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A politeness effect in learning with web-based intelligent tutors

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Abstract

College students learned to solve chemistry stoichiometry problems with a web-based intelligent tutor that provided hints and feedback, using either polite or direct language. There was a pattern in which students with low prior knowledge of chemistry performed better on subsequent problem-solving tests if they learned from the polite tutor rather than the direct tutor ($d=.78$ on an immediate test, $d=.51$ on a delayed test), whereas students with high prior knowledge showed the reverse trend ($d=-.47$ for an immediate test; $d=-.13$ for a delayed test). These results point to a boundary condition for the *politeness principle*—the idea that people learn more deeply when words are in polite style. At least for low-knowledge learners, the results are consistent with *social agency theory*—the idea that social cues, such as politeness, can prime learners to accept a web-based tutor as a social partner and therefore try harder to make sense of the tutor's messages.

Keywords: Intelligent tutoring system; Politeness; Learning

1. Introduction

Intelligent tutoring systems (ITSs) are computer-based instructional systems that seek to provide one-on-one tutoring to students based on the science of learning and artificial intelligence techniques (Anderson et al., 1995; Koedinger and Corbett, 2006; VanLehn, 2006; Mitrovic et al., 2008). Intelligent tutors work by placing students in a problem-solving situation and providing needed guidance based on their performance. Students can ask for hints when they need them and error messages are provided to indicate incorrect answers or problem-solving steps to students. With intelligent tutors, students engage in ''learning by doing, an essential aspect of human tutoring'' (Koedinger and Corbett, 2006, p. 62). ITSs have demonstrated impressive improvement in student learning in a range of domains and with different techniques (cf. Koedinger et al., 1997; VanLehn et al., 2005; Mostow and Beck, 2007). In addition, with the advancements of computer software and hardware, as well as widespread use of the world-wide web and the deployment of intelligent tutors on the web, we can now can provide many more students with economical one-on-one tutoring, something that was previously not possible (Koedinger and Corbett, 2006).

In light of advances in the development of intelligent tutors based on principles from the learning sciences, an important next step is to develop research-based instructional design principles that prescribe effective ways to promote deep learning with such software tutors. For example, the most widely used of intelligent tutors, cognitive tutors, are based on six instructional design principles, such as using immediate feedback and minimizing cognitive load (Anderson et al., 1995; Koedinger and Corbett, 2006). Yet these instructional design principles do not include how best to incorporate *social cues*, which may be an essential element in student–tutor interactions (Person et al., 1995).

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1.1. Objective

The goal of the present study is to determine how to improve the instructional effectiveness of a web-based intelligent tutor by focusing on the tutor's conversational style. In particular, our goal is to examine the cognitive consequences of incorporating potentially important social cues in the conversation provided by the tutor—using polite rather than direct wording of feedback and hints. This study is an example of the *value-added* approach to instructional design research, in which the goal is to determine whether a particular instructional feature—such as changing from direct to polite conversational style—affects learning outcomes. More generally, our goal is to determine which instructional features are helpful for which kinds of learners and on which kinds of instructional objectives when incorporated into an intelligent tutoring system.

For example, in the present study we began with an intelligent tutor for teaching students how to solve stoichiometry problems in chemistry, in which students learned by solving a series of 10 problems with feedback and hints from the tutor, with interspersed instructional videos. The software tutor was developed using authoring software specifically designed to build intelligent tutors; many software tutors have been developed with these tools (Aleven et al., 2009). Table 1 provides examples of direct and polite ways of wording the feedback and hints provided by the tutor from a corpus of over 4000 messages. We began with the direct wording of each hint or feedback message already being used by the tutor and created polite versions based on face-saving techniques (Brown and Levinson, 1987) described in the next section.

Much instructional design research on intelligent tutoring systems has focused on the cognitive issue of determining what software tutors should say to students (i.e., communication content) or when they should say it (i.e., communication pacing), whereas in this study we focus on the social issue of *how* they should say it (i.e., communication style), such as with polite or direct wording. In short, this work is based on the idea that intelligent tutors should not only exhibit *cognitive intelligence*—by knowing what to say and when to say it—but also should exhibit *social intelligence*—by knowing how to say it. In an influential paper, Lester et al. (1997) described a *persona effect*, in which learning was improved by a computer-based agent's social cues including having a life-like persona and expressing affect. Graesser et al. (2004) have shown how a web-based tutor can be designed in line with principles of human conversation, and Person et al. (1995) found evidence that politeness strategies are commonly used in one-on-one tutoring interactions between humans, although not always effectively.

1.2. Theoretical framework

The theoretical roots of this project rest in *politeness theory* (Brown and Levinson, 1987), *media equation theory* (Nass and Brave, 2005; Reeves and Nass, 1996), and *social agency theory* (Mayer, 2005, 2009), all of which focus on the role of social cues in human communication.

Politeness theory: Brown and Levinson (1987) argue that politeness reflects a universal aspect of human social interaction that goes far beyond the niceties of proper manners or etiquette. In particular, linguistic expressions of

Table 1
Examples of Direct and polite feedback and hints.

Direct version	Polite version
Hints:	
1. The tutor would like you to convert the units of the first item.	1. Let's convert the units of the first item
2. The unit conversion involved is from mg to g. The quantity provided here should be the number of g that corresponds to 1000 mg of COH_4.	2. What about converting mg to g? The quantity we provide here may be the number of g that corresponds to 1000 mg of COH_4.
3. Since 1 g is equivalent to 1000 mg of COH_4, type 1 as your answer here.	3. Since 1 g is equivalent to 1000 mg, maybe we should put 1 here.
4. The tutor wants you to calculate the result now.	4. Shall we calculate the result now?
5. Perform the arithmetic operations on the quantities that will remain after cancelling to obtain the result.	5. Let's work on the result by performing arithmetic operations on the quantities that remain after cancelling.
6. 10.6 and 1 remain in the numerators and 1000 in the denominator.	6. Did you get the values 10.6 and 1 remaining in the numerators and 1000 in the denominator?
7. Obtain the result by doing the following math: $(10.6 \times 1)/1000$.	7. So let's do the following math: $(10.6 \times 1)/1000$.
8. The result is .0106. Type .0106 in the highlighted field now.	8. Is the result you got .0106?
Error feedback:	
1. No. Molecular weight is not part of this problem. Select another reason for this term.	1. Are you sure molecular weight is part of this problem? Maybe there is another reason for this term?
2. No need to use this term for this problem. Work on the terms that are necessary, moving from left to right to solve the problem.	2. Are you sure we need to use this term for this problem? Perhaps we should work on the terms left to right, only using the terms that are necessary for this problem.
3. Wrong. Create a ratio of the target compound, i.e., put the target compound in both the numerator and denominator. $C_6H_{12}O_6$ is not the target compound.	3. Do we need to create a ratio of the target compound, i.e., put the target compound in both the numerator and denominator? If so, is $C_6H_{12}O_6$ the target compound?