Socially Capable Conversational Tutors Can Be Effective in Collaborative Learning Situations

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Abstract. Tutorial Dialog has been shown to be effective in supporting both individual as well as group learners. However, unlike the case with individual learners, teams of learners often ignore and abuse the automated tutors. Both theory and empirical work in the area of small group communication argue that group participants display both task as well as socio-emotional behaviors during interactions. However, in connection with automated conversational agents, the effects of socio-emotional behaviors are much less well understood, especially in the case of multi-party interactions. In this paper, we will describe an evaluation of a socially capable conversational tutor that supports teams of three (or more) learners in a design task. This tutor is evaluated in comparison with a socially neutral baseline agent and human capability "gold standard" tutors demonstrating that the socially capable tutor achieves significantly higher learning gains than the neutral, purely task focused tutor and learning gains not significantly different from the human capability "gold standard" tutors.

Keywords: social interaction, tutorial dialog, conversational agents, collaborative learning, small group communication.

1 Introduction

Conversational Tutors are autonomous agents that interact with users via spoken or written conversation. Automated tutoring is a widely studied application of language technologies to education. Conversational tutors have been developed for a variety of educational domains including algebra, calculus, computer literacy, engineering, foreign languages, geometry, physics, reading and research methods. Numerous evaluations show that these tutors can be effective support for learners [1][2][3].

While most of the work on conversational tutors has focused on one-on-one tutoring involving only one learner, use of such tutors in collaborative learning situations involving two or more human students has been investigated. Our previous work [2] has shown that tutors in a collaborative learning situations can lead to over one letter grade improvement. Other work [4][5][6][7] has explored a variety of interaction patterns / tactics that can be used in multi-party educational situations.

However, despite the effective support that automated tutors offer to students learning in groups, it has been reported that groups of students often ignore and abuse

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the tutor, unlike the case where students are individually tutored [2][8]. We reason that the presence of other students in collaborative learning scenarios causes the tutors to compete for the attention of the students. Since the tutors do not participate in social interaction that makes up the bulk of formative interaction in the group, they are pushed to the periphery of the learning group.

Research in the area of small group communication has shown that humans employ both task related strategies as well as social interaction strategies while interacting in groups. However, research on conversational tutors has focused on presenting only task related information, i.e., lessons and instructions in case of tutors. In this paper we report the first study in our investigation on the effects that conversational agents in general can achieve if they are equipped with social conversational skills.

The rest of the paper is organized as follows: In the next section, we motivate social interaction strategies for agents based on relevant literature from small group communication research. Section 3 describes our flexible architecture and implementation details for a tutor with social conversational skills. Results from the evaluation of the tutor against a baseline as well as human tutors are presented in section 4, and then we conclude with a discussion of current directions.

2 Small Group Communication

Theoretical and empirical study of group interaction processes has been of interest in sociology and communications research communities since the 1950's. McGrath [9] reviews various theories that address the functions of group interaction processes. Of particular interest among these are the theories proposed by Robert F. Bales [10] and Wilfred R. Bion [11]. Both of these theories propose that two fundamental processes operate within groups, i.e., instrumental (task related) vs. expressive (socio-emotional) in the case of Bales and work vs. emotion in the case of Bion. Over attention on one of these processes causes lapses on the other. Hence, interaction shifts between these two in order to keep the group functional.

In the case of conversational tutors, the task (or work) related interactions include aspects like instructing students about the task, delivering appropriate interventions in suitable form (e.g. socratic dialog, hints), providing feedback and other such tactics [12]. Some studies [13] [14] have evaluated the effect of these task related conversational behaviors in tutorial dialog scenarios. Work in the area of affective computing and its application to tutorial dialog has focused on identification of students' emotional states [15] and using those to improve choice of task related behavior by tutors. However, there has been only limited study of expressive (socio-emotional) aspects of the tutor's conversations with learning groups. Besides focusing on the expressive behavior of the tutor, the novelty of this work lies in the use of small group communication as a context for designing tutor behavior.

2.1 Social Behavior for Conversational Tutors

As discussed earlier, current state-of-the-art conversational tutors do not perform the socio-emotional function of interaction that is known to be a fundamental aspect of