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Effects of Different Types of Online Student Question-Generation on Learning

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Abstract: This study investigated the comparative effects of multiple-choice and short-answer online student question-generation on academic performance and cognitive strategies use. Two 6th grade classes from one elementary school participated for eight weeks. An online learning system was adopted. Results from the MANCOVAs found that students in the multiple-choice group had significantly elevated scores on higher cognitive levels achievement assessment and elaboration strategy use than those in the short-answer group. No significant difference was found, however, in academic performance assessing lower-cognitive level, or the use of rehearsal or organization strategies. Recommendations for classroom implementation were provided.

Keywords: academic performance, cognitive strategies use, multiple-choice, short-answer, student question-generation

1. Introduction

Empirical studies generally support student question-generation as an effective learning strategy [1-2]. A closer analysis reveals that existing studies were mostly conducted in the context of short-answer question or story problem generation [3]. Analytically speaking, in terms of learning tasks involved, both short-answer and multiple-choice question-generation require students to come up with the question and its answer or solution. Multiple-choice question-generation, nevertheless, has the added task of generating three plausible alternatives for each composed question.

According to information processing theory, learning occurs through different types and levels of information processing. Cognitive strategies, including rehearsal, organization, and elaboration, are called for to transfer or relate received information from short-term to long-term memory [5]. As different types of questions direct learner attention to different sources of information [6], and short-answer and multiple-choice question-generation entail different tasks to be completed, questions related to whether multiple-choice question generation would perform differently, as compared to short-answer question-generation, for the enhancement of student cognitive development is worthy of investigation. Specifically, two research hypotheses were investigated:

1. There would be significant difference in academic performance between students assigned to the multiple-choice question-generation (named MC QG) and those assigned to the short-answer question-generation (named SA QG) groups.
2. There would be significant difference in cognitive strategies use (rehearsal, organization, and elaboration) between students assigned to the MC QG and those in the SA QG groups

2. Methods

Two 6th grade classes from one elementary school participated and were randomly assigned to two different treatment groups: MC QG (N=27) and SA QG groups (N=32). During the 8-week study, students were directed to compose three questions of their respective type on social studies covered the current week in one morning study session. An online learning system named Question Authoring & Reasoning Knowledge System [4] was adopted to support the learning activities.

Two instruments on academic performance were included. One was the midterm exam that the participating school centrally administered to test student "*remembering*" of covered instructional content (lowest cognitive level in Anderson and Krathwohl classification of educational goals) [7]. The other test intended to tap on student "*understanding, applying, analyzing, evaluating and creating*" of covered instructional content (higher cognitive levels in Anderson and Krathwohl's taxonomy) [7]. The "Cognitive Strategies Use" Questionnaire was used to assess if there is any differential utilization of three types of cognitive strategies: rehearsal, organization, and elaboration. The 18-item 6-point Likert-scale questionnaire, adapted from the "Cognition" subscale of "High School Students' Self-Regulated Learning Inventory" [8], was pre-tested, revised, and validated.

The multivariate analysis of covariance (MANCOVA) was adopted for both hypotheses testing. Student test scores on social studies from the prior semester was used as the covariate for hypothesis #1 testing while their responses to the questionnaire completed prior to the beginning of the study was used as the covariate for hypothesis #2 testing.

3. Results

The result of MANCOVA showed that different question types had a statistically significant effect on academic performance (Wilks's $\lambda = .869$, $F(2, 55) = 4.16$, $p<.05$). Follow-up ANCOVA indicated that students in the MC QG group (M=20.37, SD=5.15, adjusted M=19.28) performed significantly better than those in the SA QG group (M=14.50, SD=6.66, adjusted M=15.59) on test primed on higher cognitive levels. On the other hand, students in the two groups had similar performance on midterm exam, which assessed recall and remembering (MC group: M=86.37, SD=4.39, adjusted M=85.07; SA group: M= 82.53, SD=7.78; adjusted M=83.83).

The MANCOVA result showed that there was a significant effect of different question types on student cognitive strategies use (Wilks's $\lambda = .84$, $F(3, 52) = 3.336$, $p<.05$). Further analyses revealed that the two treatment groups did not differ significantly in rehearsal and organization strategies use. However, students in the MC QG group (M = 25.556, SD = 4.878, adjusted M = 25.792) exhibited higher level of elaboration strategies use than those in the SA QG group (M = 21.94, SD= 7.85; adjusted M = 21.70).

4. Discussion & Conclusions

The study found that the MC QG strategy enhanced student performance on higher cognitive level achievement assessment and facilitated more frequent use of elaboration strategies than the SA QG did. However, no significant effects were observed on student academic performance assessing lower-cognitive level, or the use of rehearsal or organization strategies.

As analyzed, different learning tasks are required of MC and SA question-generation, which presumably would direct students to activate different cognitive processes and lead to different educational outcomes. Specifically, for MC QG, in addition to the construction of a question-stem and the correct answer for the conceived question, distracters are needed. Candidates for distracters are those primed on differentiating critical distinctive features among related concepts, principles, or those probed on building linkages among newly acquired contents, previously learned topics and past personal experience. Under MC QG situations, students should be more likely to be intellectually challenged and actively engaged in deep mental processes [3]. In other words, from the perspectives of information-processing theory, accomplishing the task of generating multiple-choice questions demands more frequent deployment of higher cognitive level processing and strategies use. As attested in the study, MC QG was more effective in elaboration strategy activation and higher cognitive levels academic performance than SA QG.

With its focus on integrating new information with existing knowledge, elaboration, among the three cognitive strategies, has been suggested as the most powerful and effective for meaningful learning [9]. In light of the findings of the present study, instructors are suggested to choose multiple-choice question-generation type if higher cognitive strategies and students performance in higher cognitive levels are aimed for.

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