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Exploring Student Behavior during Student-Generated Questions Activities on Programming Learning

Pham-Duc THO[a*], Chih-Hung LAI[b] & Thieu-Thi TAI[a]
[a]*Hung Vuong University, Vietnam*
[b]*National Dong Hwa University, Taiwan*
*thopham@hvu.edu.vn

Abstract: In this paper, we explored and revealed students' interaction patterns regarding Student-Generated Questions resources based on students' different identified groups of interaction with online programming learning material behavior. Our study observed that most learners possess bi-directional viewing questions reflective of the effectiveness of Student-Generated Questions treatment. This process indicates that the Student-Generated Questions treatment proposed in this study may potentially enhance learners' active learning behaviors in programming learning.

Keywords: Student-Generated Questions, student behavior, Programming Learning, Lag Sequential Analysis

1. Introduction

Over the past decade, there has been an explosion in technological advancements such as the Internet, mobile phones, and computers, with the associated issue of developing the skilled workforce needed to master the technology (Popat & Starkey, 2019). Therefore, the Computer Science field is becoming one of the fastest-growing and highest-paying career paths globally (Law, Lee, & Yu, 2010; Popat & Starkey, 2019). Computer Programming is an essential technique of Computer Technology; it is the way humans communicate with machines, and it allows us to create software like programs, operating systems, and mobile applications (Popat & Starkey, 2019). Consequently, Computer Programming has become a critical subject, and it is a basic form of literacy in the digital age (Olelewe, Agomuo, & Obichukwu, 2019; Yagci, 2018).

Notwithstanding its popularity and job prospects, Computer Programming is widely recognized as a big challenge for students (Lu, Huang, Huang, & Yang, 2017; Ozyurt & Ozyurt, 2018; Tuukka, 2015; Yagci, 2018). The reasons are various, but mainly because Computer Programming is deeply linked to mathematics, critical thinking, problem-solving skills, and logical approaches (Jenkins, 2002). Despite the advancements in programming tools and environments, teaching Computer Programming continues to be a challenge for most school teachers (Popat & Starkey, 2019; Tomas, 2018). Consequently, the rate of failure or withdrawal from the first programming course due to poor learning performance has been consistently reported to be significantly high (Minjie, 2015).

In this regard, many researchers have proposed solutions that contribute to engagement and better achievement in programming learning. The solutions include collaborative learning (Leovy, Ruth, Liliana, & Ivan, 2017), explicitly teaching problem-solving (Wang & Hwang, 2017), programming visualization (Minjie, 2015), psychological analysis and mental models (Linxiao, 2007), visual programming environments (Mcgowan & Hanna, 2015; Minjie, 2015), game programming (Piteira, Costa, & Aparicio, 2018; Vladimiras, Tatjana, & Valentina, 2018), student-generated questions (Denny, Luxton Reilly, Tempero, & Hendrickx, 2011; Hsu & Wang, 2018; C. H. Lai, Tho, & Liang, 2017). Among them, student-generated questions (SGQ) is a crucial teaching strategy that has been widely recognized for its advantages for more than a decade (Barak & Rafaeli, 2004; Yu, 2009; Yu, Liu, & Chan, 2002, 2005). SGQ has been observed to enhance the comprehension of learned content (Berry & Chew, 2008; Yu & Wu, 2016), to encourage and monitor awareness (Song, Oh, & Glazewski, 2017), and to promote algorithmic thinking skills (Hsu & Wang, 2018), motivation (Yu & Chen, 2014), engagement and learning performance (Berry & Chew, 2008; Crogman & Crogman, 2018; Song et al., 2017; Yeong, Chin, & Tan, 2019; Yu, 2009; Yu, Wu, & Huang, 2018). SGQ helps students applying learned content to new problems and link newly learned knowledge/skills to prior knowledge (C. H. Lai et al., 2017; Yu, 2009). Throughout SGQ, students adopt a different thinking mode and increase their learning strategies (Hsu & Wang, 2018; Song et al., 2017; Yu & Chen, 2014).

Although many studies have been recognized as effective assessment and learning guidance tools for Programming Learning as we mentioned, they mainly focused on showing the effectiveness of the test strategy rather than investigating what underlies the result. Therefore, it is necessary to explore students' learning processes by related methods in such learning environments. On this subject, Bakeman and Gottman (1997) introduced a method that helps researchers to examine the sequential relationship between each learning behavior based on statistical theory named lag sequential analysis. Through a series of sequential analysis matrix calculations, lag sequential analysis determines behavioral transitions (Bakeman & Gottman, 1997; Huei Tse Hou, 2012; Yin, Uosaki, Chu, Hwang, Hwang, Hatono, Kumamoto, & Tabata, 2017). Moreover, it allows us to identify the significant behavior patterns via conducting visual diagrams.

In particular, it is appropriate to discover the behavior patterns in the online learning environment (Huei Tse Hou, 2012). Therefore, in this study, we applied the combined sequential analysis and cluster analysis method shown by Huei Tse Hou (2015) to an SGQ treatment in the Programming Learning course and discovered the learners' flow state and learning behavioral patterns.

2. Methods and Experiments

2.1 Participates

Our test group consists of 38 university students(33 males and five females) enrolled in Fundamental Computer Programming, using C programming language. Students used the learning system with access to SGQ functions such as posting questions, viewing peers' questions, and answering peers' questions. All the participants were undergraduate students with a major in engineering; however, none of them were Computer Science students. Therefore, for most of the attendees, this was the first purely programming class they had ever selected throughout their academic curriculum. Although the course itself was classroom-based, it included compulsory online learning. The classroom was equipped with a dedicated PC for every student attending the course. The course was elective (i.e., not compulsory) for all the students, and after passing the final examination, they were awarded three credits counting towards their graduation.

The student using the PIPLS (Chih Hung Lai & Tho, 2016) to learn with SGQ functions such as posting questions, viewing peer questions, and answering peer questions. Then the online learning behavioral patterns of students were explored to reveal frequently performed sets of students' behavior.

2.2 Lag Sequential Analysis

By applying Cluster analysis, three clusters were identified. These clusters evince differences in students' learning behavior patterns, and therefore we assigned them slightly suggestive names:
(1) Less-engaged students
(2) Moderately-engaged students
(3) Highly-engaged students

To explore the behavioral patterns of each cluster, developing coding schemes is the first step that should be taken. It is simply said that the success of observational studies depends on the early definition of behavior (Bakeman & Quera, 1995; Huei Tse Hou, 2012). In this study, coding schemes were made from online learning that occurred in PIPLS. Some parts of the activities were inspired by previous research that share similarities in the nature of online learning (Huei Tse Hou, 2011, 2012, 2015; H. T. Hou & Wu, 2011; Sun, Lin, & Chou, 2016).

As seen from Table 1, there are seven coded actions as follows: Question is coded as 'QV' to represent that students access the question pages. Answering is coded as 'A' to describe the behavior of answering questions. Revision is coded as 'R' to represent the behavior of revising answers. Learning is coded as 'L' to represent the behavior of accessing lecture slides. Posting new Questions is coded as 'QP' to describe the behavior of submitting a new question. Editing of a Question is coded as 'QE' to represent behavior for editing questions. Finally, Comment is coded as 'C' to describe the behavior of commenting on either questions or answers.

Table 1. *Coding Schemes*

No.	Code	Behavior	Description	Example
1	QV	View Question	Access to a question by clicking a question link	The student access to a question page
2	A	Answer	Answer general questions by submitting an answer	
3	R	Answer Revision	Revise answers by submitting a new revision	
4	L	Learning	Access to learning materials by visiting resources pages	The student access to learning materials (slides, videos, etc.)
5	C	Comment	Comment to a question or an answer	The student give away a comment to a question or an answer
6	QP	Generate Question	Generate new question	The student submits a new question
7	QE	Question Edit	Edit questions by submitting a new version	

These seven activities were selected because of their frequent appearance in online learning systems with the SGQ. Moreover, they represent participative and interactive data, which are generally significant for predicting learning performance (Su, Ding, & Lai, 2017). Furthermore, of course, each action can be performed before or after one another logically. Analyzing the log data of the 38 participants yielded a total of 34,139 behavioral codes.

3. Results and Discussion

3.1 Result

We deduced the behavior-transfer diagrams of individuals in clusters, as shown in Figure 1-3. These three figures illustrate all sequences that have reached significance. The numerical values in the figures are the sequences' z-scores, and the arrow indicates the direction of transfer for each sequence.

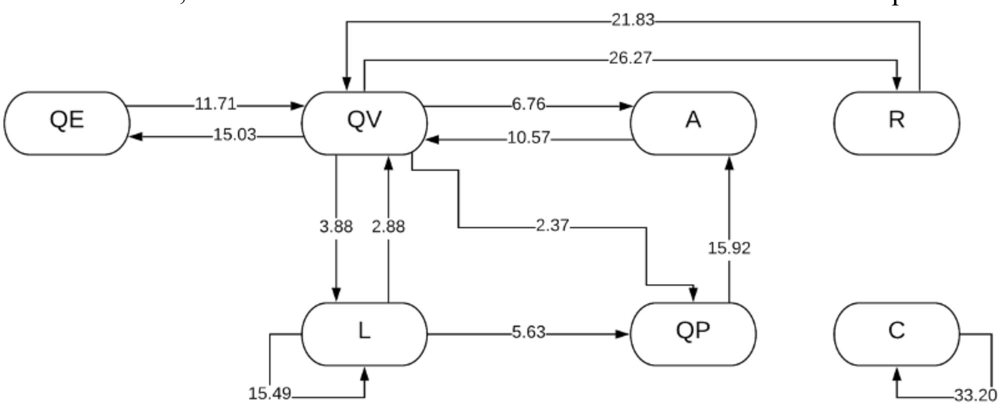

Figure 1. The behavioral transition diagram of Highly-engaged students.

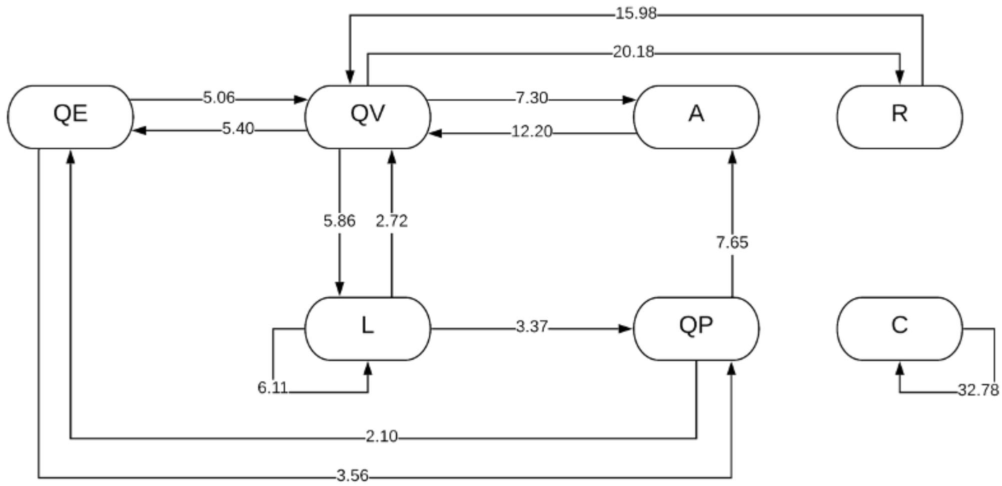

Figure 2. The behavioral transition diagram of Moderately-engaged students.

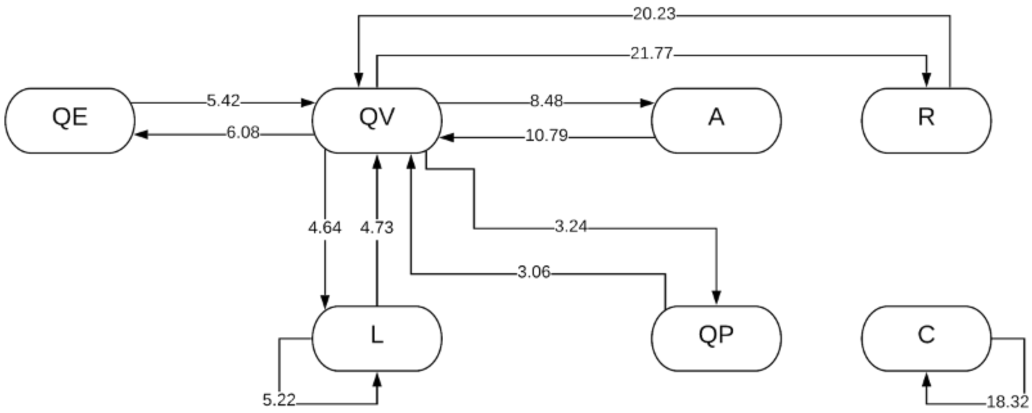

Figure 3. The behavioral transition diagram of Less-engaged students.

From the analysis results of Figure 1-3, we learned that the student's learning behavior patterns in the three clusters during SGQ shared some similarities, but some differences also existed.

The analyses reveal that integrating cluster and sequential analyses allows understanding learners' behavioral patterns in the class with SGQ. Of the three clusters, the Highly-engaged students displayed a high behavioral frequency and also have good exercise in the SGQ process. The Moderately-engaged students had lower behavior frequency and more engagement in the editing questions after posted. The Less-engaged students were characterized by a low level of behavior frequency and were less engaged in the SGQ process. All of the above analyses expose and visualize the possible behavior patterns and processes a learner may experience during the SGQ treatment context.

Our results provide the suggestion for improving SGQ in not only Programming courses but also for other courses. We found the behavioral transition of Highly-engaged students and Moderately-engaged students show that if students answer their questions immediately after they posted, it can contribute to the performance of SGQ, students' engagement, and learning achievement. Previous studies by Denny et al. (2011) and Luxton Reilly, Denny, Plimmer, and Bertinshaw (2011) applied SGQ in the Programming course with the requirement that students must answer their questions but did not explain how answering their questions help students in the SGQ process. Our result filled the gap by proving that student answering their question after generating one is crucial in SGQ and appeared in higher engaged groups of students. On the other hand, the learning process before generating questions in SGQ is essential. This is in line with previous researches claiming that the act of generating questions does not directly improve understanding but instead requires students to engage in tasks - such as reflecting on their understanding, searching relevant texts, and combining information - which helps improve comprehension (Palinscar & Brown, 1984; Rosenshine, Meister, & Chapman, 1996).

4. Conclusion and Future Work

This research explored and revealed students' interaction patterns regarding SGQ resources based on students' different identified groups of interaction with online learning material behavior.

We found the behavioral transition of Highly-engaged students and Moderately-engaged students show that if students answer their questions immediately after they posted, it can contribute to the performance of SGQ, students' engagement, and learning achievement. Previous studies by Denny et al. (2011) and Luxton Reilly et al. (2011) applied SGQ in the Programming course with the requirement that students answer their questions but did not explain how answering their questions helps students in the SGQ process. Our result filled the gap by proving that student answering their question after generating one is crucial in SGQ and appeared in higher engaged groups of students. On the other hand, the learning process before generating questions in SGQ is essential.

This study observed that most learners possess bi-directional viewing questions reflective of the effectiveness of SGQ treatment. This process indicates that the SGQ treatment proposed in this study may potentially enhance learners' active learning behaviors, as aligned with Yu (2004), and engagement (Pittenger & Lounsbery, 2011; Rhind & Pettigrew, 2012).

Future works can measure students' self-efficacy and cognitive load since it is the nature of SGQ. Besides that, exploring students' anxiety may answer the question we revealed in this study is why students in the Moderately-engaged clusters are more likely to edit their question after posting.

Future works can also deep investigate the content analysis of comments and SGQ to students' engagement and behavior. It is also interesting to investigate the effect of The Judge on students' engagement and students' behavior.

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