PERGAMON

Computers in Human Behavior 18 (2002) 650–668

Computers in Human Behavior

www.elsevier.com/locate/comphumbeh

Improving problem solving and creativity through use of complex-dynamic simulations

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Abstract

This article presents an instructional method to improve problem solving and creativity by employing computer-based simulations. The instructional method described is based upon empirical research conducted by the authors. The simulation presents contextually meaningful problem situations that require learners to analyze and prepare solution proposal(s). Following the learner input, the simulation assesses the proposal and offers back to the learners the consequences of their decisions while also iteratively updating the situational conditions. This type of simulation, unlike conventional simulations that are used for acquisition of knowledge, is complex-dynamic, requiring the learner to fully employ their knowledge base by constructing solutions to domain-specific problems. The focus of complex-dynamic simulations is to improve and elaborate learner cognitive abilities employed in the service of problem solving and creativity.

Keywords: Creativity; Cognitive strategies; Knowledge base; Problem solving; Simulations; System dynamics; Thinking strategies

1. Introduction

A national report on education concluded that society's future depends on a citizenry that can "think and reason creatively and deliberately; develop sound judgments of information and understand and contend effectively with rapid and constant change ..." (President's Committee of Advisors on Science and Technology; see Stokes, 1997). In a national science education task force report, educators were urged to develop a curricula "that emphasizes higher-order thinking strategies" (The National Academy of Science, 2001). In other words, the purpose of education

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0747-5632/02/$ - see front matter
PII: S0747-5632(02)00022-5

should include not only the acquisition of knowledge, but also the development and improvement of higher-order thinking strategies for problem solving and creativity (Miller & Babcock, 1996). Unfortunately, the achievement of these learning goals still eludes educators' even after decades of concern because of the serious lack of basic research on instructional methods that can demonstrate the improved learning of problem solving and creativity.

Two questions are proposed for education from the above survey findings. First, can education improve the learning of problem solving and creativity? And, secondly, can education improve thinking strategies for problem solving and creativity? To help answer these two questions, we need to first define problem solving and creativity; and then proceed to offer appropriate instructional methods. We define problem solving as the intellectual skill to propose solutions to previously unencountered problem situations. Creativity is defined as the cognitive skill of creating a problem situation and proposing a solution(s). Learning is the process of acquiring knowledge while thinking is the process of employing knowledge.

In the last decade of the 20th century, research findings in cognitive science have forged interdisciplinary approaches to learning and thinking such that we now seem to understand more about why and how people both acquire and employ knowledge (Tennyson, 2001b). In what can be called meta learning theories, there are means to not only more fully understand learning and thinking strategies but also the means necessary for prescribing instructional methods that can predictably improve these cognitive processes (Tennyson, 2002). Higher-order thinking strategies involve cognitive processes directly associated with the employment of knowledge in the service of problem solving and creativity (Mayer, 1992). Basically, these processes enable the individual to "restructure" their knowledge by (a) analyzing a given situation, (b) working out a conceptualization of the situation, (c) defining specific goals for coping with the situation, and (d) establishing a possible solution.

1.1. Complex-dynamic simulations

The purpose of this article is to present an instructional method that has been shown to significantly improve higher-order thinking strategies by enhancing the above described cognitive processes. The method employs computer-managed simulations that present contextually meaningful problem situations that require learners to prepare solution proposals. The simulation assesses the proposals and offers to learners the consequences of their decisions while also iteratively updating the situational conditions. This type of simulation, unlike conventional simulations that are used for the acquisition of knowledge, is complex-dynamic, requiring the students to fully employ their knowledge base by generating solutions to domain-specific problems (Peden-McAlpine, 2000).

In this article we will first elaborate on the cognitive processes associated with higher-order learning and thinking strategies so as to more clearly define the prescribed instructional method to improve problem solving and creativity. Following that presentation, we will describe the instructional method and, finally, present software examples of the method.