Conversational Strategies that Support Idea Generation Productivity in Groups

Rohit Kumar, Language Technologies Institute, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, rohitk@andrew.cmu.edu
Jack L. Beuth, Department of Mechanical Engineering, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, beuth@andrew.cmu.edu
Carolyn P. Rosé, Language Technologies Institute, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, cp3a@andrew.cmu.edu

Abstract: Our recent work has shown that conversational tutors that use social interaction strategies can achieve significant learning improvement through better management of student attention. In continuation with this line of investigation, this paper presents an experiment that measures the separate and joint effects of the nature and style of automatically generated interventions. We investigate aspects of designing intervention prompts from two different angles: first in terms of the addition of socially oriented turns over and above the instructional turns required to keep the students on track, and second in terms of the style of presentation of the tutor's instructional turns. We see positive effects of both manipulations, but on different outcome metrics. Thus, we conclude that the two directions can be productively combined into a single socially enhanced feedback approach, which contributes to the literature on dynamic forms of support for collaborative learning.

Introduction

Inquiry as an approach to learning is popular in many areas of instruction, but particularly in science and engineering instruction. *Idea generation* is of central importance in the inquiry process, and some prior work shows an important connection between idea generation productivity and learning in a scientific inquiry task (Wang et al., 2007). Notice that the goal for students here is not to select and then apply a known procedure for solving a problem. In contrast, the main purpose here is to let students actively and creatively generate the candidate problem solving steps/options by themselves. Beyond offering students the opportunity to generate possible solutions to problems, these tasks offer students the opportunity to weigh and balance trade-offs between alternative solutions proposed by themselves and their team mates. Thus, these problems draw on student creativity and offer opportunities for students to develop their social skills and creative problem solving skills at the same time.

While idea generation in groups is purported to be more effective than idea generation for individuals, it is a well known problem that when groups engage in idea generation together, a phenomenon referred to as *process loss* occurs. In particular, it has been repeatedly demonstrated that a group that is interacting while doing idea generation together may not always perform better than a collection of non-interacting individuals whose contributions are simply pooled afterwards (i.e., nominal groups), both in terms of the quantity and quality of unique ideas, and in fact may sometimes perform significantly worse (Hill, 1982; Diehl & Stroebe, 1987; Nijstad & Stroebe, 2006). Often inquiry learning tasks are done collaboratively in the classroom. To the extent that process losses that affect productivity in idea generation may lead to corresponding reductions in learning, the issue of process losses in group idea generation is an important issue to investigate. Nevertheless, learning in idea generation tasks may arise from multiple different mechanisms, not only from the idea generation process per se. For example, while evaluative statements may inhibit productivity in idea generation, it is a form of transactivity in collaborative discourse, which shows that group members are attending to one another's contributions and making explicit links between their contributions and those that came before, which is associated with learning (Joshi & Rosé, 2007). Supporting such behavior has been shown in other work to support learning (Weinberger et al., 2005). Thus, the mere existence of process losses does not lead us to conclude hastily that collaborative idea generation is ill advised from an instructional standpoint. Rather we seek to find support that can enable students to benefit from the interaction without incurring the negative side-effects.

Tutorial dialogue agents have been effective as an interactive form of support for collaborative learning including collaborative problem solving (Kumar et al., 2007a), collaborative design (Kumar & Rosé, 2011) and collaborative idea generation (Wang et al., 2007), leading to substantial improvements in learning sometimes greater than a standard deviation effect size (Kumar et al., 2007b). 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 the tutor, unlike the case where students are individually tutored (Kumar et. al., 2007b, Bhatt et. al., 2004). 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 during the formative phase of the group, they are pushed to the periphery of the learning group and have to struggle to make themselves be heard. In our earlier work (Chaudhuri et. al., 2008, 2009), we have explored the use of interaction tactics that can help the tutor grab the conversational floor before presenting its instructional content to the students. On the other hand, empirical research in the area of small group communication suggests that leaders in small groups perform optimal levels of task related and socio-emotional interaction with the group members to maintain a non-peripheral position in the group (Bales, 1958). Existing research on conversational tutors has largely focused on presenting only task related information, i.e., lessons and instructions in the case of tutors. In this paper we report observations from a study in our continuing investigation on the effects that conversational agents in general can achieve if they are equipped with social conversational skills. Recent work explores how social strategies employed by conversational agents results in greater effectiveness of their support (Kumar et al., 2010; Ai et al., 2010).

Wang et al. (2007) demonstrated that automatically generated intervention prompts increased both idea generation productivity and learning, but did not fully compensate for the loss incurred by the group. In this paper, we focus specifically on the design of the prompts, carefully manipulating both its nature and its style in order to fine tune it for increased effectiveness. Our results point to a specific design inspired by work on analysis of social positioning from the systemic functional linguistics community as being particularly promising for enhancing idea generation productivity. Furthermore, the analysis of the connection between idea generation and learning in our data suggests that the relationship may be more complex than what was indicated by the prior Wang et al. study, which raises interesting questions for future work. We conclude by outlining our next steps, which build upon these results.

Designing Conversational Strategies

Theoretical and empirical study of group interaction processes has been of interest in the communications research community since the 1950's. McGrath (1984) reviews various theories that address the functions of group interaction processes. Among these, Robert F. Bales (1950) proposed that two fundamental processes operate within groups, i.e., instrumental (task related) vs. expressive (socio-emotional). 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. Participations in the interaction balance their positioning among the task leader and social leader roles through the use of these two types of interaction processes.

In the case of conversational tutors, the task related interactions include common aspects like instructing students about the task, delivering appropriate interventions in suitable form and providing feedback. Work in the area of affective computing and its application to tutorial dialog has focused on identification of students' emotional states (D'Mello et. al., 2005) 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 (Kumar et al., 2010; Ai et al., 2010). Those studies demonstrate positive impacts of social strategies when conversational agents offer support to students learning in groups.

In our current work, we independently manipulate two different factors that influence how conversational agents deliver intervention prompts to students. One dimension is identical to that investigated in prior work (Kumar et al., 2010), which is based on Bales' IPA, and discussed in the next section. This factor determines whether or not certain social prompts are delivered to students in addition to task related prompts. The second dimension determines the form of the tutor's prompts. We apply the distinction between heteroglossic contributions and monoglossic contributions from Martin & White's Engagement system (Martin & White, 2005), where a heteroglossic assertion is made in such a way as to acknowledge the possibility of alternative perspectives and a monoglossic assertion is one that speaks matter-of-factly "as the voice of God", without such an acknowledgement. This distinction is discussed in greater detail below.

Social Behaviors Motivated by Bales' IPA

We have used the interaction process analysis (IPA) schema developed by Bales (1950) to identify the social behaviors that tutors can employ. Our choice of interaction categories from IPA is based on the appropriateness of the unit of analysis on which IPA is applied, i.e., individual utterances, since the tutor's behavior is realized typically one utterance at a time. IPA identifies three positive socio-emotional interaction categories: showing solidarity, precipitating tension release, and agreeing. We have mapped these categories to eleven practically implementable conversational strategies, which are distinguishable from each other and are relevant to interactive situation employed in our experiment. This mapping is shown in Table 1.

Most of these strategies are realized as prompts triggered at appropriate moments during the interaction by manually developed rules. For example, strategy 1e is triggered when one or more students in the group are found to be inactive for over 5 minutes. In this event, the tutor chooses to raise the status of the inactive students by eliciting contributions from them through a prompt like: *Do you have any suggestions Mike?*

Table 1: Social Interaction Strategies based on three of Bales' Socio-Emotional Interaction categories.

1. Showing Solidarity: *Raises other's status, gives help, reward*
1a. Do Introductions: *Introduce and ask names of all participants*
1b. Be Protective & Nurturing: *Discourage teasing*
1c. Give Reassurance: *When student is discontent, asking for help*
1d. Complement / Praise: *To acknowledge student contributions*
1e. Encourage: *When group or members are inactive*
1f. Conclude Socially

2. Precipitating Tension Release: *Jokes, laughs, shows satisfaction*
2a. Expression of feeling better: *After periods of tension, work pressure*
2b. Be cheerful
2c. Express enthusiasm, elation, satisfaction: *On completing significant task steps*

3. Agreeing: *Shows passive acceptance, understands, concurs, complies*
3a. Show attention: *To student ideas as encouragement*
3b. Show comprehension / approval: *To student opinions and orientations*

Prompt Variations Based on Martin and White's Engagement System

In Martin and White's (2005) specification of what counts as heteroglossic, three requirements must be met: First, some propositional content must be being asserted in some form, although it may be done in such a way as to communicate extreme uncertainty. All of the examples in Table 2 assert something, so they all meet this requirement. However, questions that are framed in such a way as the reader believes the speaker was asking an honest question, for which no specific answer seems to be presupposed do not count as heteroglossic. Rather than asserting something, questions request information. Interjections, like "Yay", that cannot be interpreted as ellipsis, and thus have no propositional content are not considered heteroglossic, however, fixed expressions like "no", and "yes" that implicitly assert the propositional content of the yes/no question they are a response to do count as expressing propositional content. For example, if someone asks "Can ease of use be increased by increasing the length of the wrench handle?" and if I say, "Yes.", then what I am asserting is "Ease of use can be increased by increasing the length of the wrench handle." The context makes it clear what I am asserting through ellipsis. Other forms of ellipsis (e.g., "titanium" in response to "Which type of metal would you choose?") and do-anaphora (i.e., "I did." In response to "Did you select a material for the wrench?") similarly also count as having propositional content.

Table 2: Examples of Heteroglossic and Monoglossic variations of the tutor's instructional turns.

Original/Neutral	*Think about how we can improve this?*
Heteroglossic	I suggest that you think about how to improve this
Monoglossic	Think about how to improve this

Original/Neutral	*Maybe we can use a safer material this time!*
Heteroglossic	Using a safer material would be strongly advisable!
Monoglossic	Use a safer material this time!

Original/Neutral	*We keep a factor of safety to avoid reaching yield stress.*
Heteroglossic	It would make sense to keep a factor of safety to avoid reaching yield stress.
Monoglossic	Keep a factor of safety to avoid reaching yield stress.

Second, an awareness must be made visible to the presence of alternative perspectives than that represented by the propositional content of an utterance. This distinction is illustrated through three examples that appear in Table 2. In each case we see a monoglossic and heteroglossic version for each of three propositions. In particular, bald claims, even if they are biased, do not acknowledge alternative perspectives. For example, "Titanium is the obviously superior choice" is undoubtedly subjective, but it is not heteroglossic. It doesn't show any awareness that someone else might disagree. If a speaker goes on, however, to give reasons to defend the statement, then that speaker is showing awareness of other perspectives. These cases will be caught by the third requirement, which is that in order to count as heteroglossic, the acknowledgement of other perspectives must be expressed grammatically (e.g., through a model auxiliary like "might") or paraphrastically (e.g., "I think") within the articulation of that propositional content. If it is implicit or signaled through the discourse structure, then that is not enough to count strictly as heteroglossic in the Martin and White sense, although they would acknowledge it as heteroglossic "in spirit".

The Engagement system begins with the distinction between heteroglossia and monoglossia, which we have just discussed. Once we have determined that an utterance counts as heteroglossic, we can then further subdivide it into utterances that Contract the positions or perspectives that are treated as viable within a conversation, or conversely, ones that Expand the scope of what is treated as viable. Either way, an acknowledgement is made that more than one way of looking at the world is at play. Utterances that contract that scope, such as making an absolute assertion that leaves no room for questioning, or out right rejecting a position, are typically seen as taking a more authoritative stance than ones that expand the options, such as making a suggestion. This notion of levels of authoritativeness is one important component of expressing the positioning of the speaker in relation to the propositional content. However, it also says something about where the speaker positions himself in relation to the audience. Taking an authoritative stance casts the other speaker into a less authoritative stance. Furthermore, when this system is again further subdivided, we see other options for positioning. For example, what is referred to as a Distancing move, in which the source of authority is ascribed to a third party, allows an authoritative statement to be made, which may contract options, but does not interfere with the positioning between the speaker and the audience. The speaker remains committed to the authoritative proposition, but is not responsible for it.

Implementation of Conversational Agents

The interaction between the students and tutor in the experiment presented in this paper is situated in a freshmen engineering course. In this course college students learn about basic mechanical engineering concepts like force, moment, stress, etc. The students interact with an automated tutor as part of a computer-aided design competition where the students are asked to design a better wrench with consideration to ease of use, safety and material cost. Students could interact with each other and the tutor using a text-based chat room that includes a shared whiteboard (Stahl, 2006; Kumar & Rosé, 2011).

Table 3: Excerpt of a tutor providing a lesson to a team of four students.

	Speaker	Contribution
64	Tutor	Intuitively, if you wanted to make the wrench easier to use, would you make it longer or shorter?
67	S5	Longer
70	Tutor	That's right. A longer wrench is better.
72	Tutor	Why is a longer wrench easier to use though! Let's look at the concept of Moment.
73	Tutor	When you use a wrench to turn a bolt, do you want a higher or lower moment?
74	S16	Higher

The task of the tutor is to provide lessons on the underlying theoretical concepts while the students work through a worksheet to explore various design choices. An excerpt of a lesson on the concept about the relationship between the length of a wrench and its ease of use is shown in Table 3 above. Besides performing its task related functions, the tutor also employs the social interaction strategies listed in Table 1. We have implemented this tutor using the Basilica architecture. Details about the inner workings of the Basilica architecture are described in a separate publication (Kumar & Rosé, 2011).

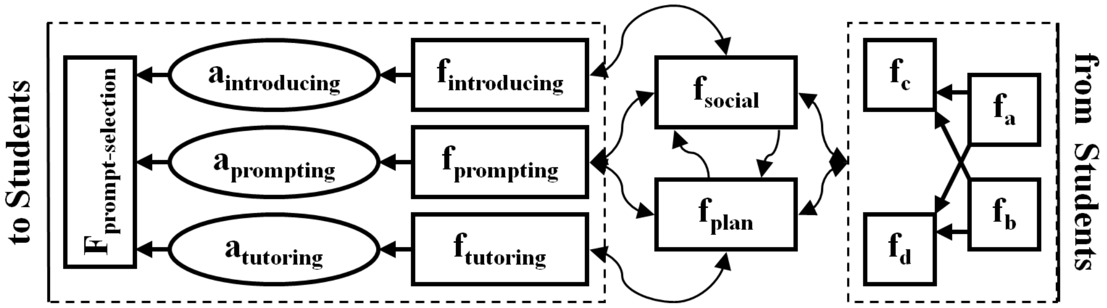

Figure 1. Basilica Component Network for Avis, the Freshmen Mechanical Engineering Tutor.

Using the Basilica architecture, conversational agents are modeled as a network of behavioral components. Each component implements a behavior that could be a combination of perception, thought and action. There are three types of components: actors (actuators / performers), filters (perceptors / annotators / coordinators) and memories. Each component can generate events carrying signals and data. Connected components can receive and process the events and generate further events. This architecture allows a developer to build agents by adding behavioral components incrementally. Since each component is only loosely coupled to a small number of other components, it provides the flexibility to easily change a single behavior. Also, it allows components to be reused between agent/tutor implementations for different tasks.

The tutor agent developed for the freshmen mechanical engineering learning domain is comprised of 22 Basilica components: four actors, sixteen filters and two memories. The tutor uses a gender neutral name Avis. Figure 1 below shows a simplified depiction of the component network of Avis. Actor components are shown as ovals and filter components are shown as rectangles. Arrows depict connections and possible directions of event flow.

Three of the actor and filter components correspond to three observable behaviors of the tutor, i.e., Introducing, Prompting/Hinting and Tutoring about concepts. Most of the other filters (depicted as f_a, f_b, f_c, f_d here) form a sub-network that processes student turns from the chatroom, as shown by filters f_a through f_d in Figure 1. This sub-network annotates turns with applicable semantic categories, accumulates them to identify inactive students and generates events that regulate the coordinators (f_{social} and f_{plan}).

The f_{plan} coordinator is responsible for executing the task-related interaction plan of the tutor. On the other hand, the f_{social} coordinator interleaves social prompts into the interaction. Before the prompts generated by the actor components are sent to the students, an appropriate variation of the prompt (*heteroglossic* / *monoglossic*) is selected by the prompt selection filter depending on the tutor's configuration.

Method

The rest of the paper describes the procedures and results from a controlled experiment we conducted to investigate the impact of the nature and style of feedback offered to students in an idea generation task.

Experimental Design

Our experimental design was a 2x3 between subjects factorial design. The first independent factor in our study manipulates whether social prompts motivated by Bales' IPA are inserted into the conversation. In the experimental condition (*Social*), students interacted with a tutor that was equipped with the eleven social interaction strategies, unlike the control condition (*Task*) which is our lower baseline condition. In both conditions, students would receive the same task related information (instructions / lessons / feedback) through the automated tutor. Based on the examples in Table 3 above, we notice that in the task condition, the tutor has features (like asking questions and giving feedback) that most common tutors do.

The second independent factor manipulates the form of the task related prompts presented by the tutor. In the first experimental condition (*Heteroglossic*), turns are presented in a Heteroglossic style. Approximately 90% of these were expressed in the Heteroglossic expand style, whereas about 10% were expressed in the Heteroglossic contract style. In the second experimental condition (*Monoglossic*), all task related prompts were authored in a Monoglossic style. In the Control condition (*Neutral*), employed as an ecological control, we used the same task prompts that were used in an earlier study (Kumar et al., 2010).

The time allotted for the interaction is the same for each group.

Procedure and Outcome Measures

We conducted a between-subjects experiment during a college freshmen computer-aided engineering lab project. 131 mechanical engineering students enrolled in the lab and participated in the experiment, which was held over six sessions spread evenly between two days. The two days of the experiment were separated by two weeks. Students were grouped into teams of three to four individuals. Each group communicated using a private chatroom (Stahl, 2006). No two members of the same group sat next to each other during the lab. The groups were evenly distributed between the six conditions in each session.

The procedure of the experiment comprised of 5 steps:

(1) Each session started with a follow along tutorial of computer-aided analysis where the students analyzed a wrench they had designed in a previous lab. Students spent about 25 minutes on the analysis.

(2) A pre-test with 11 questions (7 multiple choice questions and 4 brief explanation questions) was administered.

(3) The experimental manipulation happened during the Collaborative Design Competition after the pre-test. Students were asked to work as a team to design a better wrench taking three aspects into consideration: ease of use, material cost, and safety. Students were instructed to make three new designs and calculate success measures for each of the three aspects under consideration for their designs. They were also told that a tutor will help them with the first and the second designs so that they are well prepared to do the final design. No additional details about the tutor were given.

(4) After the students spent 35 minutes on the design competition, a post-test was administered.

(5) Following the test, student filled out a perception survey. The survey comprised of ten items to be rated on a seven point Likert-scale ranging from Strongly Disagree (1) to Strongly Agree (7). These questions

are shown in Table 4. Additionally, we asked students to check all of the following personality descriptors that they felt described the tutor agent: Encouraging, Inspiring, Assertive, Wishy Washy, Accommodating, Manipulative, Supportive, and Pushy.

Table 4: Items about Tutor and Learning Task rated by students on a 7-point Likert Scale.

Q1	The tutor provided very good ideas for the discussion.
Q2	I am happy with the discussion we had during the design challenge.
Q3	The tutor was part of my team.
Q4	The tutor was very cordial and friendly during the discussion.
Q5	The tutor received my ideas positively during the discussion.
Q6	The tutor helped keep tension low during the design activity.
Q7	The design challenge was exciting, and I did my best to come up with good designs.
Q8	Overall, I liked the tutor very much.
Q9	I think the tutor was as good as a human tutor.
Q10	Overall, I think we were successful at meeting the goals of the design challenge.

Results and Discussion

Idea Generation Productivity

In our analysis, the most important outcome factor is idea generation productivity. Idea generation productivity was estimated using an automatic measure developed in an earlier study using the same design task (Kumar et al., 2010). A dictionary was constructed using keywords from design ideas contributed in transcripts from the earlier studies. Counts of occurrences of words in this dictionary in the contributions of a student can serve as a rough estimate of idea generation productivity. Although this is a noisy measure, the effect of our experimental manipulation was strong enough to show significant differences between conditions. In order to identify the optimal design for feedback in an idea generation scenario from the standpoint of productivity, we used an ANOVA model with our estimate of idea generation productivity as the dependent variable. The two independent factors manipulated to determine the composition of feedback presented to students were each independent variables. We also included an interaction term that computes the interaction between the two independent factors in our design. There was no significant effect of the Social factor $F(1,125) = 0.0045$, $p = .97$. However there was a significant effect of the Heteroglossia manipulation $F(2,125) = 5.1$, $p < 0.01$, whereby the Heteroglossic condition was significantly higher than the Neutral condition (effect size 0.61 *s.d.*) and the Monoglossic condition (effect size 0.52 *s.d.*). Overall, this result confirms the hypothesis that a heteroglossic presentation style encourages more exploration and more productive idea generation.

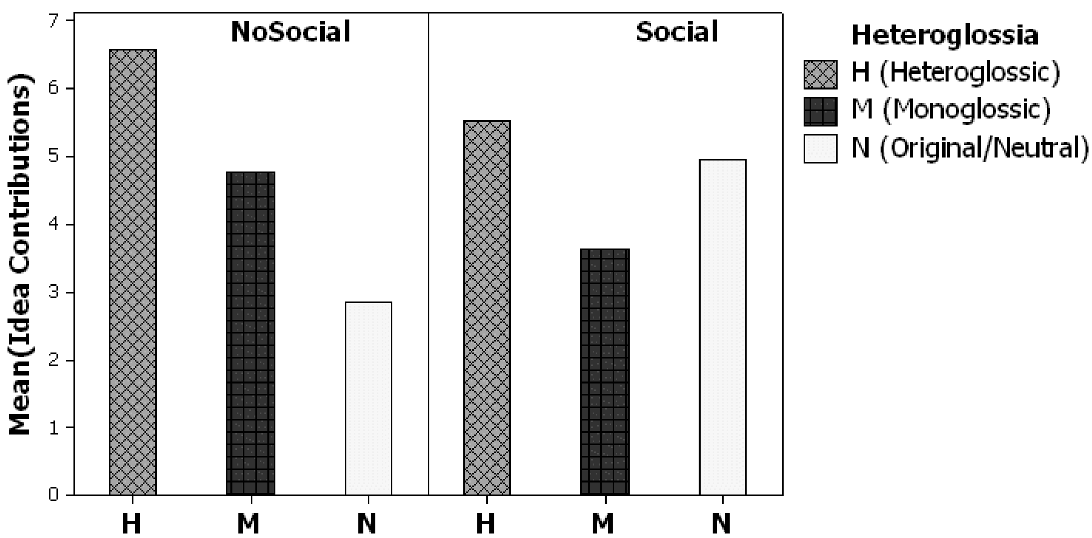

Figure 2. Interaction between the Social Manipulation and the Heteroglossia Manipulation on Idea Productivity.

There was a significant interaction effect (displayed in Figure 2) such that in the No Social condition, Heteroglossic is better than Neutral but not Monoglossic, and in the Social condition, Heteroglossic is better than Monoglossic, but not Neutral, $F(2,125) = 3.18$, $p < 0.05$. We find that the use of heteroglossic prompts could potentially compensate for the tutor's lack of social capabilities.

Learning Outcomes

There was no significant effect of either factor on learning, nor was there any significant interaction between factors on learning. Furthermore, whereas Wang and colleagues (2007) found a significant correlation between idea generation productivity and learning, we found no such relationship in our data. Wang and colleagues very carefully designed their preparatory reading materials, tests, and tasks in such a way that the act of generating an idea would provide opportunities for students to reflect on connections between facts presented in the reading materials and to generate bridging inferences akin to self-explanations (Chi et al., 1994). We believe this explains the difference in findings. In our task, learning occurs from deepening the understanding of principles through application. While we expect that factors that affect how deeply students reflect on the principles they are applying would have an effect on learning in our task, it is not necessarily the case that this level of engagement with the material corresponds to the number of design ideas students contribute to the discussion during the task. While we do not make any strong claims about learning and idea generation from our results, we believe this raises questions about the nature of the connection between learning and idea generation productivity, leading us to believe that the connection is complex and highly contextual.

Perception Ratings

On perceptual questionnaire, the Social manipulation had a relatively minimal effect. There were no significant main effects and no significant interactions between factors. There was a marginal effect of Social on Q5 such that students felt that the tutor received their ideas more positively in the Social condition, $F(1,125) = 3.55$, $p = 0.06$. Unfortunately, this is not necessarily a positive result since there was a negative correlation between the Q5 ratings and our idea productivity measure, $R = -0.34$, $p < 0.0001$.

The Heteroglossia manipulation had a larger effect. There was a significant effect of Heteroglossia on Q2, indicating that students in the Heteroglossia condition were significantly happier with the discussion than students in the Control condition, and the Monoglossic condition was not different from either, $F(2,125) = 3.65$, $p < 0.05$. There was also a significant effect of Heteroglossia on Q8, indicating that students like the Heteroglossic and Monoglossic tutor agents more than the agent in the Control condition, $F(2,125) = 3.48$, $p < 0.05$. There were also two marginal effects. First, students felt that the tutor agent was as good as a human tutor marginally more often in the Heteroglossic condition than the Control condition, with the Monoglossic agent not being different from either, $F(2,125) = 2.6$, $p = 0.08$. Similar to Q5, this was found to have a significant negative correlation with our idea productivity measure as well, $R = -0.22$, $p = 0.01$. Also, there was a marginal effect of Heteroglossia on Q10 such that students in the Heteroglossic condition felt that they were more successful than students in the Monoglossic condition, with students in the Control condition not being different from either, $F(2,125) = 2.84$, $p = 0.06$. There was no correlation between idea generation success and this perception of success.

Overall, these are relatively weak effects, although they do demonstrate some preference for the Heteroglossic style of presentation. However, when we evaluated the effect of condition on personality indicators using binary logistic regressions, the story became a little more complex. There were only significant effects of the Social manipulation such that the Social condition rated the tutor agent more Supportive and less Pushy than the Control condition. There was no effect of the Heteroglossic manipulation. Thus, we see that the Social manipulation had more of an effect on the perception of the tutor agent's personality whereas the Heteroglossia manipulation had more of an effect on how the students felt about working with the agent and how successful they were in their task. Since we do not see significant interactions between factors, we can conclude that we can achieve the best of both by combining the Heteroglossic style with the added social strategies of the Social condition.

Conclusion

First and foremost, the study presented in this paper shows that conversational tutors used in collaborative learning scenarios can be improved significantly by making them socially capable while keeping the task (tutoring) related behavior the same. In this study, we investigated social strategies from two angles. The first angle was to insert additional socially focused prompts over and above task related prompts. The effect of this addition was to make the tutor agent appear more supportive and less pushy. The second angle was to explore the style of presentation of task related prompts using the Martin and White (2005) Heteroglossia framework. Here we see an advantage in terms of supporting idea generation productivity in addition to eliciting more liking of the tutor agent and more satisfaction with the task.

In our future work we will continue to explore additional stylistic dimensions of tutor feedback and their associated effect on the student experiences in collaborative contexts, including their own social positioning within their groups, their effective participation within those groups, and ultimately their learning. In particular, we have discussed how the construct of heteroglossia introduces the notion that the voice of the speaker is situated among other voices. But beyond that acknowledgement of the existence of other voices, what we do not see in this simple binary distinction is the manner of that positioning. The details of that positioning are further specified within Martin and White's Appraisal framework (Martin & White, 2005), which includes Attitude, in which feelings are revealed towards propositional content, Graduation, in which feelings are either magnified or downlplayed, and Engagement, in which a speaker positions herself in relation to the propositional content of the utterance, positions the audience in relation to the propositional content, and positions herself in relation to the audience (Martin & White, 2005). The observed effects of the Heteroglossia manipulation in this study demonstrate how productive it may be to explore how constructs from sociolinguistics might inspire the design of more effective support for social interactions in computer supported collaborative learning.

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