Ogata, H. et al. (Eds.) (2015). Proceedings of the 23rd International Conference on Computers in Education. China: Asia-Pacific Society for Computers in Education

How to Present Example-based Support to Improve Learning in ITSs?

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Abstract: Worked Examples (WEs) and Erroneous Examples (ErrExs) have proven to be effective in supporting learning. It has been found that WEs are beneficial for novices, while ErrExs are more suitable for advanced students. However, how such learning materials should be presented in order to improve learning of different categories of students within Intelligent Tutoring Systems (ITSs) is still an open question. We focus on approaches that can be used to motivate students with different prior knowledge to gain benefits from example-based learning. As the first step, we conducted an experiment to find students' preferences between the original interface and the refined interface of SQL-Tutor. The results indicate that most of the students prefer the refined interface, since its layout is clearer and the organization is more efficient during learning. We plan to conduct a study that will investigate ways to improve interaction between students and ErrExs during learning.

Keywords: Worked examples, Erroneous Examples, Intelligent Tutoring Systems, SQL-Tutor

1. Introduction

A worked example provides a full solution for a problem with additional explanations of knowledge elements relevant for the solution. On the other hand, erroneous examples (ErrExs) solutions with errors in specific steps and require students to find and fix errors. Previous research has investigated the effectiveness of WEs and ErrExs with different types of learners. It has been found that WEs are beneficial for novices, while ErrExs are more suitable for high prior knowledge students (McLaren, van Gog, Ganoe, Yaron, & Karabinos, 2014). However, how to improve interaction between learners and Wes and ErrExs within Intelligent Tutoring Systems is still an open question.

As VanLehn (2011) pointed out, the effectiveness of human tutors who work with student one-on-one still outperforms ITSs. Versatility of human tutors is a crucial difference when compared with ITSs. How to deliver assistance within ITSs in order to be close to the effectiveness of human tutors is an open issue. One of the effective delivery strategy is the "fading strategy", when the student has to complete the omitted steps in provided examples. In a recent study, an adaptive strategy has been proved the most effective delivery strategy compared with alternating examples/problems in SQL-Tutor (Najar, Mitrovic, & McLaren, 2014). Presenting examples in different ways can provide a more comprehensive understanding of students' learning and interaction with ITSs. In order to identify differences in knowledge growth, Booth, Lange, Koedinger, and Newton (2013) indicate two steps in example-based assistance in order to ask student to explain both *what* was done in the example and *why* was either correct or incorrect by choosing a sentence fragment from a series of three menus of "*what* was done" step and a series of two menus of "*why*" step. Videos have been used in presentation of example-based assistance in order to encourage students to self-explain (McLaren et al., 2014).

A previous study conducted in the context of SQL-Tutor demonstrated learner differences in worked example processing (Najar, Mitrovic, & Neshatian, 2014). The results showed that there is no significant difference in the time of studying the examples between novices and advanced students. However, advanced students consulted database schemas more frequently than novices. Consequently, we are interested whether the design of the interface can affect how novices use database schemas. In a pilot study, we designed a refined interface, in which the location of database schema was changed to be

closer to worked examples. We wanted to investigate whether students prefer the refined interface or the original interface. This paper presents the findings from the pilot study conducted in April 2015.

2. Pilot Study

SQL-Tutor is a constraint-based ITS for teaching SQL (Mitrović, 1998), which complements traditional lectures. The original SQL-Tutor interface presented the database schema in the bottom pane (Figure 1, left). We redesigned the system interface so that the database schema is presented next to the worked example or the problem-solving area (Figure 1, right). With the database schema being closer to the main area of activity, the student might consult the schema more often. The database schema is important for learning from worked examples and also for problem solving because students need to understand the database structure, such as semantics of attributes and structure of tables.

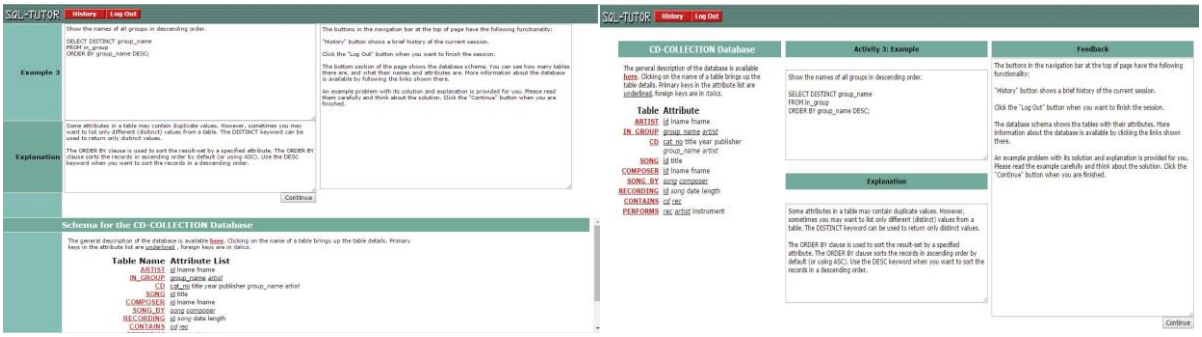

Figure 1. Screenshots of the original interface (left) and the refined interface (right)

The participants in the pilot study were 13 postgraduate students enrolled in the ITS course at the University of Canterbury. Nine participants were either completely new to SQL-Tutor, or only solved a few problems before the pilot. The remaining four students have solved many problems in the system. None of the participants have studied worked examples within SQL-Tutor.

During the pilot study, the participants watched a video presenting the process of learning from a worked example and solving a problem in SQL-Tutor using the original interface (interface A) and refined interface (B) respectively. After the video, the participants completed the questionnaire.

3. Findings

The goal of the pilot study was to identify student preferences between the two presented interfaces. Overall, no participants disliked the refined interface; the majority of participants (61.54%) preferred to use this version when studying with SQL-Tutor. Table 1 presents the questionnaire replies categorized by how much experience the participants have had in SQL-Tutor prior the study (*none*, *limited* or *extensive*).

Table 1: Percentages of responses for each question.

	None	Limited	Extensive
Learnability of the presentation, layout and navigation of Interface B	66.67% (Easy) 33.33% (Neutral)	50% (Easy) 50% (Neutral)	50% (Easy) 50% (Neutral)
Satisfaction of the organization of information on Interface B	66.67% (Pleasant) 33.33% (Neutral)	100% (Pleasant)	33% (Pleasant) 33% (Neutral) 33% (Unpleasant)
Efficiency of interface B	33% (Efficient) 33% (Neutral)	50% (Efficient) 50% (Neutral)	100% (Efficient)
Percentage of preference	66.67% (Interface B) 33.33% (Neutral)	83.33% (Interface B) 16.67% (Neutral)	25% (Interface B) 75% (Neutral)
Overall percentage of preference	61.54% (Interface B) 38.46% (Neutral)		

The participants who had significant experience with SQL-Tutor did not show any preference between the two interfaces. No participants rejected interface B, and most of the novice participants were satisfied with the design of interface B. While the students who were familiar with SQL-Tutor were neutral about the learnability of the presentation and overall layout of interface B compared to interface A, the participants new to SQL-Tutor replied that the presentation and overall layout of interface B were easy to learn and understand. The participants with no or limited experience with SQL-Tutor though that the organization of the information in interface B is pleasant and easier to locate, 66.67% and 100% respectively. The participants who had extensive experience with the system found interface B to be more efficient to use than interface A (100%). Overall, the findings illustrate that the location of database schema does make a difference of the students' perceptions of the usefulness of the interface for learning.

4. Conclusions and Future Work

Previous studies have indicated that adding worked examples and erroneous examples to ITSs is beneficial for learning. Our long-term goal is to develop an adaptive strategy for presenting problems, worked and erroneous examples based on the students' knowledge, in order to optimize learning. As the first step towards this strategy, we focused on the interface for presenting problems and worked examples. Prior study points out that novices used database schema rarely (Najar, Mitrovic, & Neshatian, 2014). One of the possible reasons is that novices might be not familiar with example-based study and they may consider database schema not important for learning, when the database schema is far from the example area in Interface A. It is interesting to investigate whether interface B, which draws students' attention to the database schema, would improve learning from worked examples for novices. Consequently, we conducted a pilot study focusing on students' preferences related to the original and a modified interface, in which the database schema is shown closer to the area presenting the main learning activity. We hypothesize that novices will pay more attention to database schema when studying examples when using interface B, and therefore improve students learning.

In order to further test this hypothesis, the next step in our work is to design a strategy for presenting erroneous examples to students in SQL-Tutor. We will then conduct a study to investigate whether erroneous examples could further improve learning, on top of learning from tutored problem solving and worked examples. The analysis of the eye gaze data would enable identifying differences in how novices or advanced students differ in learning from erroneous examples. We hypothesize that (i) novices will learn more and use less time when they use the refined interface than the original interface; (ii) students will improve their understanding while they work with erroneous examples within the refined interface.

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