Studying the Interactions between Components of Self Regulated Learning in Open Ended Learning Environments

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Abstract: This paper investigates the interactions between learners' cognitive strategies and affective states; both important components of self-regulated learning (SRL) processes that influence student learning. We study cognitive-affective relationships in high versus low performing students as they worked on a model building task to teach their agent in Betty's Brain, an open-ended science learning environment. Our initial results allow for some interesting discussions, but they also emphasize the need for fine grained affective data to match up against cognitive states to determine how they influence performance or vice versa.

Introduction

Self regulated learning (SRL) involves the temporal deployment of cognitive, affective, metacognitive, and motivational processes (Azevedo et al., 2012). SRL processes are important for successful science learning, especially in open-ended learning environments (OELEs). Related work in this area show that affect can impact cognitive behaviors like decision-making, information processing, and reasoning (Forgas et al., 2006). Previous results highlight the importance of measuring and studying the interactions of affect with students' learning performance and behaviors. These findings help us understand that detecting and alleviating negative affect leads to better learning. This paper analyzes the interactions between components of SRL, primarily cognitive strategies and affective states, in the Betty's Brain OELE (Leelawong and Biswas, 2008).

Methods

We ran a study with 87 sixth-grade students in an urban public school in Nashville, TN, USA, who worked on modeling the causes and effects of climate change in Betty's Brain over four days. Students' interactions in Betty's Brain were logged. Two trained human observers (*Cohen's kappa*, $\kappa > 0.8$) collected data on students' affective states (*bored, confused, delight, engaged concentration, frustrated, other*), as well as their task behaviors (*on-task, off-task, on-task conversation, other*) following the Baker Rodrigo Ocumpaugh Monitoring Protocol (BROMP) for field observations (Ocumpaugh, Baker, & Rodrigo, 2015). We used differential sequence mining to identify frequent cognitive strategies that differed between high and low performing students (Kinnebrew et al., 2013). We then computed the differences in affect observed for high versus low performers, and thereby studied the relationships between cognitive strategies and on-task affective states.

Results and discussions

We applied the measure of students' in-system performance, their map scores ($median\ value = 11$), to divide all the students ($n = 87$) into *High* (Hi) and *Low* (Lo) performers. Students with a map score greater than 11 were labeled "Hi" ($n = 44$) and those with a map score less than 10 were labeled "Lo" ($n = 39$). Data for students at the median value ($n = 4$) was discarded to maintain the distinction between the two groups. Next, we ran a differential sequential pattern mining algorithm (Kinnebrew et al., 2013) to identify the differentially frequent cognitive patterns between Hi and Lo performers. Table 1 presents 3 frequent cognitive strategies sorted by the difference in the two groups' instance support values. The descriptors "-EFF/-INEFF" and "-SUP/-UNSUP" attached to causal link edit actions show whether the actions were *effective* / *ineffective* (led to an *increase* / *decrease* in the map score) and *supported* / *unsupported* (*related* / *unrelated* to previous actions), respectively.

Table 1: Differentially frequent patterns for High vs Low performing students

Pattern	***i*-Frequency Diff (Hi − Lo)**	***s*-Frequent Group**	***p* value**
READ → LINKADD-EFF-SUP → QUIZ	2.1	Hi	< 0.001
QUIZ → READ	4.35	BOTH	< 0.001
READ → CONV-REQ	-0.47	Lo	0.02

We analyzed the data collected on affective states of the students by group (Hi and Lo performers). We found that the amount of time spent being bored was significantly higher for the Low performers ($p = 0.002$) when the learners were in on-task mode. On-task behavior was also naturally marked by significantly higher level of delight ($p = 0.015$) for the Hi group. Next, we studied the affective states during use of the cognitive strategies from Table 1 between Hi and Lo performing students. The results of these cognitive-affective interactions are illustrated in Figure 1.

Quiz→Read, a frequently used pattern by all students, was linked to delight or frustration for the Hi performers, versus boredom and confusion for the Lo performers. A possible interpretation of this result is that, seeing good quiz results or improvement in the results produces delight, whereas negative quiz results produce frustration in the Hi performers. Confusion and boredom in Lo performers can be attributed to not being able to analyze the quiz results to find the information to read. However, frustration in high performers caused by the lack of immediate success did not seem to affect their desire to persist (unlike the low performers who got bored and gave up). Instead, frustration seemed to be channeled into reading activities that helped them find the information that they needed to correct their maps, and, therefore, they got past their frustrated state.

Read→Conv-Req is a differentially frequent pattern for Low performers. It includes a period of reading resource pages, but not understanding the content (or finding the desired information), therefore, seeking help from the Mentor. This is good SRL behavior, however, the Lo group showed a lot of boredom during this period (implying their lack of success led them to disengage from productive work on system), while the Hi performers primarily displayed confusion or frustration (unable to understand content, therefore, confusion or frustration, but they seemed to follow up by seeking help in a productive way).

Read →LinkAdd-Eff-Sup→Quiz is differentially frequent in High performers. Here, the student read and converted the information they read into correct causal links, and then took a quiz to verify if their added link was correct. For Lo performers, who performed this strategy rarely, no affect state was recorded (hence, their affect states are not included in Figure 1). Hi performers displayed significant levels of delight during this period, indicating that they were happy because they updated the map correctly based on what they read in the resources, and the quiz results confirmed that they had added correct link(s).

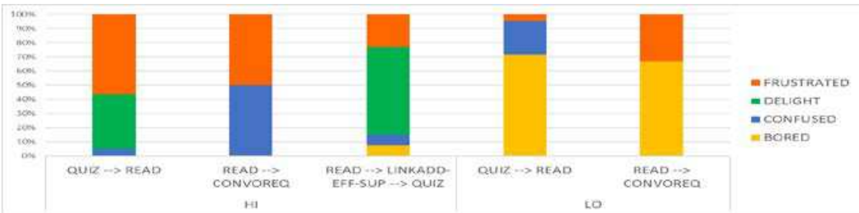

Figure 1. Hi vs Lo students - Emotions (on-task) for four different behavioral strategies.

Conclusions

The findings in this paper show that learners' affective states in an open-ended learning environment are linked to their cognitive strategies and performance in the system. As a broader research goal, we believe that establishing cause-effect relations between cognitive and affective processes will help us construct more complete models to gain an understanding of the relations between cognition, metacognition, and affect in SRL.

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