Intelligent Coaching for Collaboration in Ill-Defined Domains

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Abstract. This research seeks to improve learning by integrating intelligent coaching with peer-to-peer collaboration. We combine advanced technologies that support student freedom and exploration, allow for collaboration and peer tutoring, and provide task advice by modeling student work and behavior. We empirically evaluated both the effect of added collaborative features that enable peer-to-peer interaction and the potential to use this collaboration to improve the intelligent coaching features of the system. We found that collaboration enhances student work and that the coaching features provide opportunities to promote collaboration.

Keywords. Intelligent tutor, inquiry, collaboration, coaching, ill-defined domains

1. Introduction

Though many intelligent tutoring systems have been shown to improve learning by providing relevant, accurate, and useful advice to learners, the field is still limited by hard artificial intelligence problems including natural language processing and natural language generation. One potential work-around for some of these problems is to combine intelligent systems and peer collaboration. In this way, we can offer both the thoroughness and individual attention that computerized systems provide with the understanding and flexibility human tutors provide. Our contribution is in exploring the overlap of two areas that are rarely treated together: expert knowledge based tutoring for ill-defined domains, and collaborative learning. We examine this intersection for unique opportunities to enhance learning.

Other research has shown that peer support in the context of adaptive computer-based systems can enhance learning (e.g., [1, 2, 4, 5]). We have also seen evidence that systems can provide support and guidance even in open-ended domains such as database design and medical diagnosis [1, 2, 3]. By drawing on these prior results, we hope to study the use of an expert knowledge base to support collaboration in ill-defined domains, an area that is relatively unexplored, with exception of [1].

Our work is implemented in a system called Rashi, an inquiry tutor for ill-defined domains. The system includes a coaching module that monitors student inquiry behavior by assessing student data gathering and hypothesis formation. The coach uses an expert knowledge base to identify incomplete arguments or missing evidence to explore [3].
2. Supporting Students with Expert Knowledge and Collaboration

Originally, this knowledge based coaching was used to offer successively specific levels of coached problem solving advice [3], which was somewhat limited in its ability due to challenges such as natural language generation. We now hope to re-task this knowledge base coaching. Our hypothesis is that the system's intelligence is most appropriate to identify learning opportunities (e.g. solution inadequacies), and that humans, i.e. peers, are best at helping to improve the solution once learning opportunities are identified. With this in mind, we are building features into Rashi that prompt students to compare and contrast their work and to assist each other. For example, students might be prompted to collaborate in situations where peer arguments differ, or where peers are working on the same hypothesis or collecting related data. These features for encouraging student dialog, reflection, and targeted collaboration are still being refined and have yet to be evaluated. However, we evaluated the system with the non-intelligent collaboration features both to establish a base line for effectively assessing the intelligent features, as well as to give an indication of the potential of the intelligent features. Below we describe these studies.

3. Guiding Studies and Preliminary Results

We conducted empirical studies to evaluate two hypotheses:

- *H1*: The added collaborative features would improve problem solving.
- *H2*: In typical group work, an intelligent tutoring component can find sufficient opportunities to promote targeted collaboration

We sought support for H1 by comparing data from experimental trials given with and without collaboration features. The trials were run in both middle school and college classrooms in 2007 and 2008. Intelligent coaching was turned off for all of these trials. We compared student data gathering activity and argument creation -- see Table 1.

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<thead>
<tr>
<th></th>
<th>College Studies</th>
<th>Middle School Studies</th>
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<tbody>
<tr>
<td>With Collaboration</td>
<td>60</td>
<td>75</td>
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<tr>
<td>No Collaboration</td>
<td>29</td>
<td>30</td>
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Table 1. Students used Rashi with and without collaborative tools. Those with collaboration tools completed more work within the system.

The table compares two numbers: the average argument size, (the sum of all hypotheses and inferences formed by the student); and the average number of pieces of data collected, (all of the observations and data collected about a given case). In both trials, we see that that average data collection increases when collaboration is available. In the college studies, we see that the average argument size also increases.

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1 This hypothesis was used to test the theoretical validity of the concept that useful collaboration experiences can be found using the expert knowledge base, prior to implementation of the system.
We sought evidence for H2 by evaluating session logs to identify opportunities where the system could recognize that students were working with the same data, but one student had hypotheses about that data whereas the other student did not. This is just one example of an opportunity where an intelligent coach promoting collaboration could prompt students for discussion. We found an average of 13 instances where the coach could have promoted collaboration between college students within their groups, and an average of 20 instances for the middle school students within their entire class (group information was not recorded for the middle school trial).

4. Discussion and Future Work

We gather several conclusions from these preliminary results. The first is that the addition of even primitive collaboration features in the system seems to increase the amount of work students complete within the system. The second is that there is clearly potential for a system to promote collaboration between students by using the expert knowledge base to match students’ arguments.

All of this information leads us to believe that future plans are clear and on track. Collaborative features will add to student involvement and learning. This collaboration can be focused and made more productive through the use of the expert knowledge base. The next major step is to bring the intelligent collaborative coach into the classroom. We can compare the system with both the baseline data from this study and with a coach that simply prompts students to collaborate in arbitrary (non-intelligent) ways. With this evaluation, we will show that the intelligent system improves student work more than unprompted or naively prompted collaboration.

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References