer's work, an observational learning space—test-viewing was created and made accessible at the last 15 minutes of each online learning activity.

2.4 Measurement instrument

Three instruments were used in the study to test the learning effects of online student-constructed tests. First of all, Hung's (2002) "Learning Strategy Use Scale" was adopted. The scale consisted of two parts: "Cognitive Strategies Use Scale" (18 items) and "Metacognitive Strategies Use Scale" (24 items). The former appraises students' use of rehearsal, elaboration and organization learning strategies, and the latter reveals students' activation of metacognitive strategies for cognition regulation, such as planning, monitoring, revising and evaluating one's actions and reasoning while learning. All items were rated on a 6-point Likert scale, with corresponding verbal descriptions ranging from "no consistency" through "very inconsistent," "somewhat inconsistent," "somewhat consistent," "very consistent," to "complete consistency." The internal consistency reliability calculated after this study was .92 and .94 for the "Cognitive Strategies Use Scale" and "Metacognitive Strategies Use Scale," respectively.

Second, "Attitude toward Science in School Assessment" developed by Germann (1988) was adopted to measure students' attitudes toward science. To ensure that the instrument was translated appropriately and adequately, back translation technique was used. Results from the exploratory factor analysis and Cronbach's α with a group of fifth-grade students ($N=30$) by Tsai (2010) substantiated its validity and reliability. The instrument consisted of fourteen Likert-scale items. Each statement was rated on a five-part discrete scale, with corresponding verbal descriptions ranging from "strongly disagree" through "disagree," "no-opinion," "agree," to "strongly agree." The Cronbach's alpha values calculated after the study ($N=149$) was 0.88.

Finally, Hung's (2002) "Science Learning Motivation" was adopted for this study. The scale consisted of 14 items and used a six-point Likert scale (ranging from 1=no consistency to 6=complete consistency). The scales validated by a group of 303 sixth-graders evidenced good validity. The Cronbach's alpha values calculated after the study ($N=149$) was .94.

3. Results

As shown in Table 1, after exposed to the SCT activity, students not only activated more of cognitive and metacognitive strategy while learning science, but also formed better attitudes and exhibited heightened motivation toward science. Nevertheless, the results from one-group paired *t*-tests found significant differences only in attitudes toward science and science learning motivation, but not in the cognitive domains.

Table 1: Descriptive and inferential statistics on four observed variables

Variables	<i>n</i>	<i>M</i> (<i>SD</i>)	<i>t</i>	η^2
Cognitive strategy use				
Pretest	76	3.86(0.95)	-1.12	.02
Posttest		4.01(1.20)		
Metacognitive strategy use				
Pretest	76	4.00(0.93)	-1.56	.03
Posttest		4.17(1.19)		
Attitude toward science				
Pretest	76	4.41(1.27)	2.89*	.10
Posttest		4.76(1.09)		
Science learning motivation				
Pretest	75	4.10(1.14)	3.13*	.17
Posttest		4.47(1.15)		

* $p < .05$

4. Discussion and Conclusion

Preliminary studies on the potential of SCT supported its effects on knowledge integration and elaboration (Yu and Su, 2013a; Yu and Su, 2013b). The current study extended prior studies by substantiating its affective effects. By allowing students to construct questions around the study materials they regard as important and relevant, to allocate different weighting among different study topics and to decide the relative sequence of question items within and among question types, SCT in essence is more in alignment with what constructivism, self-regulation and self-determination theories accentuate. As a result, as found in this study, exposing students to SCT helped to increase students' attitudes toward science and science learning motivation.

However, the current study failed to find SCT helped to promote the use of cognitive or metacognitive strategies. Through in-depth analysis of the current study and prior studies, some possible explanation for the unconfirmed results are rendered. First of all, the current study involved fifth-grade students (average age=11), who just reached Piaget's formal operational cognitive development whereas prior studies involved university students, who should be mentally more prepared and ready for the whole range of tasks involved in SCT. Second, participants in this study were directed to construct tests around the study materials on a weekly basis, which may not be in its entirety. Unlike prior studies, SCT activity was arranged around the end of the semester where opportunities for inter-connecting and integrating of all topics are provided.

Based on the findings of this study, it is suggested that instructors can engage students in SCT activity for the promotion of students' affective development, in specific, attitudes and learning motivation toward the learned subject.

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