Design of a Model-based Expert-supported Learning Environment for Problem Solving Expertise Development

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Abstract: *Teaching ill-structured problem solving skills is a critical and challenge task in medical education. While problem-base learning (PBL) is widely adopted in medical schools to enable students' learning with complex problems under minimal guidance, there are concerns about its effects on development of systemic knowledge structure and efficient reasoning process. To meet the challenge, a technology-enhanced learning environment is proposed in this study to improve students' expertise in complex problem solving by scaffolding their reasoning and knowledge construction processes with support of expert knowledge and model-based cognitive tools.*
Keywords: ill-structured problem solving, problem-based learning, expertise development

1. Introduction

Teaching ill-structured problem solving skills has received increased attention in medical educational areas because most of clinical problems are ill-structured and require sophisticated knowledge structures and reasoning skills. In this context, problem-base learning (PBL) has received increased interest by educators, demonstrated by its extensive use in medical schools over the last decades. Contrary to the conventional medical instructional methods, PBL makes a fundamental shift from teacher-centered lecture-based curricula to student-centered problem-based curricula by enabling students' learning with complex problems under minimal guidance (Baig, 2006). However, a large number of empirical studies found limitations of PBL in developing complete knowledge structures and efficient reasoning strategies and providing learners with adequate expert guidance, which impede students' expertise development for ill-structured problem solving (Coderre et al., 2003).

To meet the challenge, a technology-enhanced learning environment is proposed to fit in the gap between PBL and true expertise development. The design of the learning environment is underpinned by theories in expertise development (Patel et al., 1993) and ill-structured problem solving (Seel, 2003), with a focus on scaffolding students' reasoning and knowledge construction processes with support of expert knowledge and model-based cognitive tools. Expertise for ill-structured problem solving is extracted and refined as expert support to guide learning with complex problems. Situated learning (Stillman et al., 1998) and cognitive apprenticeship strategies (Collins et al., 1991) are employed with model-based cognitive tools to facilitate students' knowledge construction and reasoning processes.

2. Proposed Learning Environment

The proposed learning environment involves an explorative learning context to engage students in authentic learning. Further, instructional strategies and cognitive tools based on cognitive apprenticeship are used to facilitate model-centered instruction and learning, and expert knowledge is employed to facilitate students' learning towards expertise development.

2.1. Instructional Strategies

Technology-supported instructional strategies based on cognitive apprenticeship is adopted in this study. *Modeling* is implemented by providing a demonstration of how a diagnostician deals with a clinical case in proposed learning environment, helping students to obtain a holistic impression on ill-structured problem solving. *Coaching* is embedded in learning cases, implemented by monitoring and recording students learning processes and providing them specific and timely help to elicit expert-like problem solving performance. *Scaffolding* is embedded in the learning environment, implemented by providing model-based cognitive tools and relevant learning activities such as model-based reasoning and knowledge construction with problem cases. *Articulation* is implemented by providing students a knowledge visualization tool to externalize complex cognitive processes and architectures of ill-structured problem solving. *Reflection* is implemented by replaying and comparing the problem-solving processes of both student and expert. *Exploration* is implemented by providing learning experience similar to the real world and allowing self-directed learning.

2.2. Model-based Cognitive Tools

A knowledge visualization tool is designed to help students to articulate and reflect on their problem-solving processes by visualizing the processes into graphic forms. For each case solved by the student or the expert, the reasoning activities such as critical information, performed examinations, and clinical analysis or judgment are externalized into a graphic mental model. In this way, distinct differences between the student and the expert in solving the case are analyzed and identified, based on which students may reflect on their reasoning process and reconstruct their relevant understanding or knowledge. Through constant practice of problem solving, students are expect to find out the crucial expertise contributing to professionalism and refine that into advanced mental models of knowledge structure.

3. Problem-Solving Learning Process

Glaucoma diagnosis is chosen as the learning topic in this study because it belongs to complex and ill-structured problem solving, and it is a common learning content for medical students. Main learning activities to be performed in the proposed learning environment are elaborated in the following.

3.1. Problem Initiation

A case is selected by the student from the case database. Then, relevant patient background and chief complaint information of the case is presented in a pop-up learning window and a problem solving process initiates. The initial problem comprises the basic information of the patient including gender, age, family and personal medical history, and anomalies such as “eyesight faintness” or “continues headache for over a month”.

3.2. Problem Solving

Based on the initial information, a preliminary diagnostic plan is formed by the student, guiding the subsequent clinical examinations and analysis. Following that, the student selects certain eye examinations for the simulated patient and received the results presented in terms of laboratory data and images (see Figure 1). After one or more such steps, the student may draw a conclusion by taking relevant or eliminating irrelevant information from a series of examination.

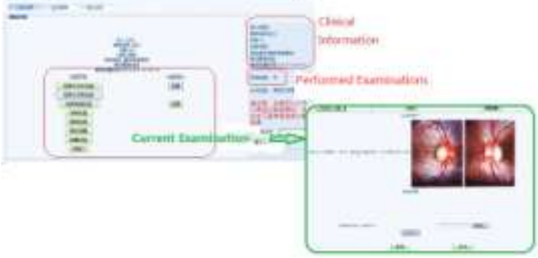

Figure 1. Problem solving process.

3.3. Reflection on Problem Solving

After submitting the diagnostic conclusion, the student can review and reflect on his/her diagnostic process captured by the system in a diagram. The diagnostic diagram includes initial information of the patient, performed examination in a sequence, and clinical judgment after each examination. Once the student's diagnostic process reaches some degree of similarity with that of the expert, the diagnostic diagram of the expert for the same case can be viewed by the student.The differences in the problem solving process between the student and the expert are also highlighted by the learning environment. Further, expert interpretations are provided to help the student to reflect on his reasoning process and underlying knowledge that supports the reasoning process (see Figure 2).

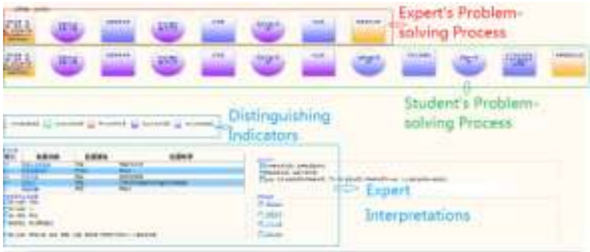

Figure 2. Reflection on problem solving process.

3.4. Knowledge Construction

After completing a number of cases, the student is required to review and summarize these cases by drawing a knowledge map to represent the domain knowledge of Glaucoma diagnosis. By comparing his/her knowledge map with that of the expert, the student may improve his/her knowledge structure and corresponding reasoning mode to improve the expertise in solving complex problems in this domain.

4. Conclusion

Although PBL is proposed as an innovative approach to facilitating learning through complex problem solving and is widely used in medical schools, it has weaknesses in knowledge construction and reasoning efficiency, which may impede the development of expertise in complex problem solving. To address the challenge, a technology-enhanced learning environment is designed and developed to improve students' knowledge construction and problem solving performance towards the expert level by providing students with model-based cognitive tools and expert support in their problem-solving practice. The evaluation study of the designed learning environment will be conducted with medical students using dynamic assessment methods and questionnaire surveys and interviews. The result of the evaluation study is expected to shed light on whether and how the designed learning environment can improve students' problem solving expertise and provide implications into future research and practice in ill-structured problem solving.

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