Intelligent Tutoring Systems for Collaborative Learning: Enhancements to Authoring Tools

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Abstract. Collaborative and individual instruction may support different types of knowledge. Optimal instruction for a subject domain may therefore need to combine these two modes of instruction. There has not been much research, however, on combining individual and collaborative learning with Intelligent Tutoring Systems (ITSs). A first step is to expand ITSs for collaborative learning. This paper investigates the expansion of the Cognitive Tutor Authoring Tools to include collaborative components for example-tracing tutors. The tools were enhanced to support flexible use of collaboration scripts so different learning goals can be supported. We introduce the collaboration features supported and describe an initial pilot study using the new features in a fractions ITS.

Keywords: Problem solving, collaborative learning, intelligent tutoring system.

1 Introduction

Intelligent Tutoring Systems (ITSs) have shown great success in increasing learning gains for individual learning [10], while collaborative learning has been shown to increase learning gains in some computer-supported settings [6]. Although there is evidence that a combination of individual and collaborative learning may be needed for optimal knowledge acquisition, there is not much research on how to combine the two modes [7]. To facilitate this kind of research, it would help to expand ITSs so they support both individual and collaborative learning. Specifically, it would help if ITSs could flexibly support *collaboration scripts,* which aim to support productive collaborative interactions within groups [3]. Prior research in computer-supported collaborative learning show that scripts can be effective means of structuring collaborations. Collaboration scripts can be defined by five components: learning goals, activity types, sequencing, role distribution, and representation types [3].

In our research, we investigate how an ITS authoring tool can flexibly incorporate these components to support collaborative learning for a wide range of learning goals. While there have been previous ITSs that include collaborative features [4-5], [9] and research has been done to standardize collaboration scripts across contexts [2], authoring tools for ITSs generally do not support a range of collaboration script features. In the current work, we extend a proven ITS authoring tool, Cognitive Tutor

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Authoring Tools (CTAT) [1], to support the authoring of collaboration scripts for example-tracing tutors. Example-tracing tutors are behaviorally similar to cognitive tutors, but instead of relying on a rule-based cognitive model, they use a generalized behavior graph to guide students during problem solving. We describe how we enhanced CTAT so example-tracing tutors support both individual and collaborative learning.

2 Collaborative CTAT Extension

We extended CTAT so an author can create tutors that allow students in two different locations to interact with the same problem synchronously. Our collaborative version of CTAT allows the five collaboration script components to be supported flexibly.

In the simplest form of collaboration supported by these tools, each student has identical views and allowed interactions. This set-up would support a low-scaffolded collaboration scenario. However, the tools also support more complex and varied forms of collaboration, in which the collaborating students have different views and interactions. As an example, consider a collaborative environment where unique information can be presented to each student. Such interaction can increase individual accountability and the effectiveness of the collaboration. The ability to divide the information supports scripts such as the “Jigsaw” script [4].

Another typical element of collaboration scripts that can be supported with our enhanced version of CTAT is the use of different interactions to create roles. Even though each student can view the entire problem, the interactions that the students can take can be specialized based on their role. In this case, a student would be able to view their partner’s interactions but not be able to take over their partner’s role. This integrated feature may help to support mutual discussions and improve learning. Peer tutoring roles could also be supported by only providing feedback on interactions to the student in the “tutor” role. Our enhanced version of CTAT also supports scripts where each student has a completely different view of the problem. This kind of script can encourage collaboration where students have varied perspectives of the problem, but the actions of one student can influence the other.

The challenge in enhancing the authoring tools to support these possibilities was to provide the flexibility needed to support a wide range of collaboration scripts. This goal was achieved by using multiple example-tracing tutor engines running in parallel, one for each student. The parallel tutor engines all receive all the input from each interface and send all output to all interfaces. This structure allows an author to develop tutors that support more complex collaboration scripts, as in the example below.

3 Collaborative Tutor Example

We created a collaborative tutor for fractions and pilot tested it with two fourth/fifth grade students for initial impressions. This work extends an existing ITS for learning fractions with graphical representations [8]. For our pilot, the students were asked to collaborate on four procedural and four conceptual problems while working in different rooms, communicating both through their interactions with the tutor and by talking to each other through an audio connection. The script elements used in these problems were unique information as seen in Figure 1 and roles as seen in Figure 2.

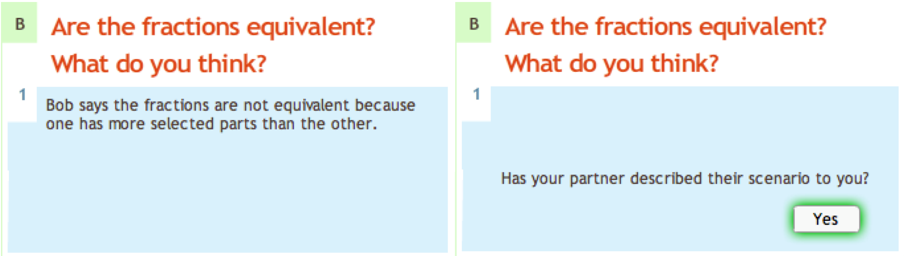

Fig. 1. Students are each provided with a unique story to share and are prompted to discuss

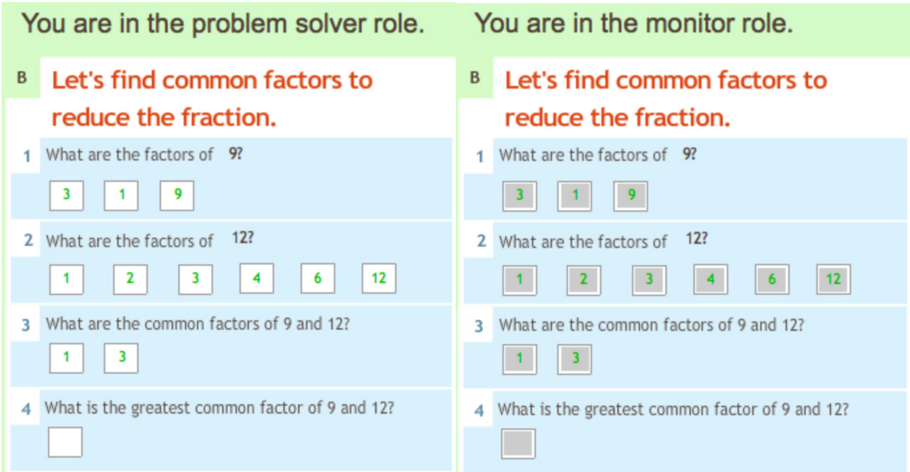

Fig. 2. Example of role assignment, where the gray indicates the component is inactive

First, each student was given unique information at the beginning of the problem and asked to share it to create individual accountability. Then they were assigned to either a monitor role, where they were accountable for asking their partner questions, or a problem solver role, where they were responsible for selecting or filling in the dyad's answers. The tutor also maintained key ITS features that have been shown to be critical to help learning, such as step-by-step guidance and hint levels [10].

4 Discussion, Conclusion and Future Work

The use of both individual and collaborative modes has been shown to be important in successful instruction [7], but how to combine the modes is not as well known. Currently, authoring tools do not flexibly support a range of collaboration script elements that would be needed to pursue this question. We extended CTAT to allow a range of collaborative scenarios to be supported. In an initial pilot, we demonstrated the feasibility of using features that support collaboration (e.g., providing unique information), helped spark a productive conversation between students, and found that the students enjoyed the collaboration. Future work will use these tools to develop a combined individual and collaborative tutor to test the basic hypothesis that optimal instruction often requires a combination of individual and collaborative learning.

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