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Effects of Academic Achievement and Group Composition on Quality of Student-Generated Questions and Use Patterns of Online Procedural Prompts

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Abstract: The main purpose of this study was to examine if and how academic achievement and group composition affect quality of online student-generated questions. In addition, the use patterns of online procedural prompts by students of different academic achievement and gender group composition were investigated. A total of 41 intermediate-level college sophomores enrolled in an English as a foreign language class participated in this study for four weeks. An online instant interactive system, Zuvio, was adopted to support in-class student-generated questions activities. All questions students generated corresponding to the study material were categorized along the revised Bloom's taxonomy for classifying the quality of student-generated questions, and content analysis along the integrated online procedural prompts (i.e., signal words plus the answer is; generic question stems) was adopted to reveal use patterns. Five important findings were obtained. First, students in both low- and high-academic levels generated the majority of questions in the high cognitive level. Second, more questions generated by students in all-male and mixed-gender groups fell in the high cognitive level than in the low cognitive level whereas there is an equal distribution of low and high cognitive level questions generated by the all-female group. Third, the results of the Fisher's exact test found no significant relations between academic achievement and quality of student-generated questions. Fourth, the results of the chi-square test of independence found no significant relations between gender group compositions (i.e., all-male, all-female, mixed-gender) and quality of student-generated questions. Finally, the results of content analysis revealed that while some same use patterns of online procedural prompts were observed for students in the low- and high academic achievement levels and different gender group composition, slightly varied use patterns by students in different academic levels and gender composition were present. Suggestions for instruction and future studies are provided.

Keywords: Academic achievement, gender group composition, individual differences, online learning activity, student-generated questions, use patterns

1. Introduction

1.1 Pedagogical Values of and Support for Student-generated Questions (SGQ)

Existing studies from past decades have generally substantiated the beneficial effects of student-generated questions (SGQ) approach for enhancing understanding (Brown & Walter, 2005; Hardy, Bates, Casey, Galloway, Galloway, Kay, & McQueen, 2014; Song, 2016), learning motivation (Lam, 2014; Poot, Kleijn, Rijen, & Tartwijk, 2017), higher-order thinking (Brown & Walter, 2005; Yu & Liu, 2008), and academic performance (Hardy, et al., 2014; Khansir & Dashti, 2014; Sanchez-Elez, et al., 2014). Despite its educational benefits, quite a number of students expressed a lack of experience and confidence in SGQ tasks (Yu, 2009). In light of this, researchers proposed different pedagogical arrangements to provide support for SGQ activities.

One type of support is through the provision of procedural prompts. For instance, 'signal words' procedural prompt (i.e., who, what, where, when, where, and how) was suggested as one of the most frequently used and easily learned types to be introduced during SGQ for promoting students' comprehension of learning materials (Rosenshine, Meister, & Chapman, 1996). Moreover, a set of generic question stems was proposed by Alison King (1990, 1995), including (a) questions that ask for self-generative examples, elaborated explanations or personal opinion with justifiable reasons (e.g., "How would you use ... to ...?", "What is a new example of ...?" "Explain why…?", "How does ... affect ...?", and "Do you agree or disagree with this statement: ...? Support your answer.") and (b) questions directing at drawing conclusions or making differentiations and connections between prior and existing knowledge (e.g., "What conclusions can you draw about…?," "What is the difference between ... and ...?," and "How is ... related to ... that we studied earlier?" (p.669). The results from a series of King's studies (1990, 1992) further showed that the devised guides positively influenced students' elaborated responses while prompting students to generate high-order thinking questions as compared to the unguided questioning situation. In regard to 'the answer is' procedural prompt proposed by Stoyanova and Ellerton (1996), it has been found to support SGQ activities for math learning (Brown & Walter, 2005) and civil education learning (Yu & Pan, 2014).

Another type of support is by leveraging the power of student peers. Specifically, cooperative learning has been suggested to assist students' inexperience in SQG tasks (Yu, Liu, & Chan, 2005) in light of its solid empirical foundations. A wealth of research has attested the efficacious effects of cooperative learning on enhancing students' academic achievement (Gull, & Shehzad, 2015; Khan & Ahmad, 2014; Marashi & Khatami, 2017; Pan & Wu, 2013), problem-solving ability, reasoning skills (Gillies, 2011; Gillies & Haynes, 2011), creativity (Jacobs, 2017; Marashi, 2017), and motivation (Marashi & Khatami, 2017; Pan & Wu, 2013).

1.2 Factors Moderating the Effects of SGQ

As described, a set of explicit procedural prompts and pedagogical interventions have been proposed to support SQG tasks, and empirical studies are generally supportive of their respective learning effects (e.g., Yu & Pan, 2014; Yu, Tsai, & Wu, 2013). Regardless of this, some pertinent issues are still under-examined, explicitly, factors that may moderate the effects of SGQ performance — individual differences in academic performance and group composition in cooperative learning situations.

Foremost, as to individual differences in academic performance, it has been noted to affect learning process and outcomes. For instance, Efklides, Papadaki, Papantoniou, and Kiosseoglou's empirical study (1997) found that individual ability had a direct influence on learning performance. Schmeck and Grove (1979) even provided an explanation regarding how individual differences affect learning performance — students with high achievement tended to process information comprehensively and elaborately; thus, they could retain the detailed original information better and have more organized higher-level ideas as compared to the students with low achievement.

As to group composition, studies done in the cooperative learning field have identified its effects on cooperative learning behavior and productivity. For instance, in Lee's study (1993), it was found that students' interactions in computer-based cooperative learning were significantly different in groups of various gender composition. When studying difference in solution-seeking behavior, Harskamp, Ding, and Suhre (2008) revealed that female students in the mix-gender group and all-female group didn't learn to solve physics problems and spent more time asking questions as compared to their male classmates. Zhan, Fong, Mei, and Liang's research (2015) reported that males performed better in mixed-gender groups, but there was no difference for female performance in both same-gender groups and mixed-gender groups.

1.3 Research Questions of This Study

While empirical studies highlighted individual difference effects on learning (e.g., Efklides et al., 1997; Schmeck & Grove, 1979), currently, limited studies examine its effects in the SGQ context. Moreover, up till now, issues regarding how group composition may affect SGQ outcomes and process are yet known. Hence, in this study the researchers would like to examine whether individual differences in academic achievement and gender composition in group situations has any effects on the quality of students-generated questions and use patterns of the integrated procedural prompts.

In specific, four research questions are proposed:

RQ#1: Whether academic achievement has any relations to the quality of SGQ?
RQ#2: Whether gender group composition has any relations to the quality of SGQ?
RQ#3. Whether academic achievement has any relations to the use pattern of online procedural prompts?
RQ#4. Whether gender group composition has any relations to the use pattern of online procedural prompts?

2. Methods

2.1 Participants and The Study Context

Forty-one intermediate-level college sophomores (males: 22) enrolled in an English as a foreign language class from the College of Management at a National University in southern Taiwan were invited to participate in this study, which lasted for four weeks. To promote student learning of the learning material, the researchers implemented the SQG approach in two sessions of this class. In particular, Stoyanova and Ellerton's (1996) 'the answer is' with 'signal words' and King's 'generic question stems' were selected as procedural prompts for SQG. An online instant interactive system, Zuvio, was introduced to support SGQ (see Figure 1). The participants could access Zuvio by any portable device of their choice (e.g., smartphones, laptop, tablets, etc.) to generate and submit questions with answers on the learned content.

For the purpose of this study, one unit with 4 lessons on the topic of *Inventions and Discoveries* was selected. Each lesson focused on the photo story (i.e., the topic), vocabulary (on technology), grammar (on past unreal conditional), and an article (on antibiotics), respectively. A brief training session on SGQ in Zuvio was arranged before the 1st SGQ activity to ensure that the participants were equipped with associated knowledge and skills for meaningful engagement in the online activity.

Two online SQG activities were scheduled after the mid-term exam. The 'signal words plus the answer is' procedural prompts were used for the 1st SQG activity after the 2nd lesson, during which each student generated one question corresponding to the delivered instruction individually (see Figure 1). For the 2nd SQG activity, it was scheduled after the 4th lesson, and the 'question stems' procedural prompt was introduced, during which students generated two questions in correspondence to the taught instruction in groups of two (see Figure 2).

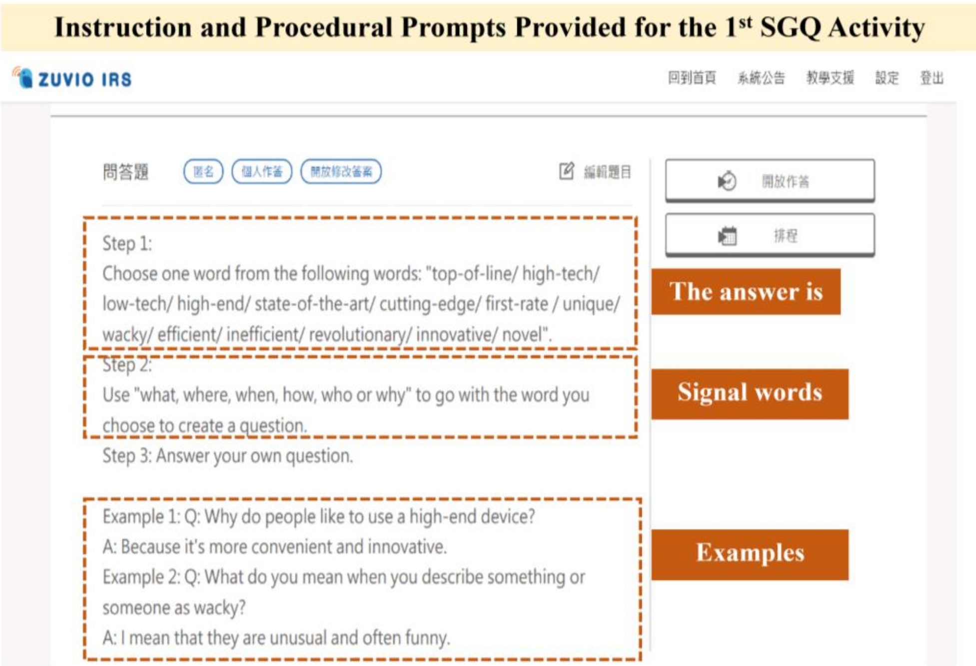

Figure 1. Instruction and Procedural Prompts in the Form of 'The Answer is' and 'Signal Words' Provided for the 1st SGQ Activity on Zuvio

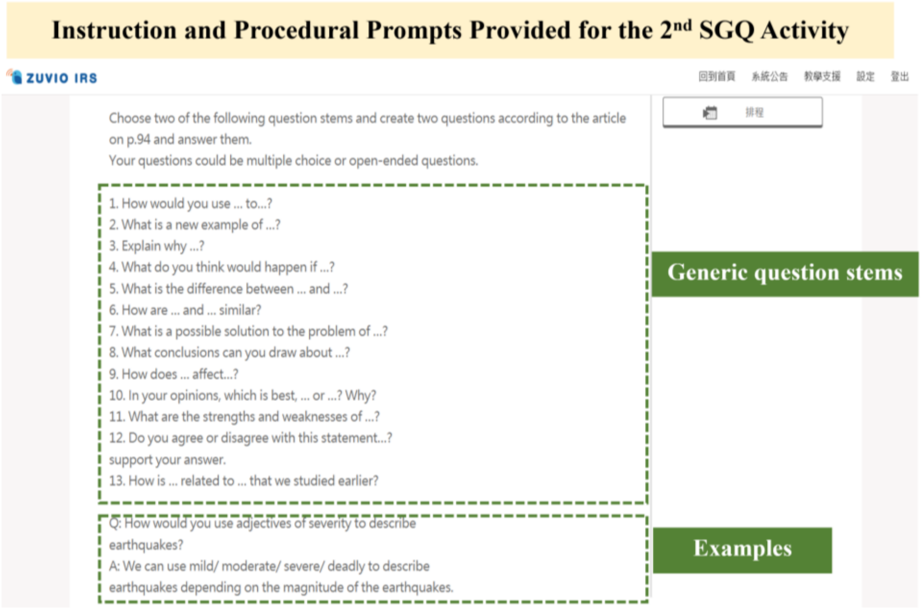

Figure 2 Instruction and Procedural Prompt in the Form of 'Generic Question Stems' Provided for the 2nd SGQ Activity on Zuvio

2.2 Classification of the Quality of SGQ

In total, 123 questions were generated by the participating students in the two online SGQ activities. The revised Bloom's Taxonomy (Anderson & Krathwohl, 2000), which has been widely used for evaluating the cognitive levels of questions in textbooks (Assaly & Smadi, 2015; Tarman & Kuran, 2015) and assessing SGQ performance (Lameese, Madalyn, Keli, Matthew, Jakob, Christina, 2015) was adopted and operationalized for classifying the quality of SGQ (see Table 1).

Table 1. *Operationalized Definitions of the Six Cognitive Levels of SGQ*

Dimensions	Definitions
Remember	Q&A* involves recalling information in the textbook.
Understand	Q&A* involves describing information in the textbook.
Apply	Q&A* involves using information in new situations.
Analyze	Q&A* involves identifying cause-and-effect or analyzing a problem.
Evaluate	Q&A* involves making judgments about the focal content.
Create	Q&A* involves synthesizing multiple units of information into new coherent entity or providing new solution.

*A question with its answer

Two experienced English teachers independently categorized each of the 123 questions the participants generated during the two online SGQ sessions along the revised Bloom's taxonomy. Percent of agreement was adopted for inter-rater reliability and evidenced adequate reliability — 82.96% and 84.38% for the 1st and 2nd SGQ activities, respectively.

2.3 Data Analysis of SGQ

Besides descriptive statistics (i.e., frequency, percentage), the Pearson's chi-square test was adopted to analyze whether academic achievement and gender group composition, respectively, has significant association with the quality of SGQ. In view of the fact that 33.33% of the cells in the contingency table had a number less than 5, to ensure valid chi-square tests and to comply with the calculation rule (i.e., requiring at least 80% of the cells to have an expected count greater than 5), the cognitive levels were grouped into a low level (by combining the bottom three cognitive levels: remember, understand, and apply) and a high level (by combining the top three cognitive levels: analyze, evaluate, and create).

For classifying students' academic achievement levels, it was originally based on the Common European Framework of Reference for Languages (CEFR) and language standard of English proficiency tests issued by Ministry of Education (2016) and TOEIC scores, and grouped to three levels (i.e., below 350 points as the low level, 351 to 550 points as the medium level, and above 551 as the high level). To comply with the chi-square calculation rule while considering approximately equal number in different groups, students' academic achievement levels were grouped to two levels, with below 450 points as the low-achieving level and above 451 points as the high-achieving level.

Finally, content analysis was applied for examining the use patterns of the integrated procedural prompts.

3. Results

3.1 RQ#1: Relations of Academic Achievement and Quality of SGQ

In total, 41 questions were generated during the 1st online SGQ activity. As shown in Table 2, the majority of SGQ from both the low- and high-achieving students were at the high cognitive level. Question at the high cognitive level generated by the high- and low-achieving students include content not based solely on the textbook, but with reference to other sources (e.g., personal experiences, daily life, internet). Sample questions include: How does the robot vacuum work? Is it efficient? (A: Yes. I don't waste time on sweeping the floor after I bought it; target word: efficient); Why is that car so expensive? (A: Because it's not only a Ferrari, but also a unique model; target word: unique).

Fisher's exact test considered a better method was adopted here instead because the data dealt with a 2x2 contingency table with small sample sizes, and there were two observed values less than 5. The results showed that there were no significant relations ($p = 1.000 > 0.05$) between students' academic achievement and quality of SGQ.

Table 2. *The Cognitive Levels of SGQ by the Low- and High-Achieving Students* (*n*=41)

		SGQ Cognitive Levels	
		Low	High
Low achieving	*f* (%)	4 (16%)	21(84%)
High achieving	*f* (%)	2 (12.5%)	14 (87.5%)
Total	*f* (%)	6 (14.6%)	35 (85.4%)

3.2 RQ#2: Relations of Gender Group Composition and Quality of SGQ

In total, 82 questions were generated during the 2nd online SGQ activity. As shown in Table 3, in the all-male and mixed-gender groups, more questions generated fell in the high cognitive level than in the low cognitive level whereas for the all-female group, there was an equal distribution of questions falling in low and high cognitive levels.

The results of chi-square test of independence further showed that there were no significant relations ($p = 0.443 > 0.05$) between gender group composition and quality of SGQ.

Table 3. *The Cognitive Levels of SGQ by Gender Group Composition* (*n*=82)

		SGQ Cognitive Levels	
		Low	High
All-male	*f* (%)	14 (38.9%)	22 (61.1%)
All-female	*f* (%)	12 (50%)	12 (50%)
Mixed-gender	*f* (%)	7 (31.8%)	15 (68.2%)
Total	*f* (%)	33 (40.2%)	49 (59.8%)

3.3 RQ#3: Relations of Academic Achievement and Use Pattern of Online Procedural Prompts

The questions generated during the 1st online SQG activity were further analyzed along the 'signal words' procedural prompt to examine their respective uses by the low and high-achieving participating students. As shown in Table 4, both 'what' and 'why' signal words were used for SGQ by both low and high-achieving students, with 'why' being used most frequently, followed by 'what' by both high- and low-achieving students. Moreover, the 'when' signal word was never used by neither group. Despite the two same use patterns by high- and low-achieving students, some different use patterns were present. Explicitly, 'who' was used exclusively by low-achieving students whereas 'how' and 'where' were used only by high-achieving students.

Table 4. *Use of Signal Words by the Low- and High-Achieving Students*

		Signal Words					
		What	Where	When	Why	Who	How
Low achieving	*f* (%)	7 (27%)	0	0	14 (53.8%)	5 (19.2%)	0
High achieving	*f* (%)	3 (20%)	2 (13.3%)	0	9 (60%)	0	1 (6.7%)
Total	*f* (%)	10 (24.4%)	2 (4.9%)	0	23 (56.1%)	5 (12.2%)	1 (2.4%)

3.4 RQ#4: Relations of Gender Group Composition and Use Pattern of Online Procedural Prompts

The questions generated during the 2nd online SQG activity were further analyzed along the set of online 'generic question stems' procedural prompt to examine their respective uses by the participants of different gender group composition. As shown in Table 5 (the right-most column), as a whole, among the 13 question stems, only about half (i.e., 7 question stems) were used for the SGQ activity. Moreover, among the seven used question stems, three question stems were used by all three groups, leading to the most frequently used question stems — 'What is the difference between … and …?', 'Explain why …?,' and 'What do you think would happen if …?' in that order.

Table 5. *Use of 'Generic Question Stems' by Different Group Composition*

Question Stems	All-male *f* [rank]	All-female *f* [rank]	Mixed-gender *f* [rank]	Total *f* (%) [*rank*]
1. How would you use … to…?	2		4	6 (7.3%)
2. What is a new example of …?				
3. Explain why …?	3	6 [1]	9 [1]	18 (22%) [2]
4. What do you think would happen if …?	4	6 [1]	7 [2]	17 (20.7%) [3]
5. What is the difference between … and …?	14 [1]	4	2	20 (24.4%) [1]
6. How are … and … similar?				
7. What is a possible solution to the problem of …?				
8. What conclusions can you draw about …?				
9. How does … affect…?	2	5		7 (8.5%)
10. In your opinions, which is best, … or …? Why?				
11. What are the strengths and weaknesses of …?	7 [2]	3		10 (12.2%)
12. Do you agree or disagree with this statement…? support your answer.	4			4 (4.9%)
13. How is … related to … that we studied earlier?				
Total	36	24	22	82 (100%)

As for the use pattern differences among the three different group composition, more question stems were used by the all-male group (i.e., seven) as compared to the other two groups (i.e., 5 question stems used by the all-female group and 4 by the mixed-gender group). Moreover, 'What is the difference between … and …?' was the question stem used most by the all-male group whereas 'Explain why …?' was used most by both all-female and mixed-gender groups.

4. Discussion and Conclusion

In view of the existing literature on educational psychology that points to possible effects of individual differences (e.g., Efklides et al., 1997; Schmeck & Grove, 1979) and group composition under a cooperative learning situation (e.g., Harskamp et al., 2008; Lee, 1993; Zhan et al., 2015), issues regarding if and how such factors may have on SGQ was the focus of this study. Specifically, individual differences in academic achievement and gender composition were targeted, and their respective relations to the quality of SGQ as well as use pattern of integrated online procedural prompts were examined.

The results on Fisher's exact test showed that there were no significant relations between students' academic achievement and the quality of SGQ (in terms of cognitive level). Although this study did not concur with past studies confirming individual differences effects, with students in both low- and high-academic levels generating the majority of questions in the high cognitive level, the authors speculated that it may be the explicit nature of procedural prompts (i.e., 'signal words plus the answer is') that help guide the participating students in generating high-level cognitive level questions; thus, it helps alleviate English capability gap between students at different English achievement levels.

Furthermore, the results of chi-square test of independence found no significant association between gender group composition and cognitive levels of SGQ. Again, despite that this study did not corroborate with existing studies attesting gender effects in cooperative group situations, with more questions generated by students in the all-male and mixed-gender groups falling in the high cognitive level than in the low cognitive level and an equal distribution of questions in both low and high cognitive levels by the all-female group, it appeared that the set of online procedural prompts provided is successful in directing the participants in different gender compositions not to delimit question-generation in the low-cognitive end, as so concerned by practitioners (King, 1990, 1992).

Lastly, while some same use patterns of online procedural prompts were observed for students in the low- and high academic achievement levels (e.g., use of the 'why' signal word most frequently, followed by the 'what' signal word) and different gender group composition (e.g., nearly half of the provided prompts were not used), slightly different use patterns were present for students in different academic achievement levels and gender composition.

4.1. Limitations and Suggestions for Instructors and Future Studies

The current study found that under the online provision of 'signal words plus the answer is' and 'question stems' procedural prompts, students with different academic performance levels and gender group compositions were found to generate significantly more questions at the high cognitive level. With a considerable proportion of students lacking experience in SGQ and worrying about their performance at the SGQ task (Yu, 2009), it is suggested that instructors take advantage of the explicit nature of procedural prompts to support online SGQ for high cognitive level question-generation.

This empirical study provided preliminary data on the relations of academic performance and gender group composition on the quality of SGQ and use patterns of online procedural prompts. Nonetheless, it should be noted that only one class of undergraduate students was involved to participate in two online SGQ activities in corresponding to a study unit on English. For future studies, larger sample sizes for an extended study period involving different topics should be considered. With an extended study period across different topics, the use pattern of different procedural prompts across different topics can be better examined and understood. With larger sample sizes, the learning processes and outcomes of male and female students in different gender compositions can be examined and compared to the findings of previous studies for better understanding (e.g., the study results of Zhan et al. found that males performed better in mixed-gender groups while their female counterparts performed similarly in both same-gender groups and mixed-gender groups). Moreover, future studies incorporating qualitative research method, in particular, in-depth interview, would be able to probe deeper and gain insight as to why and how different online procedural prompts are considered by students in different academic achievement levels and gender group composition for SGQ. Finally, individual differences in other aspects found to affect learning, for instance, general cognitive abilities and functioning (Gustafsson & Undheim, 1996; Ruiz, Chen, Rebuschat, & Meurers, 2019) may be better tapped with a larger pool of participants.

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