Chapter XIX

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ABSTRACT

In our study we collected data with respect to cognitive variables (learning outcome), metacognitive indicators (knowledge about cognition and regulation of cognition) psychological variables (self-esteem) and emotional variables (motives, anxiety). The teaching sequence was implemented using the CTAT authoring tool and the basic teaching unit was referred to fundamental concepts in Mechanics for 204th year undergraduate students enrolled in the course «Applied Didactics in Natural Sciences» of the University of the Aegean-Department of Education. Analysis of the results shows that anxiety (a negative emotion) can be reduced using CTAT, there is a transfer from extrinsic to intrinsic motivation while metacognitive indicators as well as learning performance can be improved using CTAT. The interactivity of the learning environment influences also self esteem and the results are presented.

INTRODUCTION

Intelligent Tutoring Systems (ITS) have been successful in raising student learning outcome and have been used quite widely in exploring the teaching-learning sequence (TLS). ITS have been shown to be highly effective in improving students’ learning outcome (cognitive performance) in real classrooms (VanLehn2006). The term intelligence corresponds to cognitive skills such as the ability to solve problems, learn, and understand but contemporary research has been
focused also on concepts and methods for building programs with emphasis on reasoning rather than on calculating a solution. In ITS, problem solving is achieved by applying inference engines to a knowledge base to derive new information, to create new facts and new rules, and make decisions. Usually, an inference engine is a software component which reasons over rules when the application is executed while its major task performed is conflict resolution, which determines the sequence of the consultation (Hicks, 2007).

Cognitive/Intelligent Tutors are considered learning environments based on ITS and cognitive modelling (how people learn) aimed to improve the learning outcome in cognitively-based instructional design. In parallel, they deal with cognitive task analysis and exploration of pedagogical content knowledge which is considered as a fundamental ingredient in the cognitively-based instruction (Lovett et al., 2000, Schraagen et al., 2000). Cognitive Tutors learning environments are developed in order to provide a problem-solving environment reinforced with a variety of representation tools, real world scenarios which demand algebraic reasoning, tutorial guidance in the form of step-by-step feedback, specific messages, hints in response to common errors and misconceptions, and on-demand instructional hints to be used as explanations for the concepts involved in the problem. At ITS systems advised is provided on demand in a progressive way so the learner is involved in the scientific process. ITS has also the property to dynamically adjust to individual learner’s needs and method of approach to the problem. (Aleven et al., 2006). Cognitive Tutors are based primarily on the ACT-R (Adaptive Control of Thought-Rational) theory of cognition (Anderson et al., 1995) under the hypothesis that a complex cognitive domain can be understood in terms of small knowledge components called production rules that are learned independently of each other. Production rules represent the target competence that the tutor is meant to help students acquire. Developing a Cognitive Tutor involves creating a cognitive model of student problem solving by writing production rules that characterize the set of strategies and misconceptions. Productions are written in a modular fashion, like in high order programming languages, so that they can apply to a goal and context independent of the specific issue they deal with.

Production rule model (a set of rules about behaviour) is fundamental for the domain intelligence, that is the tutoring system’s knowledge of the specific discipline.

The intelligence of the system uses two algorithms, the model tracing and the knowledge tracing algorithm.

Model tracing algorithm uses the production model in order to interpret each student’s activities and to follow students’ different methodologies and strategic plans as they work through problem solving. The results of model tracing are used to provide students with correctness, error feedback, hints and to provide advice to student about his/her justification and reasoning steps. The main ingredient of the algorithm is the use of comparison techniques, so it can evaluate student’s step against all possible steps provided by the ITS. If the action taken by the student is among these actions, the tutor provides implicit positive feedback, and negative feedback if the model registers incorrect behaviour (correct/incorrect according to the corresponding production rule). The model-tracing algorithm is also used in order to provide hints upon a student’s request. When the student requests a hint, the tutor selects one of the productions that could apply to generate a next step at this point. A hint template attached to this production is filled in with problem specific information and then presented to the student (VanLehn et al., 2005).

The knowledge algorithm is used to estimate how well an individual student has mastered the knowledge components of the particular unit. Of course it is realised with a certain probability and the upgraded information is restored in order to be used as a next step to the model tracing algorithm.