國立政治大學「教育與心理研究」
2008 年 9 月，31 卷 3 期，頁 25-52

學生出題策略與傳統練習策略對大學生學習成就、認知與後設認知策略使用之影響

于富雲* 劉祐興**

摘　要

本研究探討「學生出題」策略與「題目練習」對學生學業成就、認知策略與後設認知策略的影響。研究採取準實驗法，由同一位老師教導的兩班土木工程學系學生（共69位），以不同策略進行六禮拜的課程，之後比較兩班級的學業成就，並比較不同策略學習前、後對認知策略及後設認知策略的影響。研究結果顯示，相較於傳統「題目練習」策略，「學生出題」策略較能引發學生於聽課歷程中運用不同之認知與後設認知策略，但不同策略並未造成學業成就上的差異。根據本研究發現及相關理論根基，建議教師可於課堂中嘗試使用學生出題策略，以輔助學生認知與後設認知策略之發展。

關鍵詞：後設認知策略、認知策略、練習、學生出題

---

* 于富雲：國立成功大學教育研究所教授
** 劉祐興：國立暨南國際大學土木工程學系副教授
電子郵件：fuyun@mail.ncku.edu.tw
收件日期：2007.8.31；修改日期：2007.12.11；接受日期：2007.12.12

Journal of Education & Psychology
September, 2008, Vol. 31 No. 3, pp. 25-52

The Comparative Effects of Student Question-Posing and Question-Answering Strategies on Promoting College Students' Academic Achievement, Cognitive and Metacognitive Strategies Use

Fu-Yun Yu[*]   Yu-Hsin Liu[**]

Abstract

The study examined the comparative effects of student multiple-choice question-posing and question-answering strategies on promoting students' academic achievement, cognitive and metacognitive strategies use in a lecture-mode instructional setting. In total, 69 civil engineering undergraduates enrolled in two sessions of a required course participated in the study. Statistical analysis found that student multiple-choice question-posing strategy is a more productive strategy for inducing and engaging students in mobilizing cognitive and metacognitive strategies as compared to the traditional question-answering arrangement. In terms of students' academic performance, student multiple-choice question-posing is as effective a strategy as question-answering. Based on the present study, it is suggested that instructors who were accustomed to in-class practice

[*] Fu-Yun Yu: Professor, Institute of Education, National Cheng Kung University
[**] Yu-Hsin Liu: Associate Professor, Department of Civil Engineering, National Chi Nan University
E-mail: fuyun@mail.ncku.edu.tw
Manuscript recieved: 2007.8.31; Revised: 2007.12.11; Accepted: 2007.12.12

sessions might consider a student question-posing approach for an amiable change to promote students' cognitive and metacognitive strategies use without worrying about its less favorable impact on students' performance.

Keywords: cognitive strategies, metacognitive strategies, question-answering, student question-posing

Introduction

At the present time lecturing is still one of the most prevailing instructional methods at elementary, secondary and undergraduate educational levels worldwide. As students receive much of their information at schools via this delivery mode, encouraging students to take an active role in regulating their cognitive processes while attending to lectures is critical to their academic success.

Of the various “external events” present in normal classrooms (e.g., gaining attention, informing learners of objective, stimulating recall of prerequisite knowledge, presenting stimulus material, guiding learning, eliciting performance, providing feedback, assessing performance, and enhancing retention & transfer in Gagne’s term), practice sessions and in-class quiz are some of the few instructional events that students literally need to respond to (Gagne, 1985; Gagne, Briggs, & Wager, 1992). Such events are usually arranged by instructors in an attempt to induce students to engage in on-the-spot information processing of incoming messages while in class and to assess students’ level of understanding. Though its functional roles and associated effects are undeniable, considering that source of questions or problems are primarily from textbooks or teachers (Brown & Walters, 2005), whether there are other productive ways to induce and engage students during the process with just a slight twist drives this investigation.

To elaborate, students have traditionally solved teacher-generated questions—questions that teachers think will be of relevance, importance and interest (English, 1998). While educators as well as students seem to be conditioned to accept a pedagogy that places question-posing exclusively in the hands of instructors, the phenomena of students unilaterally receiving information conveyed by teachers and responding to questions handed down by teachers impose traditional values of a hierarchal relationship between teachers and students (with teachers assuming authoritative status).

The importance of diversifying the sources of questions (Silver, 1994), and the potential of student-generated questions has attracted researchers’ attention since the seminal work of the first edition of Brown and Walter published in 1983—*The Art of Problem Posing* (Brown & Walter, 1983). How student-generated questions might affect learning can be conceptualized by examining their impact on students' cognitive processes. Briefly illustrated, student-generated problems tend to engage students in the process of reflecting on the information received, and elaborating and transforming received information into personally meaningful forms (Bangert-Drowns, Hurley, & Wilkinson, 2004). While engaging in a question-generating learning task, students seem to be induced into a habitual state of constructing personal knowledge and strategic capabilities through the employment of cognitive and metacognitive learning strategies, which, in the view of information-processing theory and metacognition, promote learning (Yu & Liu, 2005).

In an attempt to induce and engage students in a state that accentuates interpretation and reflection of personal understanding and thinking when attending lectures, the potential of a student question-posing approach was examined in this study. Contrasting with the conventional arrangement where students respond to questions provided by teachers, the effects of directing students to generate questions, specifically, multiple-choice questions, in class were examined. The research hypotheses are:

1. There will be a significant difference in the mean academic achievement posttest score between students exposed to the multiple-choice question-posing condition and those exposed the multiple-choice question-answering condition.

2. There will be a significant difference in the sub-scales of the questionnaire measuring students' cognitive strategies use between the two different conditions.

3. There will be a significant difference in the sub-scale of the questionnaire measuring students' metacognitive strategies use between the two conditions.

Questions such as the following are examined: during lectures would multiple-choice question-posing approach, as compared to multiple-choice question-answering, induce more frequent use of cognitive strategies, like highlighting important points, relating new information to prior knowledge, and rehearsing portions of incoming messages on the learners' part; during lectures would multiple-choice question-posing in comparison to question-answering induce learners to more regularly activate comprehension-fostering and monitoring behaviors; would multiple-choice question-posing and question-answering solicit and mobilize various levels of uses of cognitive and metacognitive strategies during lecture, and result in differential academic performance.

In the following sections, an overview and analysis of the theoretical basis underpinning a student-generated questions approach was briefly provided, followed by a summary of literature supporting the value of a student question-posing strategy before moving on to the description of the study undertaken.

Theoretical Basis Underpinning Student Question-Posing Strategy

Student generated-questions have been depicted as a promising strategy to facilitate students' cognitive elaboration, achieve meaningful learning and reinforce higher-order thinking skills (Chin & Kayalvizhi, 2002; English, 1998). Two theories that could help explain why a student question-posing strategy (specifically, multiple-choice question—the focus of the present study) would be conducive to performance, cognitive and metacognitive performance are introduced briefly: information-processing theory and metacognition.

Information-Processing Theory

Researchers in cognitive psychology have long held that if information is to be retained and related to information already stored in memory, the learner must engage in some sort of information-processing, such as rehearsal, organization and elaboration (Gagne, 1985; Gagne et al., 1992). In addition to helping learners consolidate knowledge better and longer, cognitivists believe that such processing techniques can help cognitive structuring or re-constructing (Reigeluth, 1983; Wittrock, 1978).

When engaging in the task of generating a multiple-choice question, students need to construct a question-stem, the correct answer, and three additional alternatives. During the process, students must figure out which parts of the learning materials are important and worth testing, and which are not. Then, they need to tactically phrase the question and come up with the correct answer, if not already provided in the materials. In other words, question-posers at times need to go through the questions-solving stage. Moreover, they need to ponder three distractors that can effectively discriminate those who have learned the materials from those who have not. To accomplish these tasks, students would, presumably, constantly re-examine instructional materials so as to point out distinctive features and differences among closely related categories, clarify relationships among pieces of information, and compare newly acquired concepts to previously learned concepts. All in all involves the cognitive processes of rehearsal, organization and elaboration, which, in light of information-processing theory, should be beneficial to understanding and cognitive development.

Metacognition

Metacognition can be simply defined as “thinking about thinking.” Briefly stated, metacognition refers to higher order thinking that involves active control over the cognitive processes engaged in learning, and emphasizes the role of executive processes in the overseeing and controlling of cognitive processes (Brown, 1987; Livingston, 2003). The term “metacognition” is most often associated with John Flavell, who offered an early commonly accepted definition of metacognition. According to Flavell, metacognition consists of metacognitive knowledge (person variables, task variables and strategy variables) and metacognitive experience (involving the use of metacognitive strategies) (Flavell, 1979). While cognitive strategies are used to help an individual achieve a particular goal, metacognitive strategies are the mediator processes that one uses to control cognitive activities to ensure that a cognitive goal has been met (Livingston, 2003). Executive processes involve planning, monitoring, evaluating and revising ones’ cognitive processes while learning. Activities like setting up learning goals, selecting learning strategies matched with task demands, continuous assessment of one’s understanding and the attainment of the pre-determined learning goal/sub-goals, and adjusting strategic plans of approaching learning tasks so as to maximize one’s learning are metacognitive in nature (Livingston, 2003; Pintrich, Smith, Garcia, & McKeachie, 1989).

As stated, when confronted with the task of generating multiple-choice questions, several sub-tasks are involved. Completing these sub-tasks usually demands the recurring use of various metacognitive strategies. Briefly illustrated, to generate multiple-choice questions students need to make sure that they understand the materials. If that is not the case, they must determine what needs to be done to ensure that they meet the cognitive goal of understanding the text. In this instance, “monitoring” comprehension may be called in first, accompanied by “evaluating” whether the cognitive goal of understanding has been met, which may be followed by “planning” and “revising” to bring out the planned outcomes. As can be seen, a mixture of metacognitive strategies, including “monitoring,” “evaluating” “planning” and “revising“ may be activated at different points during the process. Similarly, when faced with the tasks of providing correct answer to the posed questions, finding plausible alternatives, and the like, students would need to pull in various metacognitive strategies to attain the task at hand. In view of metacognition, when learners engage in question-posing activity, monitoring one’s understanding of the presented materials and the associative activities of regulating one’s cognitive process (e.g., triggering strategic actions like reviewing notes to remedy insufficient comprehension, relating new materials to prior knowledge, integrating incoming pieces of information into a consolidated form, etc.) should be frequently observed.

In a nutshell, information-processing theory and metacognition all support the idea of engaging students in the question-posing activity to induce and engage students to more active control of their cognitive states and minds.

Literature Support the Potential of Student Question-Posing Strategy

A number of observations have been made about how questions that students compose can be of value. For students’ own sake, question-formation helps themselves focus their attention and reflect on received materials, which ends not only in improved information processing and lecture comprehension, but also elicits inferences, explanations and other high-level cognitive processes (Biddulph, Symington, & Osborne, 1986). The documented benefits gained by students from question-posing activities include: developing a deeper understanding of the subject content learned, shifting from acquiring to using knowledge, giving students a sense of ownership of the subject content as well as their learning experience, developing higher-order thinking skills, generating more diverse and flexible thinking, encouraging students to be more involved in and in control of their learning, facilitating small group communication about the interacting the interacting topic, building up students' confidence about the subject matter, and sparking students' interest and ability in the follow-up problem-solving activity. (Abramovich & Cho, 2006; Barlow & Cates, 2006; Brown & Walter, 2005; Whitin, 2004; Yu & Liu, 2005). On the other hand, from the perspective of the teacher, problem-posing holds benefits for the implementing teachers as well, particularly, in its assessment value—by revealing insight into students' abilities in the subject content and providing an accurate assessment of what their students are capable of accomplishing (Whiten, 2004).

Evidence from empirical studies further support the teaching and inclusion of student question-posing in the instructional process for the enhancement of students' reading comprehension, academic performance, question-generation ability, problem-solving ability, etc. (Davey & McBride, 1986a, 1986b; Dori & Herscovitz, 1999; King, 1992; Koch & Eckstein, 1991; Leung & Silver, 1997; Perez, 1985; Rosenshine, Meister, & Chapman, 1996; Silver, 1994; Weiner, 1978; Wong, 1985). For instance, based on her review of research on the use of self-questioning, Wong (1985) concluded that students of various grades and ability levels who had been trained in self-questioning during reading generally showed comprehension superior to that of those who used re-read or self-review strategies. Rosenshine et al.'s (1996) review of intervention studies in which students were taught to generate questions as a means of improving their comprehension found that question-generation strategy resulted in gains in comprehension. Dori and Herscovitz (1999) conducted research on scientific question-posing capabilities among 10th-grade students who were studying case studies. Analysis of the questions students posed showed that a significant increase in the number and complexity of questions posed after the activity as well as considerable improvement of their ability to analyze a related case study and to seek practical solutions to a given problem. On the basis of these findings, the researchers suggested that integrating question-posing into a case-study teaching approach is an effective strategy for improving problem-solving ability. Rather than focusing on text-processing, King extended the use of student-questioning to the context of oral lecture and found that a question-posing strategy significantly improved ninth-graders' lecture comprehension (King, 1991, 1992). Yu and Liu (2005) in their study focused on examining the potential of multiple-choice question-construction for students' learning of physics experiments. Results found that the influences of question-construction were evident in several significant ways: promoting constructive and productive studying habits, reflecting and previewing course related materials, increasing in-group communication and interaction, and breaking passive learning style and habits. Analysis with one-group t-tests further found that students' satisfaction toward past learning experience, and perceptions toward this strategy's potentials for promoting learning were statistically significant while learning anxiety was not statistically significant.

Even though past research generally provided encouraging evidence supporting the application of student question-posing for promoting comprehension, existing studies mostly compared question-posing learning activity to re-read or self-review study strategies, were conducted in primary or secondary school contexts, and examined its effects on the comprehension of presented materials. The effects of question-posing as opposed to question-answering activity—one of the few events that students are frequently asked to respond to in regular classroom settings, on performance as well as cognitive and metacognitive strategies use are not known. Accordingly, this study set out to examine the effects of multiple-choice question-posing on students' academic achievement, cognitive and metacognitive strategies use while attending lectures as compared to the traditional question-answering approach.

Methodology

Participants and Learning Context

Participants in the study were civil engineering undergraduates (ages 19~21) who enrolled in two sessions of a "Transportation Engineering" course at one university in the central part of Taiwan. The course was listed as a 3-credit hour required course to be taken in the sophomore year at the participating department. This course is the first course related to transportation at the undergraduate level. In total, 69 students registered for the course.

Experimental Design and Treatment Conditions

To examine the differential effects of question-posing and question-answering on academic performance, a posttest-only experimental design was adopted where effects on their cognitive and metacognitive strategies use were examined via a 2x2 mixed-design. To ensure that students from both classes started out similarly in term of their academic performance, *t*-tests on their calculus and physics (courses regarded as fundamental by engineering majors) taken in their freshman year were performed and proved not to be statistically significant, t=0.06 (p > .05), t= 0.37 (p > .05).

For the purpose of the study, two treatment conditions were devised—Treatment A: multiple-choice student question-posing group (namely, MC question-posing group) versus Treatment B: multiple-choice student question-answering group (namely, MC question-answering group). In the MC question-posing group, emphasis was placed on students individually constructing at least three multiple-choice questions from the current week's content. Students were informed that after the presentation of the instructional material, they would work on their own to pose three questions during the post-lecture study session (15 minutes) in class, and that the overall quality of this work would be assessed and constitute 20% of their final grade. Bearing in mind that providing feedback on the overall quality of students' questions was important, as a whole group the instructor would purposively select three students' work and use them as exemplars in the next class session, while a grading system of plus (very good), check (good), and minus (you can do better) would be given as individual feedback.

As for the MC question-answering group, emphasis was placed on students individually responding to ten multiple-choice questions matched with the current content. Students were informed that they would independently answer ten questions immediately after the information presentation session in class, and that their performance on the drill-and-practice exercise would be assessed and would constitute 20% of their final grade. The number of questions that students would respond to in the study was based on the average time students would need to compose three multiple-choice questions in a 15-minute time period as observed in a pilot study conducted in the previous semester year. Items for use in the question-answering sessions were drawn from the test bank kept by the participating instructor. Feedback on students' performance was also given in two forms. As a whole group, the three questions with the lowest accurate rate were shown and explained in the next class session, while the number of questions answered correctly by each student was marked and returned for individual viewing.

Experimental Procedures

Different treatment conditions were randomly assigned to two intact classes (with one class integrated with the multiple-choice question-posing element while the other class with the multiple-choice question-answering component). To establish baseline information on the levels of cognitive and metacognitive strategies use by participants prior to the intervention, the strategies under investigation was not introduced to their respective groups until the 3rd instructional session. This way participating students could respond to questions that inquire about their degree of cognitive and metacognitive strategies use in the normal context.

To ensure that participants possessed the fundamental skills of multiple-choice question-composing, a fifty-minute training session on question-posing techniques was arranged for the experimental group. English's (1998) proposed framework for question-posing was adopted and expanded to guide students in posing questions relevant to the present content. Specifically, question tags, such as what, why, which, how, where, under what circumstances, in what way, what if, etc., were introduced. The question-starter approach is a simple framework and should be easy to internalize by the participants. The simplicity feature of the adopted framework is essentially pertinent, considering Bean's (1985) warning that students frequently abandon the use of strategy when a complex one is introduced. Nevertheless, to avoid the possibility that students in Treatment A merely focused on memorization-type questions, comprehension- and integration-type of questions in addition to factual questions supporting different levels of knowledge construction (i.e., knowledge restating, knowledge assimilation and knowledge integration), as proposed by King (1994), were explained and stressed. Examples of multiple-choice questions on recalling, applying, analyzing, comparing, evaluating, and making connections to prior knowledge and personal experience were provided and followed by a practice-and-feedback session. Finally, in view of researchers' suggestions that informing students of the rationale for adopting a particular strategy will enhance the effects of the introduced strategy and will more likely ensure continued voluntary use of that strategy (Palincsar & Brown, 1984; Pressley, Borkowski, & O'Sullivan, 1984), students were briefed about the empirical evidence supporting question-posing. Specifically, students were informed that question-posing has been shown to significantly facilitate learners' comprehension of lecture content. Yet, the potential of multiple-choice question-posing on cognition or metacognition strategies development were intentionally left out to avoid pretesting effects or demand characteristics that might unnecessarily confound the study.

Following the question-posing strategy training for the experimental group, as a routine, a sequence of lectures and post-lecture study sessions began for six consecutive weeks for both treatment conditions. Efforts were made to ascertain all instructional components were kept essentially the same between the two classes except the incorporated strategy. That is, during the study section except that question-posing was exercised in the MC question-posing group whereas question-answering was implemented in the MC question-answering group, both classes were taught by the same teacher, who covered the same curriculum and used the same teaching materials in the same allocated time frame.

Lastly, as the incorporated strategy was being treated as a learning support tool, students in both treatment groups were encouraged to refer to the textbook and their notes during the post-lecture study sessions. The same questionnaire was re-administered individually at the end of the experimental period (2nd wave of data collection), followed by a posttest, the performance of which would constitute 20% of students' final grade.

Dependent Measures and Instruments

Two instruments were used to gauge the relative effects of MC question-posing and question-answering on students' academic achievement, cognitive strategy and metacognitive strategies use: a posttest and questionnaire.

Posttest

A 50-item multiple-choice questions was used to assess students' mastery of the instructional content as conveyed during the duration of the study. Topics covered included the following core contents: intelligent transportation systems, traffic control devices, railway engineering, urban transportation systems, airport design and planning, air control, etc. Items on the posttest were pooled from past exams with item difficulty range between 0.35 and 0.85. The internal consistency reliability of the posttest calculated after the study was .92. Sample items included, "Pragmatically speaking, which runway number can be seen at the airport? (5L-6R, 9R-27L, 3R-21R, 11L-29L); Which of the following description is not the legitimate reason supporting building rail transit systems in metropolitan area? (Reserving right-of-way, ensuring passengers traveling on time, comfort, overall construction expenditure); Intelligent transportation systems are said to enhance the quality of life in several significant ways. Which of the following is not likely to be true? (Shortening commuting time, improving congestion problems in urban areas, saving money in commuting travel, efficiently using existing resources of the roadway systems)."

Questionnaire

A questionnaire administered individually at the 3rd week and the end of the implementation session (9th week) was used to investigate the comparative effect of MC question-posing versus question-answering on students' cognitive and metacognitive strategies use. The "Cognition" subscale of Cherng's (2000) "High School Students' Self-Regulated Learning Inventory" (SRLI), based on the self-regulated learning theory, was adopted and adapted to make the items better fit the learning situation at hand (learning transportation engineering) and the target population involved (undergraduates). The "Cognition" subscale of Cherng's SRLI consisted of two parts: "Cognitive Strategies Use Scale" and "Metacognitive Strategies Use Scale." "Cognitive Strategies Use Scale" (18 items) appraises students' use of rehearsal, elaboration and organization learning strategies (See Appendix A), whereas "Metacognitive Strategies Use Scale" (24 items) reveals students' activation of metacognitive strategies for cognition regulation, such as planning, monitoring, revising, and evaluating one's actions and reasoning while learning (See Appendix B).

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." Administration time for this instrument was 15 minutes. The internal consistency reliability calculated after the study was .90 and .88 for the "Cognitive Strategies Use Scale" and "Metacognitive Strategies Use Scale," respectively. Scores for "Cognitive Strategies Use Scale" and "Metacognitive Strategies Use Scale" were generated by a simple sum of responses to the component items under each scale. Higher scores reflected more frequent use of the measured construct (i.e., cognitive and metacognitive strategies).

Data Analysis

Data on students' academic achievement were analyzed using the analysis of variance technique (ANOVA). Data on students' cognitive and metacognitive strategies use were analyzed with a repeated measures ANOVA design, in which MC question-posing and MC question-answering strategy was the between-subject factor while the repeated measures factor was defined by the two waves of measurement of students' cognitive and metacognitive strategies use. Simple main effect tests were followed if significant instructional strategy by time interaction effect were detected. A .05 level of significance was adopted for use in this study.

Results

Academic Achievement

Mean and standard deviation for the posttest appear in Table 1. Though students assigned to the MC question-posing group performed slightly better than their counterparts in the other group, ANOVA found no statistically significant differences between the two groups in academic achievement, $F(1, 67) = 0.07$, $p > .05$.

Table 1 Means and Standard Deviations for Students' Academic Achievement

Treatment Groups	Mean (*SD**)	*N*
Question-posing	81.44 (9.63)	36
Question-answering	81.27 (11.03)	33

*SD**: standard deviation

Cognitive Strategies Use

Table 2 displays the means and standard deviations for the cognitive strategies use across the two waves of data collection of both groups. Figure 1 displays the graph of the means over time by the two treatment groups. For cognitive strategies use, there was a statistically

Table 2 Means and Standard Deviations for Cognitive Strategy Use by Waves

Treatment Groups	1st Wave (pretest) Mean (*SD**)	2nd Wave (posttest) Mean (*SD**)	*N*
Question-posing	70.11 (9.15)	75.14 (9.86)	36
Question-answering	70.10 (9.98)	70.33 (9.47)	33

*SD**: standard deviation

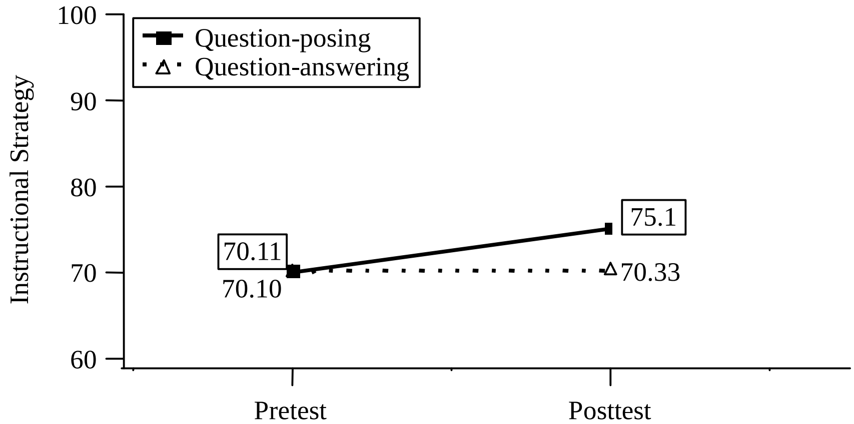

Figure 1 Means for Cognitive Strategy Use over Time

significant instructional strategy by time interaction effect, *F*=10.64, *p*<.05. A simple main effect test further found that students in the two groups reported similar levels of cognitive strategies use before the intervention (*F*=0.00, *p*>.05); however, students in the MC question-posing group reported statistically significant higher levels of cognitive strategies use after the intervention (*F*= 4.09, *p*<.05) in comparison with students in the MC question-answering group. A separate simple main effect again revealed a statistically significant difference between the two waves for the MC question-posing group (*F*=25.74, *p*<.05) with a statistically significant increase of cognitive strategies use after the intervention, but no significant differences were detected for the MC question-answering group (*F*=0.05, *p*>.05), meaning MC question-answering group's cognitive strategies use remained approximately at the same level between the two wave of data collection.

Metacognitive Strategies Use

Table 3 displays the means and standard deviations for the metacognitive strategies use at the two time points of

Table 3 Means and Standard Deviations for Metacognitive Strategy Use by Waves

Treatment Groups	1st Wave (pretest) Mean (*SD**)	2nd Wave (posttest) Mean (*SD**)	*N*
Question-posing	83.56 (12.97)	92.89 (13.27)	36
Question-answering	84.10 (17.13)	84.40 (15.26)	33

*SD**: standard deviation

data collection for both groups. The two-way interaction between instructional strategy and time is graphed in Figure 2. Overall, the findings paralleled those of cognitive strategies use. That is, there was a statistically significant instructional strategy by time interaction effect, F=10.85, p<.05. A simple main effect test further confirmed that students in the two groups started out similarly in terms of their levels of metacognitive strategies use before the intervention (F= 0.02, p>.05), but differed significantly after the intervention (F=5.51, p<.05) with students in the question-posing group exhibiting a statistically significant higher level of metacognitive strategies use. A separate simple main effect again revealed a statistically significant difference between the waves of data collection for the MC question-posing group with a statistically significant increase of metacognitive strategies use after the intervention (F=25.49, p<.05), but no significant differences for the MC question-answering group (F=0.02, p>.05), indicating that the levels of metacognitive strategies use for the MC question-answering group remained stable over the two observation points.

Discussion

Academic Achievement

As analyzed earlier, in light of information-processing theory and metacognition, a question-posing learning activity may have a facilitating effect for students' comprehension. However, ANOVA results from this study did not find that question-posing as opposed to question-answering produced better academic performance at the posttest. In other words, past studies on student-questioning that were mainly conducted in elementary to secondary levels with open-ended question-type, and its effects mostly compared to that of a re-read or review strategy found supportive evidence; however, its comparative effect to question-answering was not substantiated

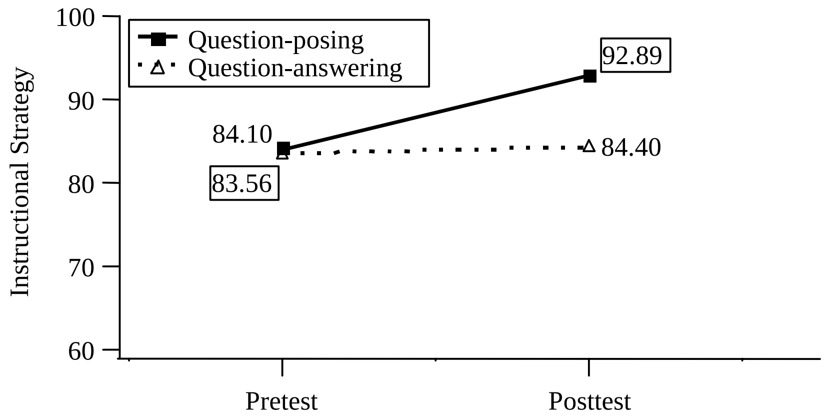

Figure 2　Means for Metacognitive Strategy Use over Time

in this study with undergraduates using multiple-choice question type.

Despite the fact that the current study did not confirm that the MC question-posing strategy is better than the conventional approach—in-class practice or quiz sessions (i.e., question-answering) that is most frequently adopted by instructors in normal classrooms for promoting academic achievement, students in both the question-posing and question-answering groups did have equivalent performance at the posttest. In fact, both groups performed satisfactorily on the posttests (M=81.44 and 81.27 for Treatment A and B, respectively), as compared to those in the previous years according to the implementing instructor.

Cognitive Strategies Use

The findings indicated that after having exposure to the ideas and practice of the multiple-choice question-posing strategy for six consecutive weeks, students expressed more frequent use of cognitive strategies while attending lectures as compared to their counterparts in the MC question-answering group. These results supported the beneficial effects of the multiple-choice question-posing strategy on students' cognitive strategies use as compared to the traditional question-answering strategy.

Cognitive strategies use reflected students' active cognitive involvement in the task at hand in terms of their use of rehearsal, elaboration and organization strategies (Gagne, 1985; Gagne et al., 1992). When faced with the task of generating multiple-choice questions, students would be more likely to resort to various cognitive strategies in order to satisfy the learning tasks assigned. First and foremost, to search for testable materials (i.e., important areas worth testing), presumably students would re-visit the information landscape either by re-examining texts and notes, or by reflecting back on what the instructor conveyed during the oral presentation. This in essence entails exercising rehearsal and organization strategies. To design plausible alternatives, on the other hand, students would need to clarify relationships and critical features differentiating closely related concepts, principles or theories. To permit comparisons, associations and linkages among newly acquired concepts, personal experiences and previously learned topics, an elaboration strategy would likely be activated for that end.

From these analyses, it is expected that a multiple-choice question-posing learning task would be conducive to students' cognitive strategies use and development. Through re-visiting and re-processing the incoming information and building inter-connectivity between pieces of information both within and outside the instructional materials while attending lectures, the present study found that students in the MC question-posing group tended to be induced to engage more in activating rehearsal, elaboration and organization cognitive strategies. Particularly, after the instructor integrated the multiple-choice question-posing element in the class, students' self-assessment of their cognitive processes was in more agreement with statements on the cognitive strategies use scale (See Appendix A for reference).

Metacognitive Strategies Use

The results obtained supported the researchers' contention that the multiple-choice question-posing strategy had a facilitating effect on students' metacognitive strategies use. It was found that students in the multiple-choice question-posing group tended to engage more frequently in higher levels of thinking, and initiated executive processes more often as compared to the MC question-answering group. More specifically, after being exposed to the multiple-choice question-posing task for six consecutive weeks, students indicated more frequent activation of the kinds of metacognitive acts included in the metacognitive strategies use scale (See Appendix B for details).

When being confronted with the task

of constructing multiple-choice questions, the sub-tasks of zooming in on materials that are testable, phrasing question stems, finding plausible alternatives, and providing the best answer for the posed question, seemed to induce students to mobilize various metacognitive strategies in class. In order to accomplish each and every sub-task involved in multiple-choice question-posing, monitoring, revising, evaluating, and planning metacognitive strategies were called upon and utilized in light of metacognition. The statistically significant results from the current study supported the researcher's expectation that multiple-choice question–posing task may entice students to be more cognizant of their learning status and become self-regulated learners, who were more prone to make changes, more accustomed to setting up plans, more effective in monitoring their understanding, and more flexible in evaluating their progress when situations arose that called for such endeavors.

Conclusions

Seeing that lecturing is one of the most frequently used instructional methods in traditional classrooms at almost all educational levels, how to cultivate a learning atmosphere within which student are induced to more actively regulate their thinking process and continuously manipulate orally presented materials (i.e., indicators of engaged learners) is an important issue for students' academic success. Student-generated questions, in light of information-processing theory and metacognition, seem to be facilitative of students' cognition-regulation behaviors and enhance comprehension of the interacting information (King, 1994; Rosenshine et al., 1996).

Data from the present study substantiated the effects of multiple-choice question-posing strategy for the improvement of college students' cognitive and metacognitive strategies use as compared to the traditional drill-and-practice strategy. Specifically, data collected via questionnaire in the study showed that posing multiple-choice questions while attending lectures helped students take better control of their cognitive and metacognitive processes, such as focusing on the lecture and learning material, discerning the organization and main points of the ideas presented, extending external connections to pre-existing knowledge and related topics, activating self-evaluation techniques to monitor comprehension along the way, etc.

Based on the present study, a student multiple-choice question-posing strategy seems to be a more profitable strategy to adopt for inducing and engaging students in their higher order thinking processes, specifically, various cognitive and meta-cognitive strategies. On the other hand, in terms of students' academic performance, student multiple-choice question-posing is as effective an instructional strategy as question-answering (traditional drill-and-practice).

In view of past and the present study, it is suggested that instructors who were accustomed to reserve parts of their instructional time for drill-and-practice sessions might consider student-generated questions for an amiable change to promote students' cognitive and metacognitive strategies use without worrying about its less favorable impact on students' performance. By permitting students to compose questions they deemed important and worthwhile, other than simply requesting them to reply to teacher-provided questions, hopefully, the traditional interaction model (teacher initiate →student reply→teacher evaluate), which viewed questions as being mainly an assessment mechanism for judging students' level of knowledge acquisition, can be gradually moved toward that of a student self-initiated knowledge construction and creation model that induces and engages students in cognitive-demanding activities along the process.

Before concluding, the researchers would like to stress that the present study focused on one type of question—multiple-choice question-posing. Research on testing effect showed that question type influences student monitoring of learning from text, which was indexed by whether the students choose to study more after testing (Pressley, Ghatala, Woloshyn, & Pirie, 1990). With preliminary results suggested that different types of questions have different stimulating effects on students' intent to future studying, that each question type possess distinct advantages and limitations, and that individuals revealed statistically differential preference toward different question-posing activities (Yu, 2008), future studies on the associated facilitating effects of various question types on students' study behaviors, academic performance and motivation will be worth exploring.

Reference

Abramovich, S., & Cho, E. K. (2006). Technology as a medium for elementary preteachers' problem-posing experience in mathematics. *Journal of Computers in Mathematics and Science Teaching*, *25*(4), 309-323.

Bangert-Drowns, R. L., Hurley, M. M., & Wilkinson, B. (2004). The effects of school-based writing-to-learn interventions on academic achievement: A meta-analysis. *Review of Educational Research*, *74*(1), 29–58.

Barlow, A., & Cates, J. M. (2006). The impact of problem posing on elementary teachers' beliefs about mathematics and mathematics teaching. *School Science and Mathematics*, *106*(2), 64-73.

Bean, J. (1985). Interaction effects based on class level in an exploratory model of college student dropout syndrome. *American Educational Research Journal*, *22*(1), 35-64.

Biddulph, F., Symington, D., & Osborne, R. (1986). The place of children's questions in primary science education. *Research in Science and Technological Education*, *4*(1), 77-88.

Brown, A. L. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. E. Weinert & R. H. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 65-116). Hillsdale, NJ: Lawrence Erlbaum Associates.

Brown, S. I., & Walter, M. I. (1983). *The art of problem posing*. Philadelphia, PA: Franklin Institute Press.

Brown, S. I., & Walter, M. I. (2005). *The art of problem posing* (3rd ed). Mahwah, NJ: Lawrence Erlbaum Associates publishers.

Cherng, B. L. (2000). *Studies of junior and senior high school students' self-regulated learning*. Technical report of National Science Council project (NSC 89-2413-H-006-021). Taipei: Taiwan.

Chin, C., & Kayalvizhi, G. (2002). Posing problems for open investigations: What questions do pupils ask? *Research in Science and Technological Education*, *20*(2), 269-287.

Davey, B., & McBride, S. (1986a). Effects of question-generation training on reading comprehension. *Journal of Educational Psychology*, *78*(4), 256-262.

Davey, B., & McBride, S. (1986b). Generating self-questions after reading: A comprehension assist for elementary students. *Journal of Educational Research*, *80*(1), 43-46.

Dori, Y. J., & Herscovitz, O. (1999). Question-posing capability as an alternative evaluation method: Analysis of an environmental case study. *Journal of Research in Science Teaching*, *36*(4), 411-430.

English, L. D. (1998). Children's problem posing within formal and informal context. *Journal for Research in Mathematics Education*, *29*(1), 83-106.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-development inquiry. *American Psychology, 34*(10), 906-911.

Gagne, R. M. (1985). *The conditions of learning and theory of instruction.* New York, NY: Holt, Rinehart and Winston.

Gagne, R. M., Briggs, L. J., & Wager, W. W. (1992). *Principles of instructional de-*

sign. Fort Worth, TX: Harcourt Brace Jovanovich College Publishers.

King, A. (1991). Improving lecture comprehension: Effects of a metacognitive strategy. *Applied Cognitive Psychology, 5*(4), 331-346.

King, A. (1992). Facilitating elaborative learning through guided student-generated questioning. *Educational Psychologist, 27*(1), 111-126.

King, A. (1994). Guiding knowledge construction in the classroom: Effects of teaching children how to question and how to explain. *American Educational Research Journal, 31*(2), 338-368

Koch, A., & Eckstein, S. G. (1991). Improvement of reading comprehension of physics texts by students' question formulation. *International Journal of Science Education, 13*(4), 473-485.

Leung, S. K., & Silver, E. A. (1997). The role of task format, mathematics knowledge, and creative thinking on the arithmetic problem posing of prospective elementary school teachers. *Mathematics Education Research Journal, 9*(1), 5-24.

Livingston, J. A. (2003). *Metacognition: An Overview*. (ERIC Document Reproduction Service No. ED 474273)

Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and monitoring activities. *Cognition and Instruction, 1*(2), 117-175.

Perez, J. A. (1985). *Effects of student-generated problems on problem solving performance*. Unpublished doctoral dissertation, Teachers College, Columbia University.

Pintrich, P. R., Smith, D., Garcia, T., & McKeachie, W. J. (1989). *A manual for the use of the motivated strategies for learning questionnaire (MSLQ)*. Ann Arbor, MI: National Center for Research to Improve Postsecondary Teaching and Learning, The University of Michigan.

Pressley, M., Borkowski, J. G., & O'Sullivan, J. T. (1984). Memory strategy instruction is made of this: Metamemory and durable strategy use. *Educational Psychologist, 19*(2), 94-107.

Pressley, M., Ghatala, E. S., Woloshyn, V., & Pirie, J. (1990). Sometimes adults miss the main ideas and do not realize it: Confidence in responses to short-answer and multiple choice comprehension questions. *Reading Research Quarterly, 25*, 232-249.

Reigeluth, C. M. (1983). *Instructional-design: Theories and models.* Lawrence, NJ: Erlbaum Associates.

Rosenshine, B., Meister, C., & Chapman, S. (1996). Teaching students to generate questions: A review of the intervention studies. *Review of Educational Research, 66*(2), 181-221.

Silver, E. A. (1994). On mathematical problem posing. *For the Learning of Mathematics, 14*(1), 19-28.

Weiner, C. J. (1978, March). *The effect of training in questioning and student question generation on reading achievement.* Paper presented at the Annual Meeting of the American Educational Research Association, Toronto, Canada. (ERIC Document Reproduction Service No. ED 158223)

Whiten, D. J. (2004). Exploring the strategy of problem posing. In G. W. Bright & R.

N. Rubenstein (Eds.), *Professional development guidebook for perspectives on the teaching of mathematics: Companion to the sixty-sixth yearbook* (pp. 1-4). Reston, VA: National Council of Teachers of Mathematics.

Whitin, P. (2004). Promoting problem-posing explorations. *Teaching Children Mathematics*, *11*(4), 180-186.

Wittrock, M. C. (1978). The cognitive movement in instruction. *Educational Psychology*, *13*(1), 15-29.

Wong, B. Y. L. (1985). Self-questioning instructional research: A review. *Review of Educational Research*, *55*(2), 227-268.

Yu, F. Y., & Liu, Y. H. (2005). Potential values of incorporating multiple-choice question-construction for physics experimentation instruction. *International Journal of Science Education*, *27*(11), 1319-1335.

Yu, F. Y. (2008, February). *Student-generated questions in physics labs: Possibilities and students' preference*. Paper will be presented at the Conference of Asian Science Education, Kaohsiung, Taiwan.

Appendix A　Cognitive Strategies Use Scale

1. While learning transportation engineering, I would read and re-read the material.
2. While learning transportation engineering, I would copy the main ideas and topic sentences of the material onto paper and recite them again and again.
3. While preparing for upcoming exams on transportation engineering, I would review instructional materials (i.e., textbooks, notes) over and over again
4. Copying important points covered in transportation engineering textbooks was the strategy I usually used for memorization purpose.
5. I would work hard on the main ideas by repetition so as to retain them well in my memory while learning transportation engineering.
6. When learning transportation engineering, I would practice answering questions at the end of each chapter several times.
7. While learning transportation engineering, I would try to associate what I learned in this unit with related concepts covered in other units.
8. While learning transportation engineering, I would try to rephrase what I read in the text using my own words.
9. While learning transportation engineering, I would think of a way to relate what the teacher conveyed in class to my own experience.
10. While learning transportation engineering, I usually used an association strategy, such as thinking about relevant themes or relationships, to help memorization.
11. While learning transportation engineering, I would paraphrase the main ideas in the text using my own words and then read those out to myself.
12. While learning transportation engineering, I would try to draw on what I've learned from other classes to help my learning of the current materials.
13. While learning transportation engineering, I would read through the textbook and take notes first, and then pinpoint the important concepts of the material.
14. While learning transportation engineering, I would locate important keywords and sentences in the text.
15. While learning transportation engineering, I tried to write down what the instructor stressed in class and would tidy up my notes afterwards.

16. While learning transportation engineering, I would underline or mark areas that I thought were important.
17. While learning transportation engineering, I would rearrange the materials in the way that seemed most comprehensible to me.
18. After finishing learning each chapter, I would identify the most important ideas.

Appendix B Metacognitive Strategies Use Scale

1. While learning transportation engineering, I would get a general idea of the content first and then study for details.
2. While learning transportation engineering, I would set goals for myself at every stage of my learning.
3. While learning transportation engineering, I would pay special attention to the beginning and ending of each paragraph.
4. While learning transportation engineering, I would think about the meaning of the heading first and then decide on how to approach this topic.
5. While learning transportation engineering, I would use the headings in the textbook to locate important points.
6. While preparing for exams on transportation engineering, I would reflect back on what the teacher said in class, and then set down my own study plan.
7. While learning transportation engineering, I would stop and reflect on what I just heard or read and then note the most important points along the way.
8. Before transportation engineering exams, I would look for more items so as to assess my level of understanding.
9. While learning transportation engineering, I tried to uncover those areas that I didn't learn well at the time of the original class.
10. While learning transportation engineering, I tried to pull together questions that I couldn't answer and then focus on those areas that I didn't understand.
11. When questions were raised in transportation engineering class, even if not directed at me, I would try to answer them to make sure that I understood the text
12. I would check to see whether I understood what the instructor taught while attending transportation engineering class.
13. Once encountering something that I couldn't understand while learning transportation engineering, I would re-read the text again in an effort to understand more.
14. After each transportation engineering exam, I would adjust my study strategies based on the experience.
15. If having a hard time understanding the text while learning transportation engineering,

I would modify my study strategies.

16. When my transportation engineering grades went down, I would change to another learning method in an attempt to improve my learning performance.
17. If I couldn’t understand what the teacher taught in transportation engineering class, I would definitely work harder on this topic after class.
18. While learning transportation engineering, I would keep practicing those questions that I frequently answered incorrectly until I could get them right.
19. After reviewing each section in transportation engineering, I would find some questions and try to answer them myself.
20. Prior to a transportation engineering exam, I would try to assess my level of understanding while reviewing transportation engineering texts.
21. While learning transportation engineering, I would refer to other sources that contain test items for self-evaluation to see if I understood the assigned content
22. Before transportation engineering exams, I would take a parallel test to help me review the content.
23. After answering simple questions, I would try to answer more difficult ones to have an idea of my competency with regard to this topic.
24. After answering questions in the textbook, I would look for questions from other sources while learning transportation engineering.