Virtual Environments for Enriching Student Learning

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I. INTRODUCTION

Higher Education faces a revolutionary opportunity for change created by the confluence of pressures from economic and societal changes along with opportunities for new modes of education offered by the advancement and widespread availability of Information and Communication Technology. Advances in learning technologies are creating opportunities to improve education in 21st century competencies such as critical thinking, complex problem solving, collaboration, and systems thinking, as well as to more effectively assess these competencies. But in order to realize these benefits we need to move beyond models of content "delivery" and think afresh about the characteristics of stimulating and engaging learning environments. I examine ways in which technologies such as intelligent tutoring systems, and simulation environments, can help to address some of the pedagogical challenges we face as educators. I illustrate with case studies from the work of my research group in the area of intelligent clinical training systems. [1]

II. TRAINING OF COGNITIVE SKILLS

COMET [2] is a collaborative intelligent tutoring system for medical problem-based learning. COMET uses Bayesian networks to model individual student knowledge and activity, as well as that of the group. It incorporates a multi-modal interface that integrates text and graphics so as to provide a rich communication channel between the students and the system, as well as among students in the group. Students can sketch directly on medical images, search for medical concepts, and create hypotheses on a shared workspace. The prototype system incorporates substantial domain knowledge in the areas of head injury, stroke, and heart attack. A major challenge in building COMET has been to develop algorithms for generating tutoring hints. Tutoring in PBL is particularly challenging since the tutor should provide as little guidance as possible while at the same time not allowing the students to get lost. From studies of PBL sessions at Thammasat University Medical School, we have identified and implemented seven commonly used hinting strategies. We have performed extensive evaluation of the algorithms in COMET, as well as its overall pedagogical effectiveness. I present results showing the accuracy of the individual and group student models, the similarity of COMET's hints with those of human tutors, and a comparison of the effectiveness of COMET versus that of human tutors in imparting clinical reasoning skills to students.

The limited knowledge available to traditional intelligent tutoring systems (including COMET) can limit their ability to foster creativity by accommodating solutions that may fall outside the scope of the codified solution. In addition, when students stray outside the scope of the system's knowledge the system is no longer able to interact intelligently. METEOR (Medical Tutor Employing Ontology for Robustness) [3] is a successor to COMET that addresses this limitation by leveraging the rich existing Unified Medical Language System (UMLS) ontology to provide a dramatically increased scope of intelligent student interaction. The system is able to use the semantic information in UMLS to automatically generate hints to guide students to create high quality solutions to problems.

III. TRAINING OF PHYSICAL SKILLS

Dental students devote several years to the acquisition of sufficient psychomotor skills to prepare them for entry-level dental practice. They traditionally train on dental mannequins with plastic teeth and on live patients. After a training session, dental experts assess procedure outcomes based on subjective measures. These traditional methods of skill training and assessment, however, have limitations such as the lack of challenging dental cases, limited availability of expert supervision, and the limited level of detail in human expert assessments. In addition, practice on live patients poses ethical concerns.

To address these issues, UNU-IIST has collaborated with the Asian Institute of Technology and Thammasart University to produce a dental training system that provides a simulated yet realistic virtual reality (VR) environment with haptic (touch) feedback [4]. With this system, dental students are able to practice dental procedures without need for expert supervision and at little or no incremental cost. The system can monitor important features of the procedure, objectively assess the quality of the performed procedure, and provide feedback on the student's performance. Incorporated with the system is an intelligent training module that allows students to practice dental procedures with varying levels of guidance.

Based on a number of human studies, we find that the realism of the graphics and haptics is acceptable for virtual training. We also find that the accuracy of the objective performance assessment and the quality of the system's training feedback are high. Moreover, students and experts agree that the intelligent training module is a valuable tool for independent training.

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