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A problem solving oriented intelligent tutoring system to improve students' acquisition of basic computer skills

Dongqing Wang [a], Hou Han [a], Zehui Zhan [b], Jun Xu [a, *], Quanbo Liu [a], Guangjie Ren [a]

[a] College of Educational Information Technology, South China Normal University, Guangzhou 510631, China
[b] Center of Educational Information Technology, South China Normal University, Guangzhou 510631, China

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ABSTRACT

Personalization and intelligent tutor are two key factors in the research on learning environment. Intelligent tutoring system (ITS), which can imitate the human teachers' actions to implement one-to-one personalized teaching to some extent, is an effective tool for training the ability of problem solving. This research firstly discusses the concepts and methods of designing problem solving oriented ITS, and then develops the current iTutor based on the extended model of ITS. At last, the research adopts a quasi-experimental design to investigate the effectiveness of iTutor in skills acquisition. The results indicate that students in iTutor group experience better learning effectiveness than those in the control group. iTutor is found to be effective in improving the learning effectiveness of students with low-level prior knowledge.

1. Introduction

Information and Communication Technology course (ICT) in Chinese academy aims at developing students' comprehensive ability of computer key applications, promoting their positive attitudes, creative thinking and operational skills. However, with a large number of students in class, lengthy pieces of work or practical constraints such as time and workload, providing effective feedback and meeting individual needs of students are difficult for teachers (Buchanan, 2000; Wang, 2007). The result shows that the average of students under private tutoring was about two standard deviations above the students using traditional didactic approach and 98% students could learn better under private tutor (Bloom, 1984). Intelligent tutoring system (ITS) can provide 'one-to-one' individualized instruction by stimulating activities of human teachers. In our opinion, a teacher usually have to complete the following activities in teaching process: (1) explain the core knowledge of a problem; (2) show how to solve the problems with specific knowledge; (3) provide solutions and worked examples of a problem; (4) give targeted feedback to students in the process of their trying to solve the problem; (5) recommend related activities based on students' cognitive state. Student model is the core element of ITS, based on which ITS is able to select the most suitable teaching strategies, provide related examples according to the needs of students, and replace human teachers to some extent (Shi, Rodriguez, Shang, & Chen, 2002).

Currently, the research on ITS is far from enough in aspects of problem solving and the method of 'learning by doing' supporting. Interactive problem solving environment is still rare, especially in general construction method. Interactive model needs further investigation. Acquisition of basic computer skills is different from the theoretical knowledge learning, which cannot obtain directly from others through passive or rote learning. Therefore, we must change the traditional teaching methods and build an interactive problem solving environment to support the method of 'learning by doing', providing worked examples and personalized feedback.

* Corresponding author. Tel.: +86 13929521905; fax: +86 20 85214991.
E-mail addresses: wangdq.scnu@gmail.com (D. Wang), xujscnu@163.com (J. Xu).

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2. Related works

2.1. Problem solving and skills acquisition

Skill as an advanced cognitive ability can be understood as the ability of using concepts and rules to solve the problem. It is difficult to be achieved by using traditional teaching methods, such as lectures, knowledge representation (Hwang, Kuo, Chen, & Ho, 2014). The learner should practice and strengthen the process continuously to complete the task. In teaching ICT, researchers gradually became aware of the importance of operational skills' training and developed a variety of teaching aids systems and simulation tools, such as RCOS (Chernich, Jamieson, & Jones, 1996), SOsim (Maia, 2003), in order to promote students' understanding of abstract concepts in computer courses and correct students' misconceptions. Some simulating teaching systems, such as MINIX (Herder, Bos, Gras, Homburg, & Tanenbaum, 2006), Nachos (Christopher, Procter, & Anderson, 1993), filtered out the complexity of the real-life situation, so that students could understand the most basic concepts of knowledge and steps in a relatively simple context (Buendia & Cano, 2006). Web-based learning platform, such as WebCT, BlackBoard, was also used to assist the instruction, providing a wide range of learning resources. Based on the platform and resources, students were able to learn the contents of each module on demand, watching video lessons, reviewing the missing contents. To some extent, it can support students to carry out resource-based learning and achieve a better learning effect, but it still cannot support the skill acquisition in an effective way.

2.2. Interactive feedback

Feedback is crucial in the process of problem solving. It is the return of information about the learning process according to particular predefined objectives (Gagne, 1985). Learning is promoted when students are guided in their problem solving by appropriate feedback and coaching (Merrill, 2002). Timely feedback and direct error analytic guidance can help learners tackle the problem (Anderson, Corbett, Koedinger, & Pelletier, 1995), get to know the quality of their work (Moore & Kearsley, 1996), the current state of skills and the gap between the current state and the desired state (Butler & Winne, 1995), based on which learners can reflect and adjust learning ways so as to achieve the purpose of effective learning. The feedback for a learner consists not only of adaptive information about his errors and performance, but also of adaptive hints for the improvement of his solution (Lütticke, 2004). Well-structured instructional feedback together with annotations added to the worked examples can promote effective learning (Lee & Hutchison, 1998).

Providing feedback and guidance for each step of the problem in the process of problem solving is significantly better and more interactive than giving worked examples only (Ashton, Beevers, Korabinski, & Youngson, 2006; Corbalan, Paas, & Cuypers, 2010). Chi, Siler, Jeong, Yamauchi, & Hausmann. (2001) found that students who engaged in a more interactive style of human tutoring were able to transfer their knowledge better than the students in the didactic style of tutoring. Results that support greater interaction have also been found in studies of intelligent tutoring systems (Person, 2003; VanLehn et al., 2005).

2.3. Prior computer experiences

Learners' prior knowledge is believed to be one of the most important factors affecting learning effectiveness (Dochy, 1994; Hailikari, Nevgi, & Lindblom-Ylänne, 2007). Dochy (1994) argued that the domain-specific prior knowledge impacted learners' achievement. Prior knowledge will facilitate skill acquisition (Posner & McLeod, 1982). Prior computer experience was an important predictor of performance on subsequent computer-based tasks (Kuo & Wu, 2013; Park, 2001). Furthermore, Charness, Kelley, Bosman, and Mottram (2001) found that breadth of experience with computer software was a strong positive predictor of learning a word-processing application.

Dochy, De Rijdt, and Dyck (2002) and Hailikari et al. (2007) argued that prior knowledge interacted with different phases of information processing. Learners lacking appropriate prior knowledge will have trouble in learning new information and constructing new understandings (Ausubel, 2000). Therefore, prior knowledge can influence learners' achievement (Dochy, 1996; Hailikari et al., 2007; Tobias, 1994). Prior knowledge is also an important variable related to e-Learning effectiveness. Learners with different levels of prior knowledge benefit differently from a given e-Learning environment (Smits, Boon, Sluijsmans, & Van Gog, 2008). Mitchell, Chen, and Macredie (2005) argued that learners with different levels of prior knowledge had different perceptions about the features of the e-Learning environment, which in turn affected their e-Learning effectiveness. Learners with poor level of prior knowledge need much more guidance (Mayer, 2002). Worked examples (Clarke, Ayres, & Sweller, 2005) together with interactive feedback provide effective learning support for different levels of students.

3. iTutor: a problem solving oriented ITS

An effective way to acquire basic computer skills is observing the worked examples and then solving the problems in context. This concept consists two aspects, one is ‘learning from examples’, and the other is ‘learning by doing’. We designed and developed iTutor system, which is a problem solving oriented ITS. It has two advantages, (1) extend the traditional model of ITS and emphasized on tracking the process of problem solving and evaluating students' skill level; (2) build a highly interactive problem solving environment, under which students can learn basic computer skills through solving the practical problems.

3.1. Extend the model of ITS

There are three parts in traditional framework of ITS, domain model, learner model and teaching model. Domain model represents the domain knowledge. Learner model used to predict students' performance. Teacher model used to describe teaching process for students. In order to enhance the ITS in the support of problem solving, traditional model of ITS need to be extended (Akhras & Self, 2002). The paper presents an extended ITS for the design of iTutor, which is from the domain model to the problem solving situation model, the student model to the interaction and process model, and the teaching model to feedback model, as is shown in Fig. 1.