Multi-Year, Large-Scale Field Studies of the Fundamental Skills Training Project's Intelligent Tutoring System

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Project Background

Since 1990, the Air Force has been engaged in a long-term research effort, the Fundamental Skills Training (FST) project, designed to bring state-of-the-art intelligent tutoring technology to bear on literacy skills problems in mathematics; help school children attain basic literacy skills; and evaluate the effectiveness of the software in enhancing critical thinking skills.

To accomplish this goal, an intelligent tutoring system (ITS) called the Word Problem Solving (WPS) tutor was developed. This system was evaluated in 15 year-long field studies involving 40 schools in 10 states over a 10 year period. Each year these studies have involved 40-50 teachers and nearly 3,000 students.

The goal of this paper is to present to researchers, teachers, administrators, and managers a quick summary of the methods and results of the research conducted from September 1991 through May 1999.

The Suite of FST Intelligent Tutoring Systems

The Word Problem Solving (WPS) tutor teaches individuals general problem solving strategies as well as how to solve specific word problems. Specifically, the WPS tutor helps students learn to analyze and solve word problems by applying a pedagogy derived from contemporary cognitive science, including principles of active problem solving (Anderson, 1994), elaboration theory (Riegeluth, 1987, 1992), categorization by prototype (Rosch, 1988a, 1988b), mastery learning (Bloom, 1984), and worked examples (Ward & Sweller, 1990). The tutor consists of 24 independent modules of instruction that correspond to critical curriculum elements in ninth grade algebra. The WPS tutor is designed to enhance, not replace, traditional classroom instruction. During the course of traditional instruction, the class periodically goes to a computer classroom to allow students to work individually and receive automated feedback and guidance from the WPS tutor. Because the WPS tutor does the majority of teaching, the teacher is free to work individually with students who are having a particularly difficult time learning.

Research

In the studies, the focus of the research has been on three sets of questions including:

1.) Instructional effectiveness of the tutor (i.e., "Do students gain more using the tutors vs. traditional educational approaches?")
2.) Effectiveness of individual tutor components
3.) Implementation issues in the use of educational technology

This paper primarily focuses on the instructional effectiveness of the tutor.

Subjects

In general, the subjects were seventh, ninth, and tenth grade students enrolled in sections of pre-algebra and algebra at 40 junior and senior high schools in states across the nation. Students were demographically diverse (e.g., inner city youth, suburban youth, varying levels of SES, gender, etc.) and participated in this research as part of their normal math classes. On average, classes spent 15-20 hours in the computer lab throughout the school year.

Methods

Since random assignment was not feasible, (i.e., the schools having designated students to classes and teachers) the studies employed a quasi-experimental design.

In each of the studies, to determine instructional effectiveness, students devoted a partial class period to pretesting during the first six weeks of the academic year. After taking the pretest, the experimental students attended a computer lab approximately one day, every two weeks during their normal class time for an average of 15-20 contact hours during the academic year.

Control group subjects returned to their normal classes where instructors covered the same material. At the end of the academic year, students were given a posttest measure to quantify instructional gains.

Results

Description: A large-scale evaluation of the WPS tutor was conducted at seven schools in three states across the nation. The treatment group used the WPS tutor software and classroom instruction; the placebo group used the same set of computerized word problems but with no theory-driven instructional approach and classroom instruction; and the control group used traditional classroom instruction only. The study involved 632 students and 20 teachers (Wheeler & Regian, 1999).

Outcome: Students who used the WPS tutor outperformed students who used the placebo tutor and students who received traditional classroom only. The treatment group improved by 29%, while the placebo group improved by 18% and the control group improved by 19%. Further implementation issues dealing with site communication were raised and solved. In addition, differences in improvement between students' concrete reasoning skills and abstract reasoning skills were examined. In all three groups, there were larger increases in concrete reasoning performance than in abstract reasoning performance (see Table 1). The differences in change scores among the groups on both concrete and abstract reasoning scores were significant.

Groups	Percentage change on concrete reasoning	Percentage change on abstract reasoning
WPS Tutor	31%	20%
Placebo	19%	15%
Control	22%	11%

Table 1. Percent Changes in Concrete Reasoning Skills and Abstract Reasoning Skills

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