On Scaffolding Adaptive Teaching Prompts within Virtual Labs

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ABSTRACT

Despite a growing development of virtual laboratories which use the advantages of multimedia and Internet for distance education, learning by means of such tutorial tools would be more effective if they were specifically tailored to each student needs. The virtual teaching process would be well adapted if an artificial tutor can identify the correct acquired knowledge, recognise the erroneous learner’s knowledge and suggest a suitable sequence of pedagogical activities to improve the level of the student. This paper proposes a knowledge representation model which judiciously serves the remediation process to students’ errors during e-learning activities. The model is inspired by recent researches on computational representation of the knowledge and by cognitive psychology theories that offer a refined modelling of the human learning processes. Experimental results, obtained via practical tests, show that the knowledge representation and remediation approach facilitates the planning of tailored sequences of feedbacks that considerably help the learner.

Keywords: computational modelling; student knowledge; tailored feedback; virtual laboratories

INTRODUCTION

Virtual laboratory-based learning is likely to have a profound impact on the whole area of education by affecting the way we learn, what we know, and where we acquire knowledge. In the educational community, a large amount of enthusiasm has been engendered for highly interactive virtual laboratories, exploiting the multimedia features and the Web advantages for a remote teaching purpose, and which behave according to laws and constraints of subject-matter domains, permitting the student to experience the nature of those domains through free/guided exploration or scaffolding adaptive learning.

The original notion of scaffolding assumed that a more knowledgeable tu-
tor helps an individual learner, providing him/her with exactly the help s/he needs to move forward. A key element of scaffolding is that the tutor provides appropriate support based on an ongoing diagnosis of the learner’s current level of understanding. This requires that the tutor should not only have a thorough knowledge of the task and its components, the subgoals that need to be accomplished, but should also have knowledge of the student’s capabilities that change as the instruction progresses.

Considerable success has been achieved in the development of software scaffolding that has been employed within interactive learning environments and virtual labs to offer a means of enabling learners to achieve success beyond their own independent ability (Hammerton & Luckin, 2001). Jackson, Krajcik, and Soloway (1996) showed that an approach which attempts to design adaptable learning environments, which offer learners guidance and tools to make decisions for themselves, also should address the importance of maintaining the fine balance between system guidance and learner control. However, evidence from other researches into learners’ use of scaffolding assistance has indicated that less able and knowledgeable learners are ineffective at selecting appropriately challenging tasks and seeking appropriate quantities of support and guidance (Luckin & du Boulay, 1999; Wood & Wood, 1999). This, among others, led to explore the way that Vygotsky’s Zone of Proximal Development (Vygotsky, 1986) can be used in the design of learner models.

To provide appropriately challenging activities and the right quantity and quality of assistance, du Boulay, Luckin, and del Soldato (1999) have presented a categorisation which suggests three principled methodologies for developing teaching expertise in artificial tutoring. First is the Socratic tutoring that provides a number of detailed teaching tactics for eliciting from and then confronting a learner with her/his misconceptions in some domain. The second methodology is the contingent teaching which aims to maintain a learner’s agency in a learning interaction by providing only sufficient assistance at any point to enable her/him to make progress on the task. The third methodology is an amalgam of the previous two. It builds a computational model of the learner and derives a teaching strategy by observing the learner’s response to different teaching prompts selected with regards to the model. Scaffolding in the form of prompts to help students reflect and articulate has been developed under different types, either by varying the activities according to their difficulty, or content of the task (Bell & Davis, 1996; Jackson, Krajcik, and Soloway, 1998; Luckin & Hammerton, 2002; Puntambekar & Kolodner, 2005).

Furthermore, it is a generally held position that the process of learning will improve when learners are given virtual tutoring that allow for interactive access tuned to the specific needs of each individual learner. If we aim to develop virtual laboratories in complex domains which are equipped with tutorial strategies able to interact with learners having various levels of intelligence and different abilities of knowledge acquisition, then understanding the human learning mechanism and the manner of structuring and handling knowledge in the course of this process is a fundamental task.

Recent multidisciplinary researches (Wang, 2003; Wang & Kinsner, 2006; Wang, Liu, & Wang, 2003; Wang & Wang, 2006)—that study processes of the brain and that investigate how human beings acquire, interpret, and express knowledge by using the memory and the mind—lead
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