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Metacognitive reflection in ITS math problem solving

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Abstract. High school students used a self-reflection feature integrated into a mathematics ITS to indicate what they found difficult about a math problem, and what insights were required to solve it. Results indicated that students could often identify what specific information would help them solve a problem, and could evaluate what was helpful and not helpful about the multimedia explanations. Future work will focus on the impact of self-reflection on students' problem solving and transfer.

Introduction

This poster presentation will describe our preliminary work on an ITS feature to encourage students to reflect on their math problem solving. Human tutors will often ask the student to summarize a successful strategy or prompt for an analysis of the problem, rather than simply move on to the next item. These types of metacognitive activities help students consolidate their skills [1].

A related goal of our project is to explore how users can help with improving the effectiveness of the help features in the ITS. If one student does not understand the explanation for a problem, then others may have similar difficulties. Yet often there is no mechanism through which users can comment on the ITS problems and help resources, unless the researcher happens to be standing nearby and can make a note of the problem. We were also interested in capturing user input in real time as an initial step towards the goal of open learner modeling, in which users can influence the pedagogical decisions of the ITS through their input. Given that our target user group is high school students in public school classrooms, it was not clear that they would be willing, interested, or able to report on their problem solving.

1. Reflection feature architecture

A prototype Reflection feature was integrated into the Wayang-West ITS for mathematics problem solving [2]. In the ITS, students view a series of SAT-Math problems (see sample problem in the left side of Figure 1). The student can request help if he or she does not know how to solve the problem.

The new Reflection feature is accessed via a Review button (adjacent to the "help" and "next problem" buttons) which brings up a two part window (see right side of Figure 1). In the upper part, students are asked, "Why is this problem challenging to you?". They respond by typing into the open area. Below, the question is "What insight is required to solve this problem?" with an open region for students to respond.



Figure 1: SAT-M problem with first step of help (left) and Reflection window (right)

2. Feasibility study

We conducted a small-scale feasibility study with two geometry classes at a large suburban high school in Los Angeles. Students came to the computer-equipped school library during their regular mathematics class. 24 students worked with a version of Wayang-West ITS that included the prototype Reflection feature.

Students used the Reflection feature on an average of four problems, with a range of 1 to 12 problems per student. The feature functioned well in spite of heavy local network traffic, and student entries were successfully saved. Although they seemed initially a bit puzzled about what to write, many students did become engaged in the activity and all comments were on-task: e.g., "The problem wording is very difficult and confusing"; "The answer was different from what I thought. Because the other angles look like they had least area space"; "All I need to do was use congruency".

Students' responses to the first question, "Why is this problem challenging to you?" were categorized into themes, as shown in Table 1.

Response themes	Sample responses	% responses
We haven't learned this yet	"I don't understand this at all, I have not yet learned this in my geo class!!!"	13%
Problem is too hard	"Its just a challenging problem"; "Too hard"; "this problem is confusing my brain was saying ????????"	33%
Specific information not known	"I don't know the measurements of X or Y" "perimeter formula"	11%
I'm not good at this	"I'm not good with these kinds of problems"; "I dont spike English"	6%
Problem is easy; easier than expected	"this problem didn't seem as challenging as I thought it was"	19%
Other	"a pic may make it easier"	10%
No text entered	null	6%

Table 1: Student responses to "Why is this problem challenging?" (spelling & other errors in original entries)

Most often, students indicated that the problem was just too difficult (33%). Some (13%) indicated that they had not learned the material: "My teacher never taught this"; "We haven't learn this yet". However, their teacher indicated that the relevant skills had been covered in class. In fact, classroom performance is not always a strong predictor of students' scores on high stakes math tests, in part because test items often require novel combinations of skills [3].

There was evidence that on occasion (11%) students could identify what specific information would make the problem easier: "It gives me too much information, I think that it needs to be shorter"; "there is no picture that is why it is too difficult"; "it needs to show me other angles"; "the problem wording is very difficult". Students also appreciated the multimedia help: 19% indicated that once they saw the explanation, the problem was not as challenging as they had thought: "I got help and I learn that I should just put all the points in one line so after that I didn't think it was that hard to do". Half (50%) of the responses to the "What insights...?" question focused on specific information provided in the help: "the help was good because it showed me that when you use the side lengths of the squares you can find the length of the shaded boxes"; "all I need to do is just add up the angles"; "It didn't make sense at first but the help truly helps". In these cases, it seems that students did understand and learn from the help features.

However, we also discovered that there were students who did not seem to understand or learn from the help features for some problems. Specifically, 32% of the "what insights?" entries were vague comments such as "more help...lots of it!"; "to know how to solve it"; "someone to teach me"; "need to explain more"; "its good explanation but I just do not know the material"; "I got the answer after I got help but I still don't really know if I got it right". In these cases, students might benefit from seeing an alternative explanation for the problem (Wayang-West includes two forms of help for most of the problems). We will use these comments to identify explanations that need to be improved. In addition, we will investigate the impact of the reflection feature on student problem solving behaviors such as errors, reliance on help, and performance on transfer tasks.

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