Inferring unobservable learning variables from students' help seeking behavior

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Abstract. Results of an evaluation of students' attitudes and their relationship to student behaviors within a tutoring system are presented. Starting from a correlation analysis that integrates survey-collected student attitudes, learning variables, and behaviors while using the tutor, we constructed a Bayesian Network that infers attitudes and perceptions towards help and the tutoring system.

1 Introduction

One of the main components of an interactive learning environment (ILE) is the help provided during problem solving. Some studies have found a link between students' help seeking and learning, suggesting that higher help seeking behaviors result in higher learning (Wood&Wood, 1999; Renkl, 2002). However, there is growing evidence that students may have non-optimal help seeking behaviors, and that they seek and respond to help depending on student characteristics, motivation, attitudes, beliefs, gender (Aleven, 2003; Ryan&Pintrich, 1997; Arroyo, 2001). There are yet many questions to answer in relation to suboptimal use of help in tutoring systems, such as: 1) How do different attitudes towards help and beliefs about the system get expressed in actual help seeking behavior? 2) Can attitudes be diagnosed from students' behavior with the tutoring system? 4) If non-productive attitudes, goals and beliefs can be detected while using the system, what are possible actions that can be taken to encourage positive learning attitudes? This paper begins to explore these questions by showing the results of a quantitative analysis of the presence and strength of these links, and our work towards building a Bayesian Network that diagnoses attitudes from behaviors, with the final goal of building tutoring systems that are responsive and adaptable to students' needs.

2 Methodology

The tutoring system used was Wayang Outpost, a geometry tutor that provides multimedia web-based instruction. If the student requests help, step-by-step guidance is provided. The hints provided in Wayang Outpost therefore resemble what a human

teacher might provide when explaining a solution to a student, e.g., by drawing, pointing, highlighting critical parts of geometry figures, and talking. Wayang was used in October 2003 by150 students (15-18 year olds) from two high schools in Massachusetts. Students were provided headphones, and used the tutor for about 2 hours. After using the tutor, students filled out a survey about their perceptions of the system, and attitudes towards help and the system. Results of a correlation analysis of multiple student variables are shown in figure 1.

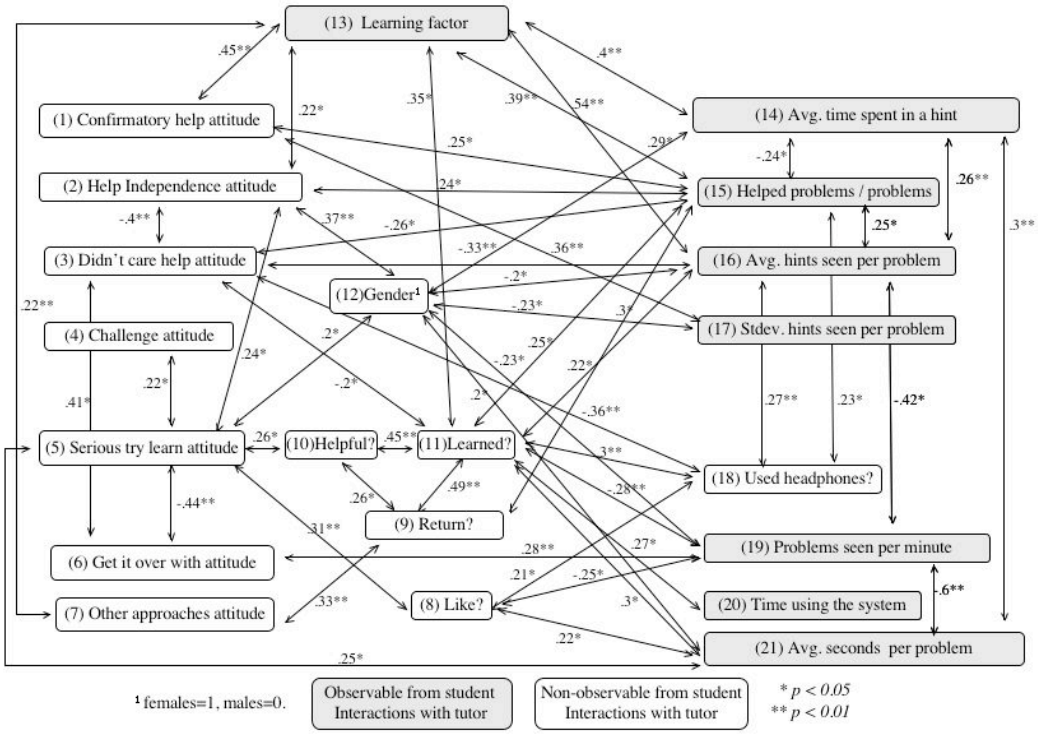

Figure 1. Correlations among attitudes, perceptions and student behaviors in the tutor

Variables on the left of figure 1 are survey questions about attitudes, those on the right are obtained from log files of students' use of the system. Two learning measures were considered. One of them is students' perception of how much they learned (*Learned?*), collected from surveys. The second one is a *'Learning Factor'* that describes how students decrease their need for help in subsequent problems during the tutoring session. Performance at each problem is defined as the 'expected' number of requested hints for this problem (for all subjects) minus the help requests made by the student at the problem, divided by the expected number of requested hints for the problem by the current student. For instance, if students on average tended to ask for 2 hints in a problem before answering it correctly, and the current student requested 3 hints, performance was 50% worse than expected, and thus performance is -0.5. Ide-

ally, students would perform better as tutoring progresses, so these values should increase with time. The average difference of performance between pairs of subsequent problems ($performance_t$ − $performance_{t-1}$) in the whole tutoring session becomes a measure of how students' need for help fades away before choosing a correct answer. This measure of learning is higher when students learn more.

From the correlation graph in figure 3, a directed acyclic graph was created by: 1) eliminating the links among observable variables; 2) giving a single direction to the links from non-observable to observable variables; 3) for links between non-observable variables, unidirectional links were created; 4) eliminating or changing the direction of links that create cycles. The resulting DAG was turned into a Bayesian Network by: 1) discretizing variables; 2) creating conditional probability tables from those new discrete variables. Preliminary analysis suggest that feeding this BBN built from data with different values for the observable variables result in the diagnosis of different attitudes and perceptions of the system.

3 Conclusions

We conclude that there are links between students' behaviors with the tutor, attitudes and perceptions exist. We found correlations between help requests and learning, which are consistent to other authors' findings (Wood&Wood, 1999; Renkl, 2002). However, help seeking by itself does is not sufficient to achieve learning: students need to stay within hints for higher learning. Learning and learning beliefs are linked to behaviors such as hints per problem, time spent per problem or in hints. Data collected from post-test surveys were merged with behavioral data of interactions with the system to build a Bayesian model that infers negative and positive attitudes of student users, while they are using the system. Future work involves estimation of accuracy of this model, and evaluations with students of a new tutoring system that detects and remediates negative attitudes and beliefs towards help and the system.

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