The Effects of Questioning Strategies on Young Girl Students in Webquest Activities

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The Southeast Asian Conference on Education 2020
Official Conference Proceedings

Abstract
Promoting the science learning and science performance of girl students continues to be an important issue. This study explores the effects of questioning strategies on young girl students in a webquest activity. A quasi-experimental design was adopted for 46 fifth-grade girl students. These students participated in a mixed-gender group activity aided by questioning strategy with detailed question stems, simple question stems, or no questions. There were 11 groups of three in each kind of activity. Students were asked to study a scientific article and ask questions and answer questions about the article, then the students of each team were required to produce a science report collaboratively. The results showed that the girl students using detailed question stems had better results for their science report scores and science test scores. The findings of this study provide evidence to confirm that applying detailed question stems is a helpful strategy for young girl students undertaking webquest activity.

Keywords: questioning strategy, science learning, question stem, webquest activity.

Introduction

Female learners are still of great concern to social scientists and policy makers in science-related issues (Stoet & Geary, 2018), while researchers continue to investigate strategies to help girls' science learning (Brotman & Moore, 2008). Erickson and Eriokson (1984) pointed out that disparities in science achievements increased with age, showing that men perform better than women. Simpson and Oliver (1985) made similar findings. Schibeci and Riley (1986) found that men have a more positive attitude towards science-related courses than women, and that attitude made men's science achievements higher than those of women. Becker (1989) analyzed 30 research papers; he pointed out that scientific achievements have gender differences among subjects, but the degree of the effect was quite small. However, no difference has been identified between school grades and science achievements. In other words, scholars have been inconclusive about the relationship between gender and scientific achievements.

Questioning is an important process for students to construct knowledge and metacognition (King, 1989); it also plays an important role in active learning, meaningful learning and scientific inquiry. Scientific dialogues such as explanations, assumptions, assessments, inferences, and clarifications all begin with questioning. High-quality cognitive questions can support the construction of scientific knowledge and scientific thinking. Some researchers have pointed out that asking questions and developing critical thinking are the core of science learning (Chin & Osborne, 2008; Zoller, Tsaparlis, Fatsow, & Lubezky, 1997).

When primary school students engage in online questioning activities, they have more opportunities for questioning and thinking. However, the prior knowledge and metacognitive skills of primary school students are not as good as those of high school and college students. If they are only dealing with the internet, they may not be able to benefit from such learning. Therefore, some researchers have proposed some strategies to assist students in asking questions: for example, peer-questioning and questioning tips (Choi, Land, & Turgeon, 2005). King (1989, 1993) used question-stems to scaffold and refine questions and deeper thinking for students, and also found that question-stems have positive effects on students' learning. However, related online questioning studies primarily serve high school students, college students, graduate students, and postgraduate students, and are less applicable for elementary school students (especially young girls). Therefore, the actual benefits od such learning are uncertain.

As such, the purpose of this study is to investigate the effects of different question-stem strategies on the quality of scientific reports and the gain scores regarding science achievement for K-5 girls in webquest activities. The two research questions are as follows:

1. Which question-stem strategy results in better quality science reports for K-5 girls?
2. Which question-stem strategy results in better gain scores of science achievement for K-5 girls?

Literature review

girl students and science learning

Many researchers have compared variables such as achievement, attitude, motivation, interest, and performance among boys and girls (Erickson & Erickson, 1984; Greenfield, 1997; Jovanovich & King, 1998; Morrell & Lederman, 1998; Simpson & Oliver, 1985; Wan & Lee, 2017). Furthermore, there is ample evidence that men have a more positive attitude towards science and are more motivated to practice science (Baker, 1983; Suchner, Miller & Shanks, 1983).

Becker (1989) used meta-analysis to analyze 30 research literatures related to academic achievement. The study found that while boys have significant advantages in biology, general science, and physics, girls and boys show no significant differences in mixed science, geography, earth science, and chemistry learning. Sadker, Sadke, and Steindam (1989) found that although boys performed better in mathematical reasoning and spatial relationships than girls, in terms of academic achievement, the results of elementary school girls in mathematics and science were significantly better than boys.

Tenenbaum and Leaper (2003) surveyed 52 middle-income families' 11-year-old and 13-year-old children's science achievements and found that there were no differences in science achievements, self-efficacy, and interests among different genders and grades. However, parental beliefs affected their children's interest in science and self-efficacy; parents' expectations of boys' science performance were higher than those of girls.

Reynolds and Walberg (1991) used meta-analysis to study Walberg's literatures in 1981, proposing three important factors that affect students' science achievements, namely: personal factors (such as ability, gender, age, learning motivation); teaching factors (such as teaching time and teaching quality); and psychological factors (such as class environment, family environment, peer environment, and learning media). Among them, the greatest influence on students’ science achievements was their own abilities (prior knowledge), and gender was not the most important factor affecting students' scientific learning achievements.

Questioning learning

In science learning, students’ questioning is an important and necessary cognitive skill (Hu, Chiu, & Chiou, 2019). Questioning is an important strategy to promote learning and thinking (Buchanan Hill, 2016; Chikiwa & Schäfer, 2018; Dillon, 1981; Elder & Paul, 1998), and is widely influential in teacher instruction and student learning. Questioning strategies can arouse students' motivation and interest (Simpson & Anderson, 1981), suggesting learning priorities, facilitating learning discussions and student cognition, and assessing teaching effectiveness (Hunkins, 1972; King, 1989). When students face problems, they need to recall their experiences, analyze, summarize, organize, judge, and then attain appropriate answers; this process can bring about deeper thinking, assist students in elaborating upon their ideas, expand their breadth of thought, and enhance their level of thinking (Carin & Sund, 1971). Therefore, teachers can make good use of questioning techniques and questioning strategies to enable students to generate cognitive conflicts and then construct new knowledge. As such, this enhanced effectiveness of learning will bring about considerable benefits.

King (1994) pointed out that asking a “good question” can help a student’s thinking process. Eggleston et al. (1976) (demonstrated that in order to develop students' knowledge structure, teachers must first confirm that students have basic knowledge before they can enter high-level questioning—thus, low-level questions are necessary. Bloom's cognitive taxonomy (1956) posits clear distinctions between levels, from simple to complex and from low to high, so it is often used in questioning learning. Bloom's taxonomy in the cognitive field is divided into the following categories: knowledge, understanding (comprehension), application, analysis, synthesis, and evaluation. Questions according to the six cognitive categories can be further classified into high-level questions (analysis, synthesis, evaluation) and low-level questions (knowledge, understanding, application). Based on these clear cognitive levels, teachers can design suitable questions in compliance with the achievement level of students to guide their engagement in learning activities

Methods

A quasi-experimental design and convenience sampling method were adopted.

Participants

46 fifth-grade girl students from a primary school in southern Taiwan participated in the study. These girl students participated in a mixed-gender group activity and they were divided into three groups with different questioning strategies: detailed question-stem strategy (Gd, 17 girls), simple question-stem strategy (Gs, 16 girls) and no question-stem strategy (Gn, 13 girls). Each group had 11 teams and each team (mixed-gender) had 3 students.

Questioning strategy

There were three questioning strategies for this study—detailed question-stem, simple question-stem and no question-stem. The detailed question-stem strategy provided students with unfinished sentences, the simple question-stem strategy just provided students with one or two words as an opener, and the no question-stem strategy did not provide any hints, as Table 1.

Table 1: Some Samples of Detailed-stem, Simple-stem and No-stem

Detailed-stem	Simple-stem	No-stem
1. What concept is applied to …? 2. What do you think causes …? 3. How do you solve…if…?	1. How to apply…? 2. What result…? 3. If…?	No prompts given.

Webquest Activity and Procedure

In science activities, students explored and compared possible factors and differences that affected rainfall among the three cities. At the beginning of the activity, students read a related article, asked and answered questions about this scientific article, and then collected rainfall data for all months of the year. Students then needed to draw statistical graphs based on this rainfall data to assist in analyzing the data. Finally, the members of each team needed to collaborate to produce a scientific report about the differences in rainfall among the three cities. Students implemented this webquest activity in an online system (Hu et al., 2019).

The experiment of this study was carried out weekly during science class; students were led by the same science teacher each time in the computer lab. This activity lasted for 3 months. Before the activity, students had a pre-test of achievement test, while after the activity, students had the post-test of achievement test.

Measurements

Students' scientific reports and achievement tests were measured in this study.

Scientific report quality. The scientific reports were assessed by their science teacher based on evaluation criteria, as shown in Table 2 (Hu et al., 2019). Since each scientific report was written in cooperation with the team members, the score of report was also the score of individual team members.

Table 2: The Scoring Criteria for the Scientific Report

Report evaluation criteria	point
1. The title of the report is clear and understandable	10
2. The information collected meets the learning task requirements	10
3. The information collected is complete and recorded correctly	10
4. The presentation of the data has good organization	10
5. The analysis of the data has a logicality	20
6. The content of the discussion can meet the task’s topic	20
7. Conclusions have sufficient basis and support	20

Achievement test. A quiz was developed by researchers to evaluate the effect of the students’ gain score. This quiz contained right and wrong questions and short answer questions which were related to scientific knowledge of rainfall.

Data analyses

ANCOVA was used in analyzing the quality of the scientific report. The covariate was the science exam score at school. ANOVA was used to determine whether the achievement gain was significantly different among the three groups. The achievement gain in this study referred to the acquisition of knowledge. Gain scores were counted to analyze learning outcomes. There were three kinds of gain score in the study: 1) the gain score of total score; 2) the gain score of right and wrong scores; and 3) the gain score of short answer scores. The gain score was calculated for each individual student by measuring the difference from pre-test to post-test (M = posttest - pretest).

Results and Discussion

Scientific Report Quality

The assumption of equality of variance, F(2, 43) = .182, p = .835, and the homogeneity of regression assumption, F(2, 43) = .696, p = .505, were accepted. The results of ANCOVA revealed a significant difference among the three groups; F(2, 43) = 4.074, p = .024, partial η^2 = .162. The LSD test further showed that Gd had significantly better quality than the Gn did (p = .007); however, neither Gd and Gs nor Gs and Gn showed significant difference in the quality of their scientific report. The results showed that detailed question-stem strategy made helped girls to write better quality scientific reports than did the other two strategies. This detailed question-stem may serve to provide more tips, so that students can easily conduct Q & A discussions, focus on scientific tasks, and thus have better results. The study also found that the students in the simple question-stem group asked more invalid questions (incomplete questions), perhaps because only one or two words at the beginning of the sentence were provided, preventing students from deep thinking and having less in-depth discussion, thus affecting its effectiveness. The no question-stem group, because of no prompt, had the worst effect (adjusted means were $M_{detailed}$ = 56.82, M_{simple} = 52.94, and M_{no} = 44.00, respectively）

Achievement Gain

The results of ANOVA showed a significant difference among the three groups (as Table 3). In the gain score of the total, the results of post hoc comparison showed that Gs had a more significant performance than Gn. In the gain score of short answer questions, girl Gd had a more significant performance than Gn. In the gain score of true-and-false questions, girl Gs had a more significant performance than Gn. From the results, the girl students' performance was not good in no question-stem group, and the girl students of Gs had a better gain score for the total and true-and-false questions. However, it was interesting to find the girl students of Gd had a better performance in the gain score of short answer questions. It seems that Gd's students were provided with more clues and guidance, so that those girl students had more in-depth thinking, enabling them to have more complete and deeper answers for the short-answer questions. Although the Gs is more effective in the gain score of the total, it may be caused by the better scores of the right and wrong questions; however, the short answer questions were not performed well. Since there was no guidance for the no question-stem group, it did not help those girl students much.

Table 3: ANOVA Results of Gain Score of Total, Right and Wrong, and Short answer

Group	N	M^a (SD^a)	M^b (SD^b)	M^c (SD^c)	F	Post Hoc comparison
Detailed	17	9.93 (6.56)	2.64 (2.26)	7.29 (6.36)	F^a (2,43) = 5.51**	Gs^a-Gn^a, p = .009
Simple	16	13.63 (12.30)	1.38 (3.14)	12.25 (11.75)	F^b (2,43) = 3.85*	Gd^b-Gnb, p = .029
No	13	0.65 (12.72)	-0.12 (2.61)	0.77 (12.58)	F^c (2,43) = 4.40**	Gs^c-Gn^c, p = .018

Note. *p < .05. **p < .01.
[a]The gain score of total questions
[b]The gain score of short answer questions
[c]The gain score of true-and-false questions

Conclusions

In this study, we compare the effects of different question-stem strategies on the quality of scientific reports and science achievement for girl primary school students in a webquest activity. The results revealed that the detailed question-stem strategy better facilitated the writing quality of science reports and improved scores for short answer questions, the simple question-stem strategy had the best gain score for achievement tests, and the no question-stem strategy was disadvantageous for girl students' science learning. Although the detailed question-stem strategy did not always provide the best result in each variable, it worked well for girl students in variables that require more in-depth thinking. It may provide an idea for elementary school teachers in supporting and encouraging girls to engage in science learning. Future research can consider different question-stem strategies for different collaborative tasks. Moreover, the issue of personal learning styles of girl students should be discussed in future research. In the study, we used a special online questioning system, a cooperation model of a three-person team, fifth-grade girl students, and a small number of participants; as such, the results of the study should not be definitively inferred.

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