Use of Feedback According to Students' Affective State during Problem Solving

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ABSTRACT: Pattern-finding analytical techniques to improve our understanding of the use of feedback and scaffolding during problem-solving processes have attracted great attention. This study used the lag sequential analysis to unfold the learning patterns according to affective states during students' problem-solving processes. The results have shown that the significant transitional sequences of learning activities before and after requesting feedback and seeking scaffolding differ between students associated with positive and negative affective states. This study highlights the importance of providing tailored support based on students' affective states, to further enhance their technology-mediated learning experience.

Keywords: Problem solving, learner support, affective states, learning analytics

1 INTRODUCTION

The importance of problem solving has been highlighted frequently in contemporary education (Greiff, et al., 2014). One of the most common ways to foster students' problem-solving skills is to assign problem-based tasks to be completed in intelligent tutoring systems. In such learning environments, some form of support, such as feedback, scaffolding or elicited explanations, is usually provided to help students explore effectively (Liu, et al., 2004). In such explorations, students' affective states are, to a large extent, associated with their learning experiences and outcomes (Scotty et al., 2004). Positive affective states may contribute to learning (Csikszentmihalyi, 1990), while negative ones may undermine learning (although we acknowledge that some negative affective states can be necessary in learning, as students progress towards understanding) (Woolf et al., 2009). This is particularly the case in students' problem-solving processes. Previous research has focused on how to detect students' affective states using varied methods, and has attempted to identify correlational or causal relationships between affective states and learning outcomes quantitatively (i.e. Calvo & D'Mello, 2010; VanLehn et al., 2017). Nevertheless, how students' affective states affect their use of feedback and scaffolding during their problem-solving processes is still not fully understood. Thus, this study attempted to identify patterns of feedback requesting and scaffolding usage during problem-solving processes, and to explore whether there are any differences between students with different affective states.

2 METHODS

2.1 Participants and setting

Our project involved 189 students (aged between 9- and 10-years) from six classes of three primary schools, which were all in or around Beijing, China. For approximately 45 minutes, the students were asked to complete 18 fraction-related tasks in a computer-based exploratory learning environment called Fractions Lab. Fractions Lab is designed to help students learn by interacting with different representations of fractions, while being aided by learner support such as different types of feedback and scaffolding, to solve given tasks. Built upon our previous work (e.g., Mavrikis, M., Holmes, W., Zhang, J., & Ma, N., 2018), Task 10 was selected for this study as the case to explore further how use of feedback and scaffolding was associated with affective states. Task 10 was "Using two fractions with the same denominator, create an addition that equals 9/12". This task was selected as students tend to present different affective states while working on it. In this study, 57 students were found to have positive affective states (including "enjoyable" and "interesting") while 15 students assigned themselves to negative affective states (including "frustrating", "confusing" and "boring").

2.2 Data Analysis

While the students were interacting with Fractions Lab, their interactive logs (e.g. id, events) were collected and saved automatically. Events were categorized into nine different activities: *GenF* (generating fraction), *ChaF* (changing the denominator or numerator of a fraction), *TraF* (deleting fraction), *LabC* (dragging fractions to the balance to compare, add or subtract), *TasO* (opening the description of the present task), *TasR* (resetting the present task), *SeeS* (seeking scaffolding to solve the problem, such as, creating the equivalent fraction, changing the color of the numerator, etc.), *StaR* (showing the current states, such as, true, false or unfinished), and *FeeB* (requesting feedback or hints to resolve the task). The Mann-Whitney U test was used to test for the different uses of learner support (e.g. requesting feedback and seeking scaffolding), according to the two groups of students with different affective states. The lag sequential analysis method (Sackett, 1978) was adopted to compare patterns of feedback requesting (FeeB) and scaffolding seeking (SeeS), to identify the significant transitions with regard to these two types of learner support, by using the version 5.1 of Generalized Sequential Querier (GSEQ 5.1).

3 RESULTS AND DISCUSSION

3.1 Significant Transitional Sequences during Problem-Solving Process

Although there was no significant difference between the two groups of students associated with positive and negative affective states, in terms of how many times they requested feedback (z=-.238, p=0.812 > 0.05) and scaffolding (z=-.151, p=0.880 > 0.05), the transitional sequences of learning activities were significant. The lag sequential analysis was used to probe the significant transitional sequences during the students' problem-solving processes. To reach a statistically significant result of the sequence, a z-score higher than 1.96 (Bakeman & Gottman, 1997) was used to evaluate the significance of transition. As shown in Figure 1, the significant learning activities before and after feedback requesting (FeeB) and scaffolding seeking (SeeS) differed between the students associated with the different affective states.

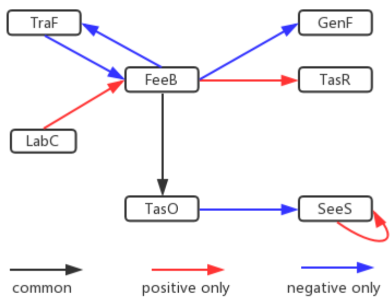

Figure 1: Significant sequences of feedback requesting and scaffolding seeking

The students who requested feedback after deleting a fraction were likely to indicate that they were frustrated, confused or bored. This perhaps implies that they failed to complete the task and had to request feedback in order to achieve the learning goal. In this matter, feedback was requested for the purpose of “telling me the answer”. After receiving feedback, they tended either to delete the fraction (TraF) or generate a new one (Genf) to make another attempt. Scaffolding (e.g. creating the equivalent fraction, changing the color of the numerator) was sought after they had opened the task, before they first explored how to solve the problem. This further confirms that the learner support embedded in Fractions Lab was used immediately to complete the task without any prior exploration. As Fractions Lab was defined as an exploratory learning environment, where feedback was designed to ask students to “think and explore”, or “try, fail, and learn”, such open and reflective feedback may not provide “the support as the answer” that these students expected to receive. Thus, the students who expected learner support to provide them with answers were likely to feel frustrated, confused or bored.

Students who requested feedback after using the balance tool to confirm their results tended to enjoy or be interested in the learning task. These students with positive affective states seemed to be more proactive in terms of using scaffolding embedded in Fractions Lab, such as the balance tool, before requesting feedback. After receiving feedback, they tended to reset the task (TasR), which implies that they were not afraid to start over again. During such a learning process, they requested feedback to help them explore the learning task further. This was further confirmed by the significant transitional sequences of scaffolding seeking with itself (as indicated in the self-loop from SeeS to SeeS in Figure 2). In this way, the students attempted to try out all possible scaffolding (e.g. creating the equivalent fraction, changing the color of the numerator) designed in Fractions Lab, which illustrates that these students were in an exploratory mode of learning.

4 CONCLUSION

In this study, an attempt was made to use pattern-finding analytical techniques (e.g. Mavrikis, 2010) to improve our understanding of the use of feedback and scaffolding during the problem-solving process. These important correlates of learning have been researched extensively (e.g. Aleven, Stahl, Schworm, Fischer, & Wallace, 2003; Porayska-Pomsta, Mavrikis, & Pain, 2008) but outcomes remain conjectural. Learning analytics will provide a new perspective for examining transitional sequences of learning activities according to different affective states during the problem-solving process, and will thus inform future intervention in exploratory learning environments. This work is important in that it uses interaction patterns of requesting feedback and scaffolding to gain insights into student’s reasoning processes. It further highlights the importance of students’ affective states which will significantly alter their behaviors, and in turn can be affected by how learner support is provided in exploratory learning environments. Careful investigation of how students behave before and after the use of feedback and scaffolding in Fractions Lab will be able to provide increasingly tailored support based on students’ affective states, to further enhance their technology-mediated learning experiences.

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