Positive technological and negative pre-test-score effects in a four-year assessment of low socioeconomic status K-8 student learning in computer-based Math and Language Arts courses

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ABSTRACT

Motivated by the Federal Title I program to improve the Math and Language Arts learning of underachieving students of low socioeconomic status, the Education Program for Gifted Youth (EPGY) at Stanford University has developed computer-based online Math and Language Arts courses for such students in elementary and middle schools. Using several large student samples, the four-year statistical assessment of state test performance is the focus of this report. The main statistical conclusion is that sustained and careful computer-based work, guided by motivated teachers, can be done by many, when taught on an individualized basis, at their current level of competence. The gains made by individual students are, to a large extent, monotonically increasing in their amount of net correct computer-based course work, and to an even larger extent monotonically decreasing as pre-test scores rise, a result that favors technological support of the more underachieving students.

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1. Introduction

This introduction covers briefly the objectives and background of this study.

1.1. Objectives of the study

The first, and certainly the most important, objective of this study is to assess the effectiveness of a supplementary technologically driven computer-based instruction program in Math and Language Arts for underachieving low socioeconomic status K-8 students.

The second objective is to assess with a hierarchical linear model (HLM) the classroom and school effects on student learning.

The third objective is to report on the use of complex computer software to assess the grammatical correctness of students' written work in the Language Arts course. This is the most sophisticated software used in the study.

1.2. Background of the study

Title I federal funding to public schools, as part of the 1965 Elementary and Secondary Education Act (ESEA), is committed to narrowing the gap between underachieving students of low socioeconomic status (SES) and their middle-class peers. In school year 2006–2007, Title I served more than 17 million students; about 60% were in Grades K-5 and 21% in Grades 6–8. Beginning in 1992, the Education Program for Gifted Youth (EPGY) at Stanford University has been developing computer-based distance-learning courses in Mathematics and Language Arts for Title I students. These two computer-based courses are actually derived from computer-based course work that began, even before Title I, at Stanford in 1960 in the Institute for Mathematical Studies in the Social Sciences, which the first author directed from 1960 to 1992. An account of this early work can be found in (Suppes, Jerman, & Brian, 1968; Suppes & Morningstar, 1972; Suppes, 1978, 1981; 1989).

Given the well-recognized difficulty of developing instructional regimes that measurably improve the performance of Title I students, EPGY Math and Language Arts courses have tried to do this by using important technological features: (*i*) progress is individualized for each

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student according to a stochastic motion driven by a learning model embedded in a computer program; (*ii*) responses to exercises are continually made by students seeing supporting visual displays and hearing associated audio lectures, ordinarily no longer than 90 s; (*iii*) hints, tailored to a student's wrong answers, are given by a computer program; (*iv*) immediate reinforcement determined by computer evaluation of individual responses is given at the end of each exercise.

All computer-based courses offered by EPGY use computer programs as the primary instructional resource. The computer presents students with multimedia lessons that introduce and illustrate concepts. Students have considerable control over the presentation and may review as often as they wish. The brief lectures are kept intentionally short and focused, usually ranging from thirty to ninety seconds.

Multimedia presentations are followed by exercises, which range from questions with exact mathematical answers, to ones in which students compose sentences in Language Arts. Their written sentences are evaluated for the correctness of their grammar and meaning.

Student work is evaluated by the computer and students get immediate individualized feedback. Incorrect answers are typically followed by individualized tutorial hints, in which students are given further instruction and asked to try again. These tutorial hints try to mimic the behavior of an expert tutor guiding a student to an understanding of an exercise for which the student has given an incorrect answer. This often requires different hints for different incorrect answers to the same exercise.

As a student progresses through an EPGY course, the software, using the results of prior assessments, individualizes the student's sequence of exercises. As a result, students who readily master a concept move quickly on to a new one, while students who need more, receive additional instruction and practice. Moreover, material that a student has trouble mastering is reviewed with a higher degree of frequency than material that the student learns quickly.

The Math course content has been correlated with the standards for a number of states, and also with those of the National Council for the Teachers of Mathematics, and the Common Core State Standards for Mathematics. Similar correlations have been done for the Language Arts courses.

2. Materials and methods

Subsection 2.1 describes the large samples of students that participated in this study. Subsection 2.2 describes the computer-based Math and Language Arts courses used in this study. The courses themselves were not created as part of this study. Subsection 2.3 describes methods of analysis used to study the data of students in the two courses. Subsection 2.4 concerns methods of assessment of student performance.

2.1. Sample sizes of student study groups

The data analyses that follow are for three Title I sample groups which include twelve study groups shown by year or multiple years, for example, Memphis Math, 08–09. The sample size of the study groups is shown in Table 1. One Title I sample group is made up of Memphis math elementary- and middle-school students, located in the Memphis City School System in Tennessee in 2007–2011. Four single-year and two multi-year studies are included for this group of students.

The second Title I sample group is made up of Memphis Language Arts (LA) students located in Memphis in 2009–2011 (two single-year and one multi-year studies are included for this group of students). The third Title I sample group is made up of the math students from seven California middle school districts in 2008–2011.

Table 1 shows the sample size of each study group. As would be expected, data from the same students are used in more than one sample group, mainly when single-year sample groups are included in multi-year sample groups.

2.2. Math and Language Arts courses

The most important materials of this study are the versions of the EPGY Math and Language Arts courses used in this study. These are the versions used by many students other than those in the study during 2007–2011. We emphasize these courses were not created, changed or modified for the purposes of this study.

Table 1
Sample sizes for each study group.

Sample group I	Sample size
Memphis Math, 07–08	11,397
Memphis Math, 08–09	27,500
Memphis Math, 09–10	20,821
Memphis Math, 10–11	19,438
Memphis Math, 08–11	4570
Memphis Math, 07–11	1659

Sample group II	Sample size
Memphis LA, 09–10	11,872
Memphis LA, 10–11	14,024
Memphis LA, 09–11	5149

Sample group III	Sample size
IES California Math, 08–09	724
IES California Math, 09–10	1445
IES California Math, 10–11	881