Experimental Evaluation of Polite Interaction Tactics for Pedagogical Agents

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ABSTRACT
Recent research shows that instructors commonly use politeness strategies to achieve affective scaffolding in educational contexts. The importance of affective factors such as self-confidence and interest that contribute to learner motivation is well recognized. In this paper, we describe the results of a Wizard-of-Oz experiment to study the effect of politeness strategies on both cognitive and motivational factors. We compare the results of two different politeness strategies, direct and polite, in assisting seventeen students in a computer-based learning task. We find that politeness can affect students' motivational state and help students learn difficult concepts. The results of the experiment provide a basis for the design of a polite pedagogical agent and its tutorial intervention strategies.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *evaluation/methodology, graphical user interfaces, prototyping, theory and methods, training, help and documentation.*

General Terms
Design, Experimentation, Human Factors

Keywords
Politeness, affective interfaces, pedagogical agents, user evaluation, proactive and agent-based paradigm

1. INTRODUCTION
Historically speaking, intelligent tutoring systems (ITSs) have focused on attending to students' cognitive needs — suggesting actions to perform, correcting mistakes, and explaining concepts— and have tended to ignore students' affective states such as self-confidence and interest. ITSs that do not attend to student motivational states can inadvertently undermine them, for instance when the system says "Your answer is wrong" (affecting learner self-confidence), or "Now execute this action" (affecting learner initiative). However, educational researchers increasingly recognize the importance of affective factors and their contribution to learner intrinsic motivation [22] and hence to learning outcomes.

The present study is based on the idea that the student affective goals can be taken into account by implementing a model of politeness into a tutoring system. A polite tutor would respect the student's need to be in control, by suggesting rather than imposing actions; it would reinforce the student's self-confidence, by emphasizing his successful performances, or by suggesting that he and the tutor are solving the problems together; it would make the student more comfortable and motivated towards the learning task, by trying to build up a positive relationship, or rapport, with him; and it would stimulate the student interest, by unobtrusively highlighting open and unresolved issues.

This paper describes the way in which politeness theory, based on the work of Brown and Levinson [4], has been implemented in an intelligent tutoring system incorporating an animated pedagogical agent. The work is part of a larger project building a socially intelligent pedagogical agent able to monitor learner performance and provide socially sensitive coaching and feedback at appropriate times [11]. Animated pedagogical agents can produce a positive affective response on the part of the learner, sometimes referred to as the persona effect [16]. This is attributed to the natural tendency for people to relate to computers as social actors [21], a tendency that animated agents exploit. Regarding politeness, the social actor hypothesis leads us to expect that humans not only respond to social cues, but also that they behave politely toward the agents.

Real tutors, instructors, and designers of computer games recognize the importance of affective strategies to student motivation, and the recognition of the importance of affect and motivation on learning has led increasingly to the development of socially-aware pedagogical agents as reflected in the work of del Soldato et al. [8] and de Vicente [7]. Heylen et al. [10] highlight the importance of these factors in tutors, and examine the interpersonal factors that should be taken into account when creating socially intelligent computer tutors. Cooper [6] has

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shown that profound empathy in teaching relationships is important because it stimulates positive emotions and interactions that favor learning. Baylor [3] has conducted experiments in which learners interact with multiple pedagogical agents, one of which seeks to motivate the learner. User interface and agent researchers are also beginning to apply the Brown & Levinson model to human-computer interaction in other contexts [5, 17]; see also André's work in this area [2].

Porayska-Pomsta [18] has also been using the Brown & Levinson model to analyze teacher communications in classroom settings. Although there are similarities between her approach and the approach described here, her model makes relatively less use of face threat mitigating strategies. This may be due to the differences in the social contexts being modeled: one-on-one coaching and advice giving is likely to result in a greater degree of attention to face work.

Other researchers such as Kort et al. [1, 14], and Zhou and Conati [24] have been addressing the problem of detecting learner affect and motivation, and influencing it. Comparisons with this work are complicated by differences in terminology regarding affect and emotion. We adhere to the terminological usage of Lazarus [15], who considers all emotions to be appraisal-based, and distinguish emotions from other states and attitudes that may engender emotions in specific contexts. In this sense our focus is not on emotions per se, but on states (i.e., motivation, face wants) that can engender emotions in particular contexts (e.g., frustration, embarrassment). Although nonverbal emotional displays were not prominent in the tutorial dialogs described in this paper, they do arise in tutorial dialogs that we have studied in other domains, and we plan in our future work to incorporate them into our model.

2. THE POLITENESS THEORY OF BROWN & LEVINSON

Brown and Levinson [4] have devised a cross-cultural theory of politeness, according to which everybody has a positive and negative "face". Negative face is the want to be unimpeded by others (autonomy), while positive face is the want to be desirable to others (approval). Some communicative acts, such as requests and offers, can threaten the hearer's negative face, positive face, or both, and therefore are referred to as Face Threatening Acts (FTAs). Consider a critique of the learner such as "You didn't save your factory. Save it now." This is an example of what Brown and Levinson term a *bald on record* FTA; there is no attempt to use politeness to mitigate the face threat. There are two types of face threat in this example: the criticism of the learner's action is a threat to positive face, and the instruction of what to do is a threat to negative face.

Speakers use various politeness strategies to mitigate face threats, according to the severity, or "weightiness", of the FTA. The assessment is based on three sociological factors: 1) the "social distance" between speaker and hearer, 2) the "relative power" of hearer and speaker and 3) the "absolute ranking of impositions", that is, the severity that each face threat is considered to impose, according to cultural norms.

A speaker may choose simply to avoid the face threatening act altogether if the cost of making the threat is greater than the potential benefit. In the above case ("You didn't save your factory. Save it now."), the tutor could omit the criticism of the learner and focus on the suggested action, i.e., to save the factory. Alternatively the tutor could perform the face-threatening act *off record*, i.e., so as to avoid assigning responsibility to the hearer. An example of this would be "The factory parameters need saving." The face threat of the instruction can be mitigated using negative politeness tactics, i.e., phrasing that gives the hearer the option of not following the advice, e.g., "Do you want to save the factory now?" Positive politeness strategies can also be employed that emphasizes common ground and cooperation between the tutor and learner, e.g., "How about if we save our factory now?" Other positive politeness strategies include overt expressions of approval, such as "That is very good".

Tutorial interactions occur in a social context, and therefore are subject to politeness theory. In their study modeling cognitive and affective scaffolding, Porayska-Pomsta and Pain [19] observe that teachers employ linguistic indirectness so as not to threaten a student's face, and that a teacher's corrective feedback can be interpreted in terms of both content and illocutionary specificity. To more precisely explain the notion of face in educational circumstances, they extend the definitions of *autonomy* to include the level of content specificity appropriate to accommodate the student's cognitive needs, and *approval* to include the level of illocutionary specificity appropriate to accommodate the student's affective needs. In other words, less information means more autonomy, and more references to achievement means more approval.

3. POLITENESS AND STUDENT MOTIVATION

To investigate the role that politeness plays in learner-tutor interaction, we videotaped interactions between learners and an expert human tutor while the students were working with the Virtual Factory Teaching System (VFTS) [9], a web-based learning environment for factory modeling and simulation. When the expert tutor offered advice he phrased the comments so as to subtly engage the learner's interest and motivation, while leaving the learner the choice of what to do and how. Learners tend to learn better and more deeply if they are motivated by an internal interest and desire to master the material, as opposed to extrinsic rewards and punishments such as grades. Researchers in motivation have identified a number of factors as conducive to intrinsic motivation, including the following: curiosity in the subject matter, optimal level of challenge, confidence and sense of control.

The expert tutor's comments tended to be phrased in such a way as to have an indirect effect on these motivational factors, e.g., phrasing a hint as a question reinforces the learner's sense of control, since the learner can choose whether or not to answer the question affirmatively. Also, the tutor's comments often reinforced the learner's sense of being an active participant in the problem solving process, e.g., by phrasing suggestions as activities to be performed jointly by the tutor and the learner.

Although politeness theory and motivation theory come out of distinct literatures, their predictions regarding the choice of tutorial interaction tactics are broadly consistent. This is not surprising, since the wants described by politeness theory have a clear motivational aspect; negative face corresponds to control,

and positive face corresponds somewhat to confidence in educational settings. Therefore, we are led to think that tutors may use politeness strategies not only for minimizing the weightiness of face threatening acts, but also for indirectly supporting the student's motivation. For instance, the tutor may use positive politeness for promoting the student positive face (e.g. his desire for successful learning), and negative politeness for supporting the student negative face (e.g. his desire for autonomous learning).

4. A MODEL OF POLITENESS FOR TUTORING DIALOGS

In order to apply the theory by Brown and Levinson to the context of interactions in ITSs, we have realized a computational model of politeness in tutorial dialog. Our hypothesis is that politeness theory can apply to human-computer tutorial interaction as well as human-human tutorial interaction.

In this model, positive and negative politeness values are assigned beforehand to each natural language template that may be used by the tutor. Such values measure the degree to which a template redresses the student's face. We also assign positive and negative politeness value to the tutor, i.e. the degree to which we want the tutor to address the student's positive and negative face. During each communicative act, the template with the politeness values that is closest to the tutor politeness values will be selected and used to product an utterance.

Based on transcript of the interaction between learners of the VFTS and the expert human tutor, we grouped the tutor's politeness strategies into eight categories, as shown in Table 1:

Table 1. Categorization of politeness strategies in tutoring interactions

Politeness Strategies	Example sentences
Joint goal	We should set the planning methodology.
Question	Did you set the planning methodology?
Bald on record	Now set the planning methodology.
Tutor Goal	I would set the planning methodology.
Conventional Indirectness	The machine wants you to set the planning methodology.
Request	I suggest that you set the planning methodology.
Student goal	You could set the planning methodology.
Socratic hint	What about the planning methodology?

We implemented a natural language generator in to produce appropriate interaction tactics [13]. The generator takes as input a set of language elements, or – short noun and verb phrases in the target domain, chooses an utterance pattern, and then passes the generated utterance to the virtual tutor. A text-to-speech synthesis "speaks" the utterance to the student. The utterance patterns and language elements are specified in XML.

There are 7 different types of utterances in our model: suggest action, explain concept, explain tutorial, feedback, Socratic hint, explain interface operation, explain interface object. For each utterance type, a set of politeness strategies is available, ordered by the amount of face threat mitigation they offer. Each strategy is in turn described as a set of dialog moves. A politeness module selects an appropriate face threat mitigation strategy to apply to each utterance. The combined dialog generator takes the desired utterance type, language elements, and a set of parameters governing face threat mitigation (social distance, social power, and motivational support) as input and generates an utterance with the appropriate degree of face threat redress. Using this framework, our tutor can generate comments about the same topic with different degrees of politeness. For example, a suggestion to save the current factory description, can be stated either bald on record (e.g., "Save the factory now"), as a hint, ("Do you want to save the factory now?"), as a suggestion of what the tutor would do ("I would save the factory now"), or as a suggestion of a joint action ("Why don't we save our factory now?").

To set the positive and negative politeness values of NL templates, we gave a questionnaire to 47 subjects from University of California Santa Barbara and asked them to assign positive and negative politeness values to example sentences. Each sentence was representative of a given politeness category, and was used in the context of an interaction between student and tutor. The politeness values could range from 1 (very impolite) to 7 (very polite). The data collected from the questionnaire, as we expected, showed that the NL templates from different politeness categories have different average negative and politeness values, and can therefore be organized according to those values.

5. A WIZARD-OF-OZ SYSTEM FOR GENERATING AND EVALUATING POLITE TUTOR INTERVENTIONS

To evaluate the intervention tactics, we created a Wizard-of-Oz experiment system. The student's interface is shown in Figure 1. The Virtual Factory Teaching System (VFTS) [9] is displayed on the left. The VFTS is a web-based factory modeling and simulation system developed for industrial systems engineering students for a product inventory and management class. Students model factories by specifying properties of machines and

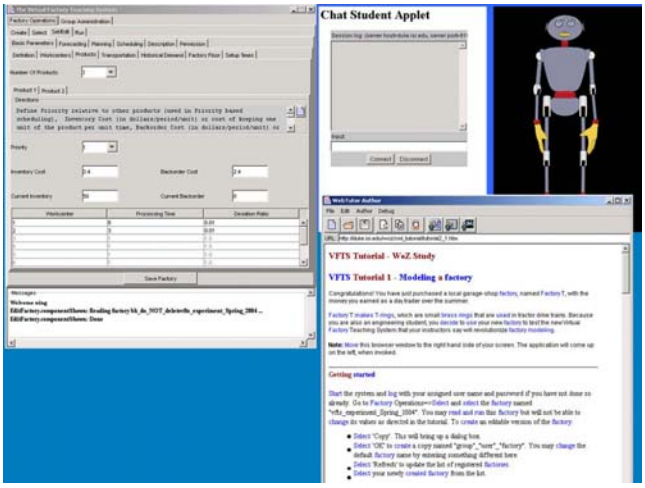

Figure 1. Student's screen during the Wizard-of-Oz experiment.

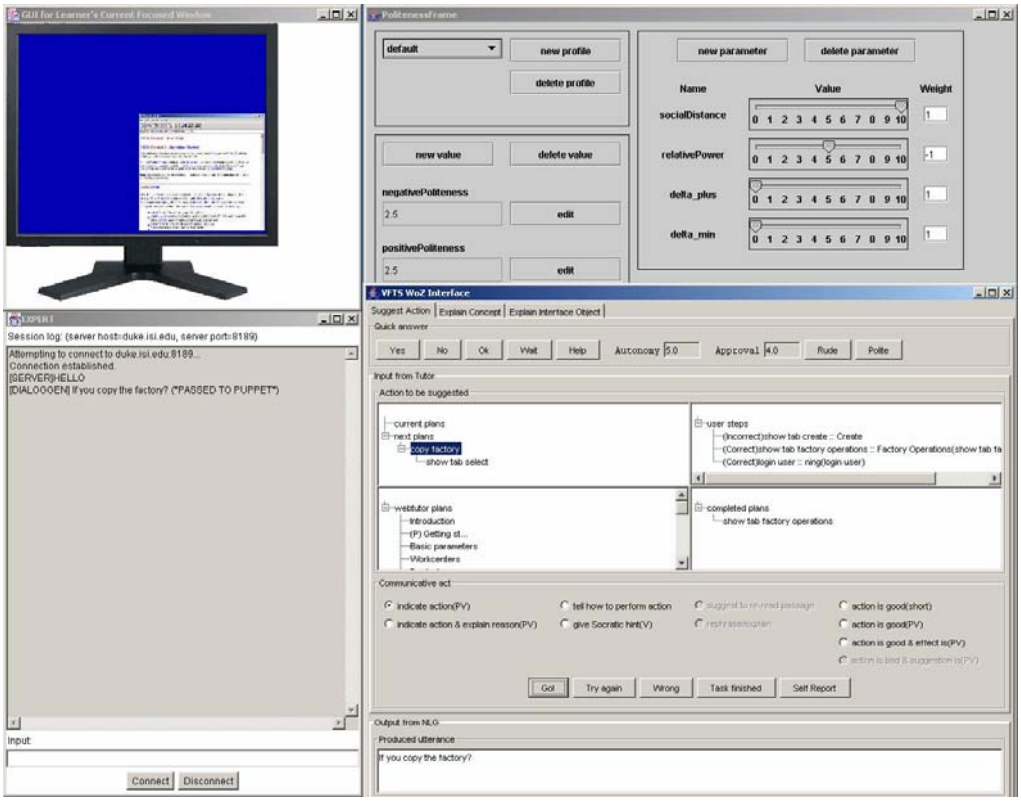

Figure 2. The tutor's screen during the Wizard-of-Oz experiment: The learner's focus of attention, is shown on the top left, tutor's communication interface is shown on the bottom right.

products, forecasting product demand, planning product release, and simulating product production for their factory.

At the top right of the interface is the *Agent Window*, which contains a chat window for communicating with the agent (or human tutor during the Wizard-of-Oz experiment) and an animated character that generates speech and gestures. On the bottom right is a browser containing the tutorial. Students follow the tutorial on the VFTS using a browser that supports inline questioning, with all questions directed to the Wizard-of-Oz tutor. The tutorial teaches the concepts and skills needed to understand and use the VFTS.

All student keyboard and mouse input are sent back to the server for the Plan Recognizer to analyze [20]. The Plan Recognizer compares the student's action with the expected action, categorizes the action as 1) progress toward the goal, 2) an error or inappropriate actions, 3) a step performed in wrong order, and indicates what the next step should be.

A web camera is placed on top of the monitor to track learner's gaze. This, combined with keyboard and mouse information, is used by Focus of Attention model to infer learner's focus window [20]. This interface thus provides information that is similar to the information that human tutors use in tracking learner activities.

Figure 2 shows the Wizard-of-Oz interface. This semi-automated interface enables a human tutor to select tactics and use the politeness model to generate the tutorial dialog for those tactics. The main panel, with its four student activity windows, is on the lower right hand side. The windows display the student's 1) *completed plans* (a group of actions that together achieve a specific goal), 2) *current action*, and 3) the *inferred next plan* from the VFTS Plan Recognizer. A fourth window displays the paragraph of the tutorial that is currently visible.

To communicate with the student, the tutor selects an item in the student activity window (e.g., "copy_factory") then chooses from among a set of communicative acts associated with the current pedagogical goal (e.g., "indicate action & explain reason" or "tell how to perform action") and generates an intervention. The intervention is sent to the Agent Window on the student interface. An animation engine [23] produces the gestures and a text-to-speech synthesizer synthesizes speech from the text.

The window at the top right is the interface for setting the parameters of the politeness model. The parameters are initialized at the beginning of a tutorial session and are modified infrequently if at all. The window at the top left shows which area of the screen the learner is focusing on, inferred by the Focus of Attention model [20]. This enables the tutor to tell whether the learner is currently reading the tutorial, working on the VFTS or reading/typing in Agent Window.

6. EXPERIMENTAL METHOD

To assess the effectiveness of the WoZ setup for evaluating interaction tactics on politeness, we first conducted a pilot study of the system. Our experiment protocol consisted of the following steps:

1) Students completed a Background questionnaire which collects information about gender, age, engineering background and familiarity with factory management, etc.

2) Students completed a Personality questionnaire which measured four traits of the students' personality: self-esteem, need for cognition, extroversion and optimism.

3) Students sat down in front of the experiment computer. There were two speakers on each side of the monitor. One camera was placed on top of the monitor to track learners' gaze. Another camcorder was placed behind the monitor to record the learner's face.

4) Students read an explanation of the windows showing on the computer screen. During this time, the experimenter adjusted the cameras if necessary.

5) When students were ready, the experimenter left the room.

6) Students followed the tutorial (learning material) on the screen, performed actions in the VFTS and asked/received help from the tutor through the Agent Window. The tutor was in another room using a two-monitor computer to assist student. One monitor displayed the Wizard-of-Oz tutor interface, shown in Figure 2, and the other displayed the student's screen, shown in Figure 1.

7) After students finished, they left the experiment computer.

8) Students completed a Tutor and Motivation questionnaire that assesses learner attitudes toward the tutor, motivation-related factors.

9) Student completed a Learning Outcomes questionnaire that assesses learner ability to solve problems on the VFTS.

The tutorial used in the pilot study consisted of a task to help the student get familiar with the basic concepts of inventory management and VFTS interface. It included explanations of these concepts as well as specific instructions on how to perform forecasting and planning tasks using the VFTS.

Five local students participated in the pilot study. They were randomly assigned to either a *Polite* treatment or a *Direct* treatment. In the Polite treatment, positive and negative politeness values varied randomly in a moderate to high range, causing the tutor to use politeness in a variety of ways both in giving hints and in providing feedback. In the Direct treatment, positive and negative politeness values were fixed at minimum values, forcing the tutor to communicate directly and not allowing for the migration of face threat. In all other respects the two treatments were identical. Although politeness can manifest itself in other ways, e.g., through small talk [5], we did not vary the amount of small talk in the two treatments, since that would have also changed the frequency of interaction between the tutor and the students in the two groups, and would have made it more difficult to assess the cause of any differences between the treatments.

Results of pilot study showed that students in both groups found the task presented in the tutorial easy. By relying on the tutorial instructions alone, students could perform the task without difficulties in about 30 minutes and tutor intervention seemed to be generally unnecessary. (This was not the case with the initial study [12], perhaps because, unlike in the initial study, these five students all studied or worked in an engineering discipline.) To increase the likelihood that a student ask the tutor for help and increase the number of student-tutor interactions necessary for assessing the politeness model, we added a second part to the tutorial that asks students to apply what they learn in the first section to solve two new problems with minimal instructions.

The next phase of the experiment used the extended tutorial. Eleven students participated. Again, all the students were males who studied or worked in an engineering discipline. Again, half of the students were assigned a Polite treatment, and half were assigned a Direct treatment. Due to the small sample size, the results should be considered tentative.

7. EXPERIMENTAL RESULTS

We grouped data from second phase by treatment groups. For each group, we calculated the average score of the Learning Outcomes questionnaires. We also calculated averages for each question on the Tutor and Motivation questionnaire. We applied a Student's ttest and a Wilcoxon Mann-Whitney test to analysis the data, but neither of the tests is suited for our sample size (table 2).

Table 2

Results of Student's ttest and Wilcoxon Mann-Whitney test between Polite and Direct group		
	Student's ttest (p)	Wilcoxon Mann-Whitney test (p)
6	0.135620749	0.3258
8	0.016338962	0.0177
11	0.123883845	0.1901
18	0.014445066	0.0118
24	0.382970408	0.7364
26	0.036322146	0.0766
27	0.5	0.8277

We decided to focus on those questions for which the students' answers differed substantially between the two groups. These questions are listed in Table 3; the first column indicates the number of the each question in the questionnaire. We discuss these results next.

Table 3

Post-Questionnaire Questions with Differing Group Results	
6	I felt like the tutor was making decisions for me at each step.
8	The tutor made it easier for me to follow each step.
11	The tutor unnecessarily intervened when I didn't need any help.
18	The tutor praised me when I did something right.
24	I thought the tutor was friendly.
26	I think my performance improved as the tutorial progressed.
27	I think my interest increased as the tutorial progressed.

7.1 Socio-Affective Results

With respect to the students' evaluation of the tutor, we find four main differences (see Figure 3). Students in the polite treatment said the tutor praised them when they performed a correct action

(Question 18). This is not surprising because this is one of the tactics used by the Polite tutor. Students in the Polite treatment also agree that the tutor made it easy for them to follow each step (Question 8). Students tended to disagree in general that tutor was making decisions for them (Question 6), but the level of agreement is much lower in the polite group. Students in the direct treatment felt that the tutor unnecessarily intervened when they didn't need any help (Question 11).

These differences show that polite tactics can influence students' perception of difficulty of the learning material and make tutor offers of help seem less intrusive.

Regarding the students' evaluation of their motivational states, we find one real difference (see Figure 4). Both students' interests (Question 27) and self-efficacy (Question 26) in factory managements increase only a small amount for both groups. But in the polite treatment, students' self-efficacy improves significantly compared to students from direct group.

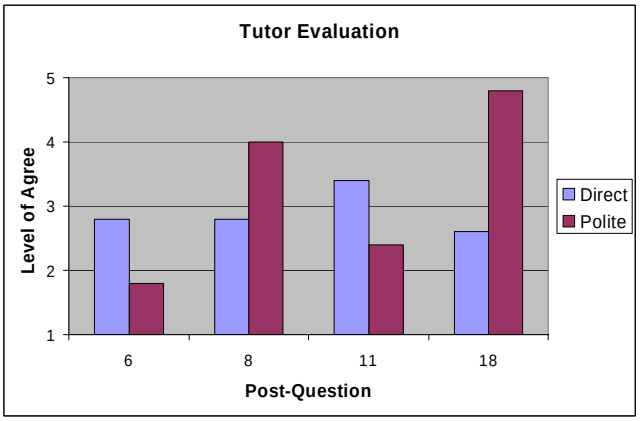

Figure 3. Students' evaluation of tutor from post-questionnaire (see Table 3 for Post-Questions).

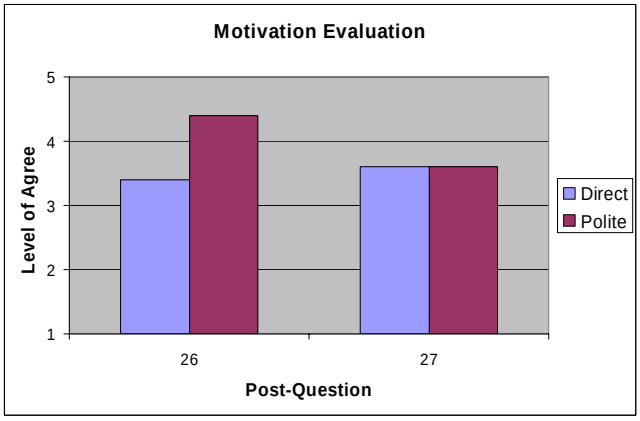

Figure 4. Students' self-evaluation of motivation from post-questionnaire (see Table 3 for Post-Questions).

7.2 Cognitive Results

With respect to learning outcome, students in the polite treatment scored a little higher than students in the direct treatment. When we break down the learning questions based on their difficulty, students score the same on the easy questions, but students in the polite group score 10% higher than those in the direct group (Figure 5).

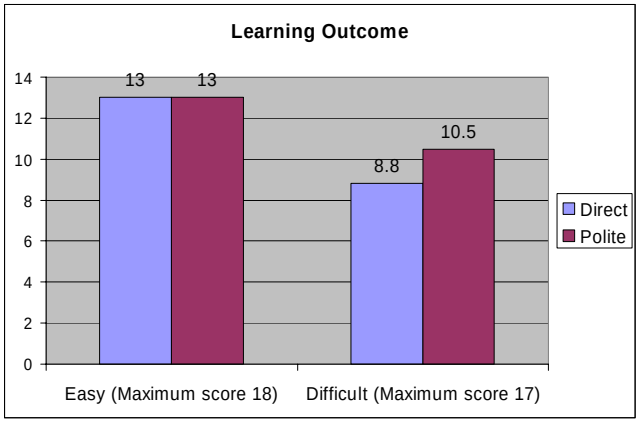

Figure 5: Students' learning outcome from post-questionnaire.

7.3 Personality and Politeness

In the Background questionnaire, we collected information about the students' preferred learning styles, and in the Personality questionnaire we measured four personality traits - self-esteem, need for cognition, extroversion and optimism. Our hypothesis is that there is a high correlation between 1) extroversion and a preference to work alone or collaboratively, 2) self-esteem and a student's perception of control, 3) the need for cognition and intrinsic motivation. Though our sample did not vary much on the three of the traits, we found a good variation for extroversion. Figure 6 shows that six subjects scored above 3.5 and five scored below, forming two groups of students: a high extrovert group and a low extrovert group. Student scores for Learning Preferences confirm that low extrovert students prefer to work alone more often than high extrovert students. We also notice that high extrovert students tend to agree that the tutor was friendly (Question 24) and that their performances improve as the tutorial progresses (Question 26), when interacting with a polite tutor. (See figure 7.) These students also seem to disagree that a polite tutor is making decisions for them (Question 6).

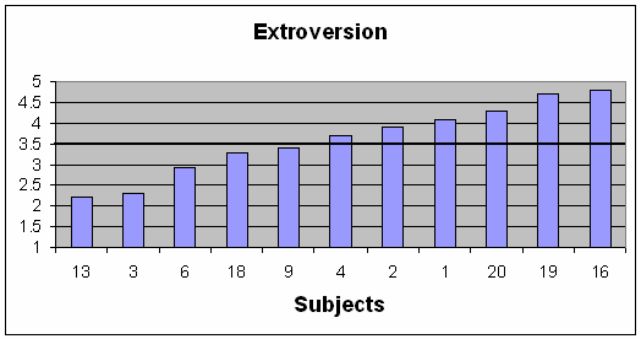

Figure 6: Students' score on extroversion from personality pre-questionnaire.

Students who scored low on the extroversion trait also rated the polite and rude tutor differently in terms of friendliness and autonomy (See figure 8). These ratings follow the trend of all students in the polite and direct condition on autonomy. Students think that the polite tutor made it easier for them to follow at each

step (Question 8) and the direct tutor intervened unnecessarily (Question 11). But surprisingly, students rated the direct tutor friendlier than polite tutor (Question 24).

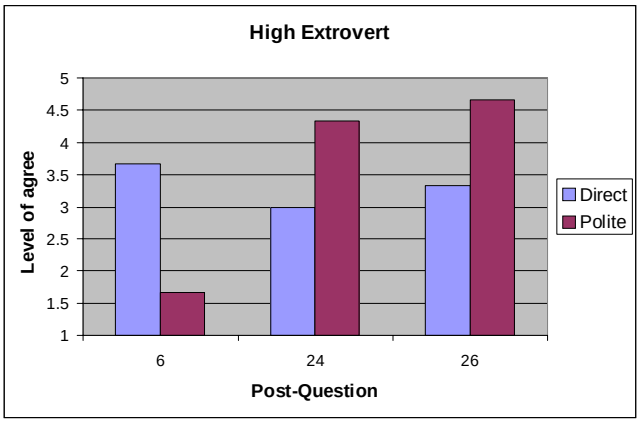

Figure 7: Tutor and motivation evaluation from students score high on extroversion (see Table 3 for Post-Questions).

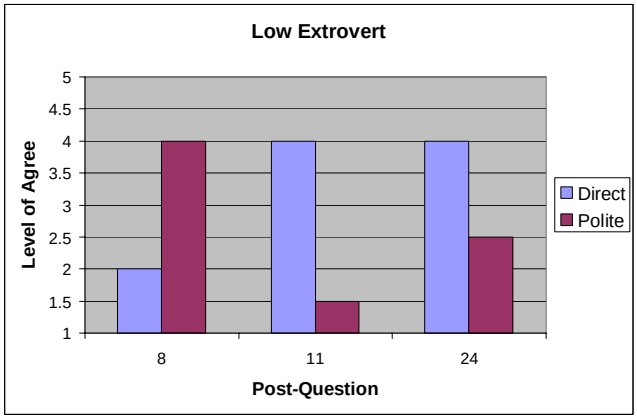

Figure 8: Tutor and motivation evaluation from students score low on extroversion (see Table 3 for Post-Questions).

7.4 Pre/Post Questionnaire Correlation Analysis

We ran a correlation test between the pre-study and post-study questionnaires to understand the relations among the students' various evaluations. The test is done by pairing questions from the pre-study and post-study questionnaires. The numbers within the brackets are the correlation coefficients.

- [.80] Students who reported the tutor helped them identify their mistakes feel more confident about their ability to complete a problem on the VFTS than before.
- [.88] Students who reported the tutor worked with them towards a common goal like the tutor more.
- [.85] Students who reported the tutor praised them when they did something right more tended to agree that the tutor made it easier for them to follow each step. This also confirms our finding that positive feedback can increase students' self-efficacy and help them follow learning materials.
- [.88] The more students felt that they had freedom in making decisions at each step, the less they thought the tutor was critical to their performance.
- [.80] When the students thought their interest increased while the task progressed, they also thought the tutor was critical of their performance.
- [.80] When students felt like they had to follow the instructions of the tutor, they also thought the tutor helped them make correct decisions in selecting methods. This could be explained in situations when tutor persistently asking students to correct a mistake or complete a missed step that would affect results on later tasks.
- [.88] Students who scored higher on the Learning Outcomes questionnaire were less likely to report that their "relationship" with the tutor grew as the task progressed. This is interesting because the less students feel that they rely on the tutor, the better they appear to learn.

A week after the experiment, we carried out an interview with five of the subjects. Four of them received the polite treatment and one received the direct treatment. During the interview, the students were asked questions about the tutor and whether there was anything that might have affected their evaluation of the tutor. All of the students believed that they were working with a software agent, not a human tutor. Most students found the tutor to be very helpful. In terms of possible bias of perception, some students considered the tutor as a software entity without human feelings, thus the tutor couldn't "be friendly" or "like him". Some students thought they would be more willing to work with a tutor with a natural (i.e., not synthesized) voice. Some students were hesitant to interact with the agent because of their concerns about the natural language understanding ability of the agent. In this case, adding small talk at the beginning of a session might encourage a student to interact with the tutor more. But this might also decrease the social distance between the student and tutor and affect other results.

8. DISCUSSION

From the data we collected in this study, we argue that politeness can make a difference in a learning experience and should be considered as a factor when building socially intelligent pedagogical agents. We are aware of the fact that the analysis is based on a small sample of data. Our subjects were all males with high self-esteem and relatively little interest in factory management, who all work or study in engineering field. This might account for the fact that these students didn't consider the direct tutor too unfriendly.

9. FUTURE WORK AND CONCLUSION

In this paper, we have discussed the politeness model as part of an interaction tactics for pedagogical agents and have evaluated the model. The results presented show that politeness can influence a student's learning experience. For example, giving student positive feedback about their achievement can help student follow the learning material. Being polite can help student learn difficult concepts and increase their self-efficacy. Being direct could sometimes be considered intrusive to the students. These results have bearing not just on pedagogical applications, but also on

other user interfaces that provide users with help and feedback on their actions. We have few data to conclude on the influence of personality on the interpretation of politeness. Our data show some of the trends that we predicted and we will conduct further experiments at University of California, Santa Barbara to test their statistical significance.

10. ACKNOWLEDGMENTS

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