ABSTRACT

ANDERSON, MARK BUSEY. Features of PLATO, a Computer-Assisted Instruction Learning System, that Promote Students’ Mathematics Achievement: A Literature Review. (Under the direction of Lee V. Stiff.)

Many studies and analyses have sought evidence in support of computer-assisted instruction (CAI) programs, in general. PLATO, specifically, has gathered much attention as an alternative educational solution to traditional instruction. This learning system provides student users with a self-directed medium for learning. In addition to quality of content, three program features are important. Self-pacing and self-mastery features are integral parts of the PLATO software. The instructor-as-tutor feature is a resulting effect on the learning environment.

First developed over 40 years ago, PLATO has helped produce significant achievement scores and gains in a variety of learning contexts. However, little is known about how the features of self-pacing, self-mastery, and instructor-as-tutor contribute to the success of PLATO. Nor is it known whether PLATO is more effective and efficient than traditional classroom instruction. This paper addresses these concerns.

Based on a review of 22 studies, the aforementioned features of PLATO seem to reorient instruction around the student user, who assumes a greater degree of control over their own learning. Teachers become tutors, or guides, to students in a PLATO classroom. However, a limited population of students seems to have benefited from the use of PLATO programs. Hence, questions of equity and access are addressed.
FEATURES OF PLATO,
A COMPUTER-ASSISTED INSTRUCTION LEARNING SYSTEM,
THAT PROMOTE STUDENTS’ MATHEMATICS ACHIEVEMENT:
A LITERATURE REVIEW

by

MARK B. ANDERSON

A thesis submitted to the Graduate Faculty of
North Carolina State University
in partial fulfillment of the
requirements for the degree of
Master of Science

MATHEMATICS EDUCATION

Raleigh

2003

APPROVED BY:

Karen F. Hollebrands
E. Jacquelin Dietz

Lee V. Stiff
Chair of Advisory Committee
DEDICATION

This thesis is dedicated to my beautiful wife, Lisa. Thank you for your patience, support and love. To Wilmington we go!
BIOGRAPHY

Mark Busey Anderson was born in Topeka, Kansas to Bob and Sara Anderson, but grew up entirely in Cary, North Carolina. As a junior in AP English, ironically, Mark found inspiration to become a math teacher. Graduating from Cary High School in 1997, Mark attended North Carolina State University as a Teaching Fellow. He actively participated in the program and served as vice-president in his third year. Mark met Lisa Schaffer early in college, started dating his junior year, and was engaged before starting graduate school after his senior year. They are now married and plan to move to Wilmington where Mark will begin teaching in a high school.
ACKNOWLEDGEMENTS

First and foremost, I thank the Lord for His faithfulness and love for me. Might I always hide in my heart and demonstrate in my actions two of my life verses:

“Trust in the Lord with all your heart and lean not on your own understanding; in all you ways aknowledge him, and he will make you paths straight.” Proverbs 3:5-6

“Whatever you do, work at it with all your heart, as working for the Lord, not for men, since you know that you will receive an inheritance from the Lord as a reward.

It is the Lord Christ you are serving.” Colossians 3: 23-24

I thank Lisa, my best friend and wife – what a blessing you are to me! Thank you for finding creative ways to push me along with this work. I love you.

Thank you, Robin Rider, for listening to my rough ideas and helping me make sense of them and for your thoughtful insights. You are a great teacher and a wonderful person. You have really inspired me to be a hard-working and caring teacher.

Thank you, Dr. Lee Stiff, for providing me with direction when I most needed it, for demonstrating a zeal for math but more for students, and for showing me what a smart and deeply concerned teacher can do.
# Table of Contents

## CHAPTER ONE: INTRODUCTION  
1

- Brief History of PLATO  
  4
- Courseware Features  
  5
- Research Questions  
  6

## CHAPTER TWO: REVIEW OF LITERATURE  
7

- Effectiveness and Efficiency  
  7
- Review of Case Studies  
  8
  - Supplementary Implementations  
    10
  - Primary Implementations  
    13

## CHAPTER THREE: ANALYSIS AND DISCUSSION  
24

- Features  
  24
- Effectiveness and Efficiency  
  25
- Observations  
  27

## REFERENCES  
30
Chapter One: Introduction

“If having every student in the fourth grade use a comprehensive drill and practice math program is called integrating technology into the curriculum, then it will fail.” So says David Warlick in his book, Raw Materials for the Mind (2002, p. 6). Educators must not assume that any computer-based educational program having all the latest bells and whistles will be a viable educational remedy to student underachievement. Only careful research can determine whether a computer-based program can effectively improve student achievement. The term ‘computer-based learning systems’ is an all-inclusive descriptor. They are increasingly diverse, from “the fully assimilated usage of computer technology” (Papert¹, 1993, p. 41) in computer-assisted or computer-aided instruction (CAI) programs, to computational tools (calculators, spreadsheets, etc.), to microworlds that enable students to explore mathematical subdomains (e.g., Papert’s Logo Geometry as a medium for geometry exploration). This paper will investigate a computer-assisted instructional tool, the PLATO learning system, and its specific features. This analysis is valuable to those already using the program, and could provide insight into the program’s important features.

The tendency of some educators to embrace new technology should not override the necessary analysis of its effect on students. Similarly, parents, school administrators, policy makers, curriculum writers, and researchers must not be blinded by the commercially-marketed potential of CAI, in general, and PLATO in particular. Instead, any new computer-based learning system should undergo a systematic evaluation of its use. Seymour Papert, in The Children’s Machine, commented: “Statistical studies show that the introduction of CAI will often modestly raise test scores, especially at the low
end of the scale. But it does this without questioning the structure or educational goals of traditional school” (1993, p. 42). Any sensible use of CAI must be sensitive to the instructional objectives of the school (or school system) in which it is implemented.

Computers have long intrigued educators as a futuristic cure-all for school instruction. More powerful hardware and dynamic software promise to change education in significant ways. However, the challenge is to determine if more than the medium of instruction is changing – from chalkboard to computer screen. In other words, are these new systems and tools simply computerizing traditional worksheets? (See Papert, 1993, p.25.)

A key question is, How can computer-assisted instruction be soundly integrated into a curriculum? (See Warlick, 2002.) Three characteristics of computer-assisted instruction may provide important insights into this question. First, computer-assisted instruction often allows students to pace themselves. That is, students may opt for help (by clicking on the appropriate icon) or choose to move directly to a mastery test. Second, computer-assisted instruction can determine an individual student’s level of mastery, according to data collected from student practice. After completion of the automatically-delivered mastery test, the program scores the responses. Remediation follows for substandard results, or, for above-standard results, the program may move to the next topic. Third, computer-assisted instruction engages students in such a way that teachers may serve as tutors or coaches for students as they work through computer-assisted modules, or sets of predetermined lessons. This shall be referred to as “instructor-as-tutor,” which is in addition to the available tutorial options built into
PLATO. Through the scope of a literature review, this paper will evaluate PLATO and analyze these three specific features of computer-assisted instruction.

But what constitutes a “sound” integration of computer-assisted instruction into a curriculum? Of course, a program must present topics appropriate per grade level. But the effectiveness and efficiency of computer-assisted instruction will help qualify the soundness of a program’s integration. Examination of a program’s usage could point to its features that promote learning. (Hereafter, “features” will refer to options or qualities that are intrinsic or extrinsic to the program.) Therefore, the features of self-pacing, self-mastery, and instructor-as-tutor can be used to help determine the effectiveness and efficiency of a computer-based program in promoting students’ learning.

There are many benefits of computer applications in the classroom. Computers “furnish visual images of mathematical ideas, they facilitate organizing and analyzing data, and they compute efficiently and accurately” (NCTM, 2000, p. 24). A good CAI program empowers students to be autonomous in their learning. This autonomy does not imply that the students are completely independent of the teacher. For example, the microworld Logo Geometry has been cited as promoting student autonomy, which is beneficial to students’ heuristical learning (Clements and Battista, 2001). Nevertheless, Logo Geometry allows teachers to guide students through learning experiences by prompting them with activities and leading questions to promote greater reflection on ideas. In a similar way, CAI has the potential to promote students’ autonomy. An effective computer-based learning system enables teachers to multiply their efforts because they are freed to attend to an individual student’s needs, while others are continuously engaged in learning.
Brief History of PLATO

Current computer-based learning systems evolved out of primitive computers. As early as 1830, computers were emerging as tools for processing information. Charles Babbage invented the “Analytic Engine,” which could receive input and produce output in arithmetic computations. The first fully computer-based learning system, MARK I, was developed at Harvard University in 1944. Two years later, ENIAC was built at the University of Pennsylvania. These two early systems were the basis of all future computer-based educational systems.

A review of the history of PLATO is essential to understanding its teaching potential. PLATO exists now as software available on single computers or networks of computers. It grew out of NovaNET, which was originally, and still is, a “thinking machine.” That is, the system evaluates user input individually (i.e., per question) based on “judges” in its open language of code that calculate correct responses. This means that the system can accept a range of equivalent expressions or responses instead of a single or limited set of answers. The system also provides immediate feedback to the user. PLATO does not judge answers individually like NovaNET. PLATO judges responses holistically, meaning that the program detects a student’s level of mastery after a set of practice problems has been completed.

But how is PLATO categorized among the myriad computer-based programs that have educational applications? Goodyear defined “courseware” to be “any form of computer-based learning material or computer-aided learning system” (Goodyear, 1995;
see Goodyear, 1994). He presented a hierarchy (see Table 1) of three courseware types (see Mayes, 1993). According to his classification, PLATO is a Type I CAI program.

<table>
<thead>
<tr>
<th>TYPE I</th>
<th>Complex, large computer-based learning systems created by multidisciplinary teams</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE II</td>
<td>‘Desktop’ courseware produced by a lecturer or trainer for use in his/her own courses</td>
</tr>
<tr>
<td>TYPE III</td>
<td>Produced by learners as a product or by-product of their learning activity</td>
</tr>
</tbody>
</table>

Courseware Features

The three features of computer-assisted instruction that are important to analyze are self-pacing, self-mastery, and instructor-as-tutor. Using CAI without implementing these features would make CAI instruction resemble traditional instruction, in which the focal point of instruction is the teacher. In a typical classroom, the teacher determines when to begin the next topic, decides when to test, and employs a teacher-centered mode of instruction, such as lecture. In contrast, PLATO affords the opportunity for students to take responsibility for their own learning. Teachers have the opportunity to support students as they take on a new responsibility. PLATO offers a shifting of “epistemological authority” (Heid, 1997, p. 9).

The self-paced feature allows the student to regulate the speed at which he or she feels comfortable engaging the content. This means that a student may work through an extra problem to understand more fully a concept at issue. The self-mastery feature imposes an established standard to which the student will be held accountable. These objectives can even be chosen by the teacher prior to students’ use of the software. Self-mastery and self-pacing puts the student’s focus more on the software than the teacher (see Clements and Battista, 2001), thus encouraging the student’s cognitive autonomy.
The instructor-as-tutor feature is a by-product of the other two. That is, instructor-as-tutor is essentially a consequence of the self-pacing and self-mastery. As discussed previously, the instructor is freed by the students’ increased autonomy. With this freedom, teacher can act as facilitators of students’ learning, rather than a provider of subject material.

**Research Questions**

The goal of this paper is to draw attention to the particular qualities of educational software, programs, and systems that impact student learning. What attributes or features of PLATO contribute to improved student achievement? This paper will focus on the three features self-pacing, self-mastery, and instructor-as-tutor to determine their impact on students’ learning of mathematics in an effective and efficient way.

Stated simply, an effective CAI program is one that helps students score higher or perform better on achievement or competency tests than they would have without the computer-assisted instruction. An efficient CAI learning system, on the other hand, is one that is comparably effective as traditional teaching methods in comparable amounts of instruction time or less. In other words, effectiveness achieved in a shorter period is greater efficiency. Foshay cites Bracey (1982), who asserts “students learn more, retain more or learn the same amount faster using computers ... [but] no studies have been completed yet that tell us why that may be [emphasis added].” The analysis found in this paper is an attempt to say “why.”

¹ Seymour Papert does not support CAI, but does describe the type of program with succinct clarity.
Chapter Two: Review of Literature

The CAI program analyzed in this paper, the PLATO learning system, was chosen based on its interactivity, availability to schools, and ease of use. Interactivity can be identified by any element of the program that either illustrates some contextual change as prescribed by the user (e.g., applets) or provides feedback for learning within a specified time period. Interactivity can be either instantaneous (an immediate response, e.g., “You are correct!”) or delayed (test grade returned several hours or a few days later). PLATO is widely available across the country; it is available for kindergarten learners through adult learners. It is instructionally diverse and flexible, in that it teaches a variety of concepts within a variety of contexts. PLATO is easy to use. The program is simply navigated by even young users. PLATO’s design and structure guide users through predetermined lessons (usually based on a specific curriculum) in an easy straightforward manner. Based on these key elements and the current popularity of the PLATO learning system, an analysis of the program and its features is appropriate.

Effectiveness and Efficiency

Each CAI system or program can be described at some level of effectiveness and efficiency. Computer-based learning systems are effective if they have been empirically and scientifically shown to provide students a rich mathematical learning experience. Clements and Battista (2000) “take ‘effective’ to mean simultaneously pedagogically efficacious and fecund in the development of theoretical and empirical research” (p. 761). Specific features of such learning systems can be identified that promote fruitful learning. Less effective computer-based systems produce average results, and are comparable to
traditional teacher-led instruction. They could be used simply to reorient the locus of instruction from teacher to the computer without a drastic change in student achievement.

An efficient computer-based learning system will do all that an effective system can do, but in less time. A program is efficient that structures its lessons in such a way that students who have actually mastered a concept are moved on to the next concept quickly and naturally (i.e., connecting concepts meaningfully). Concepts are presented with a high “degree of transparency” (Heid, 1997) so that learners encounter the mathematics in an illustrative representation, thus maximizing time on task.

For example, in many cases, more than one representation more fully illustrates a particular concept. This second or even a third representation is also incorporated or weaved into the lesson, and not approached separately or disconnected from the primary representation of use. Efficient CAI systems provide learners with an encounter with a particular concept so that the students learn the concept effectively and in a proportionally short amount of time (depending on complexity).

**Review of Case Studies**

In *An Overview of the Research Base of PLATO® Software* (Foshay, 2002), a broad groundwork is laid to demonstrate the impact of PLATO on students’ learning. This technical paper presents a host of independent evaluations of PLATO. They include experimental as well as case studies. Each study was designed to evaluate the effectiveness of PLATO, in a variety of instructional settings. Foshay notes the importance of studying various implementation strategies, in order to make
recommendations for expected gains under different usage scenarios. Several other independent studies, not affiliated with Foshay, are also included.

Where no specific subject matter is cited, the concepts taught and learned in the study were topics from a curriculum assumed to be traditional per grade level. Because PLATO was studied in many contexts, the synthesis of data found in them provides a good opportunity to make conjectures about the capacity of the software, specifically its attributes of self-pacing, self-mastery, and instructor-as-tutor.

Each study was designed to evaluate the effectiveness of the PLATO learning system. This paper will provide a synthesis of the studies’ conclusions and extend to an analysis of the instructional attributes of the learning system. Therefore, the studies are used to make inferences about the program’s design features and its means of teaching the mathematical material.

The research on the PLATO system covers a range of implementation strategies. The three types of implementation strategies are supplementary, complementary, and primary (Foshay, 2002). With increasing instructional involvement, these strategies either supplement that which is being taught with other means through review and reinforcement; complement that which is being taught with other means by adding new content and instructional modes such as problem-solving activities, enrichment, remediation; or replace the usual means of instruction with PLATO as the primary medium for teaching new material. Because of its features, PLATO is most frequently used in a primary function, that is, to present concepts before, or, even in place of, an instructor teaching the concepts. Therefore, a majority of the studies evaluated PLATO in primary implementations. This review looks at studies that are either supplementary, or
primary; there were no studies that used the complement strategy. Studies are reviewed according to increasing ages of participating students.

**Supplementary Implementations.**

In a rural K-8 school in Arizona (Foshay, 2002), 100 elementary students participated in a case study, which was designed to evaluate the PLATO learning system, specifically on young students’ learning of math. Large numbers of minorities were represented in the sample. They included Hispanic, American Indian, Asian, and Black students. Implemented with a supplementary strategy, the study tested the effect of the program on students learning remedial elementary math, as well as elementary reading and language arts. A locally developed test was used during the study (used as pre- and posttest for grade 3), which lasted four weeks during a 64-hour summer program.

The most significant gains were in Grade 3 math where there was a 25% average improvement on the posttest compared to the pretest. Researchers found these correlations between PLATO use and achievement (reported as gains for grade 3) significant at p-value<.001. Only posttest scores were available for other grades; they showed all students were at or above the 63rd percentile among school-wide test scores.

Researchers also surveyed participating instructors. Overall, they rated the software “above average.” Instructors evaluated their own PLATO experience highly. In evaluating their students’ experience, however, the same instructors gave slightly lower ratings.

A case study (Foshay, 2002) conducted in a technical-vocational high school in Massachusetts evaluated the supplementary implementation of PLATO involving 77
ninth grade students. The urban students were bilingual or non-English speaking, and some had identified learning disabilities in math. The study was conducted during a 5-week summer remedial program. Participants had been the lowest scoring students of the lowest scoring school in the state, based on results from the school system’s standardized test. The case study was designed to assess the effect of PLATO on students’ learning of secondary mathematics. Students averaged 9-12 hours on the software, which was employed as a supplement to instruction, and they used the software 40-50 minutes each day, 4 days per week, for almost two months. The pre-and posttest used for measurement was a test commonly used by Boston Public Schools.

Data showed an increase from the pretest to posttest. The study showed a positive correlation, $r = .37$, between number of PLATO modules mastered and posttest scores. Although instructors and students favorably rated the PLATO software, they also reported a difficult learning curve in its use along with difficulties with the hardware. Furthermore, researchers found the participants – both teachers and students – somewhat skeptical about their use of the program. Teachers described the PLATO assessments as lengthy and sometimes repetitive of the practice material. Students, on the other hand, seemed to worry over their time spent with the software, reporting slight uncertainty (mean 2.4 out of 5, on a post-treatment survey) when evaluating the statement, “I feel I’m studying what I need to.” Lastly, teachers rated PLATO low on training, possibly indicating a less than perfect knowledge of the software. This discomfort could suggest a poor performance as tutors or coaches to the students.

A case study conducted in suburban North Carolina (Foshay, 2002) assessed the effects of two years of PLATO usage on 333 high school students’ learning of secondary
math. Almost all (320) students of the racially diverse population sampled were seeking recovery of credit that they had not yet received for required courses, because they had previously taken and not passed the courses. The study was implemented with a supplementary strategy and used the North Carolina Competency Test as its measure for the pre- and posttests.

All 320 students successfully recovered credit with the help of PLATO. But data for the remaining 13 students, who received test review and preparation for the same competency test in two separate groups, showed an average positive correlation, $r = .58$ (p-values slightly above $\alpha = .05$), between PLATO mastery and competency test scores. (It should be noted for comparison that higher correlations between PLATO mastery and competency test scores for reading, $r = .831$, and language arts, $r = .833$, were obtained.) Participating instructors reported that PLATO software contributed to student performance on the competency test.

A comparison study (Thayer, 1992) conducted in two urban high schools in Florida was designed to examine the effects of two different treatments on standardized test scores. The schools enrolled a predominantly Black population. The experimental group received both computer-assisted instruction through PLATO software and traditional instruction. Students used PLATO for one hour per week for 18 weeks. The control group received only traditional instruction. The State Student Assessment Test was used to gather post-treatment data on students’ use of the software.

The study did not conclude that changes in test scores of students in the experimental group (supplemental implementation) significantly exceeded test scores for students in the control group.
Primary Implementations.

A case study in an elementary school in Ohio (Foshay, 2002) gathered data on student achievement gains after three years. Of the 88 participating students, 84% were Black and more than half came from low-income families. They were students in grades 3-5 Title I math classes, which were taught using a traditional elementary curriculum in a block scheduling structure. Students would use PLATO as primary instruction for 30 minutes, and then rotate into small groups with teacher supervision for another 30 minutes. The measure used was the Ohio State Performance Test for mathematics.

Only 4% of students scored highly (i.e., proficient) on the pretest, while 24% of students showed end-of-year proficiency on the posttest. In contrast, the school-wide average showed 12% with end-of-year proficiency and in the school’s district an average of 14% showed proficiency. More than 80% of students showed gains. Low- and high-ability students showed similar gains.

An experimental study conducted in Grades 3 through 8 in California by Gifford (1980) investigated the rate of mastery learning of basic mathematics lessons. The study consisted of a series of modules, or instructional units with PLATO. Data were collected on the first four modules mastered by each of the 44 students for both minutes to complete a unit successfully and the number of failures before passing each mastery test. The testing measures used were the mastery tests given within the PLATO software. From the data the researcher found rate and failure trends and reported them as linear regression slope coefficients.

Average scores for failures from module one decreased on module two, but increased on both modules three and four. Using a t-test to analyze the rate of progress
between mastery tests, the researcher found no significant observed trends in the students’ performances. The study also accounted for level of entry knowledge and age. No significant effects were detected for these factors.

A comparison study at a suburban high school in Oregon (Foshay, 2002) evaluated PLATO used in a school remediation program. A total of 208 students participated in the study. The 117 learners using PLATO were given 45 minutes in a computer lab every other day for 1 school year; the 91 learners not using PLATO received only traditional classroom instruction. The 208 participating students were in ninth grade and had failed at least two parts of the state standardized assessment test in the eighth grade. Hispanics were the largest minority (20%) in the sample, and many students came from low-income families (30% on reduced meal plans). PLATO, in this study, served as a means of remediation of skills and concepts, through a primary implementation in the school’s learning lab.

Data showed an increase of four points for students using PLATO, which amounted to a statewide rank on the posttest in the 41st percentile. Non-PLATO learners showed lesser gains and lost nine points in their state ranking, moving from the 54th to the 45th percentile. Also, a significant correlation (r = .19, p < .001) was found between PLATO module mastery and post-test scores.

In surveys given, PLATO students reported increased confidence about their work in school. Learners using the program not only “found PLATO easy to use,” but were reportedly motivated by it to learn the presented material. Also, students agreed that the computer did not make them nervous. Teachers, on the other hand, reported that they believed students might have needed more time to complete the PLATO-based program.
A two-year case study designed to evaluate the effect of PLATO software on students’ learning of secondary math topics was conducted in a suburban high school in Florida (Foshay, 2002). The 31 participants – nearly a third of whom were minorities, and half from low-income families – had failed the state competency test and were using the PLATO software in a remedial lab, which taught skill remediation, SAT preparation, and other specific skill development.

Scores reported on pre- and posttests showed significant increases in math scores, with an average gain of 40 points and average exit mean of 717 points out of a possible 1000 points. All students passed a retest.

A case study (Foshay, 2002) conducted in North Carolina involved 25 rural high school students, who were from a population considered highly transient (i.e., from military or migrant worker backgrounds). The study was designed to assess PLATO in a remedial program for students who had failed the state competency test. The same state competency test was the instrument of measurement used in the study. The program was subject to the school’s structured block schedule, in which some of the school’s courses met between two and three times per week every other day for 90 minutes. The program lasted nearly an entire semester, or about four months.

Sixty percent of math students passed the state competency test after receiving primary instruction from PLATO software. Students gained a mean grade level of 1.68 in math. Instructors reported positive impressions about PLATO software and expanded its use to other applications within their curriculum.

A comparison study (Foshay, 2002) at a rural high school in Texas assessed PLATO as the primary means of instruction for a pullout program involving 264
students. The students’ performances were compared to state averages on the Texas Assessment of Academic Skills. This test and its corresponding practice test were used as measures in the program. Students used PLATO software at least twice a week (at least one hour per week) for two years. The diverse student population (56% minority, mostly Hispanic, 38%) participating in the program had either previously failed the state assessment (144 students in grades 11 and 12) or were considered at-risk (120 students in grade 10).

While the pass rate for the 11th and 12th grade students increased from 69% before the program to 83% after the program, these percentages still fell below the 86% statewide average for passing the assessment test. Nearly 75% of the high-risk 10th grade students passed the assessment test. The study also reported that 87.5% of at-risk 11th and 12th grade students, who had previously failed the assessment test, had passed the same test on a second attempt.

A quasi-experimental study (Wright, 1983) at two urban high schools in California was designed to compare PLATO (as well as a similar program on Apple computers) to traditional classroom instruction. Specifically, the study was an attempt to determine whether students using CAI would receive greater gain scores than students in conventional instruction. Participants were high school age and attended three classes during a six-week summer school session. The Comprehensive Test of Basic Skills was used to assess their achievement.

It was determined that students receiving traditional instruction were similar to those receiving CAI programs in terms of their academic abilities. Analysis of the
performance data showed that CAI (including PLATO) produced significantly higher scores compared to scores of students in the traditional instruction control group.

An experimental study conducted in a high school in Michigan (Elliott, 1985) was designed to investigate the effects of computer-assisted instruction, specifically PLATO, on basic skills of secondary vocational students. The experimental group, consisting of 96 students, received nearly a full academic year of regular use of the PLATO software. The control group, consisting of 95 students, received traditional instruction over the same period of time. The 3-R’s Standardized Achievement Test, Forms A and B, were used as pre- and posttests, respectively, at the beginning and end of the school year, respectively.

The data showed no significant difference between pre- and posttest scores for mathematics in the experimental group. Furthermore, no significant difference between experimental and control groups was found. However, students reported a preference for the PLATO method of learning over traditional methods of learning.

At a high school in Louisiana, a comparison study (Foshay, 2002) evaluated PLATO software for one year in a test preparation program with 138 low-performing students nearing graduation. The students were tested on basic secondary math topic with the Louisiana Education Assessment Program. The study was designed to measure students’ achievement with PLATO against other students’ achievement without the software.

Almost 80% of students using PLATO passed the assessment test, while only 50% of the students not using the software passed. Teachers cited PLATO as the reason for students’ success. They noted its self-pacing and self-mastery features as positively affecting student achievement. Students reported that they liked the software.
A case study conducted in Indiana (Foshay, 2002) gathered data over two years on 136 suburban high school students. Data were collected for one semester each year in alternate 90-minute blocks in a classroom and a computer lab equipped with PLATO software. The study sought to evaluate PLATO in a remedial program, in which the software was the primary means of instruction and a range of secondary math topics was covered. Students involved in the program had failed the Indiana State Test for Educational Progress. The students came from several levels of income; some were from military families; 25% were minority; and 30% performed below grade level.

After one semester of study during year one, math mean scores increased by 26 points; after two semesters of study math mean scores had increased by a total of 36 points. Researchers found these increases to be statistically significant. They also found positive correlations ($r = .44$, p-value < .001, and $r = .33$, p-value = .028, for the two semesters) between mastery of PLATO modules and success on the state test. On surveys teachers reported observing fewer discipline problems when students were using the PLATO software.

At an alternative, urban high school in Minnesota (T.H.E. Journal, 1990), a case study was conducted on the effect of PLATO instruction on students. Over the three-month treatment period, PLATO was the primary means of instruction, and students also received teacher support and extensive counseling outside the computer lab. All students were once dropouts and behind several grade levels, but were re-enrolled and, nonetheless, nearing graduation.

The students showed noticeable improvements, although no pre- or posttest was given. The study analyzed students’ gains on grade level and found the students had
improved their math computational skills by an average of 1.2 grades. Researchers also noted a “surprising” number of graduates enrolling in four-year colleges.

A quasi-experimental designed study was conducted to determine whether PLATO computer-assisted instruction or individualized instruction was more effective than the other in raising students’ achievement levels (Hakes, 1986). The 39 participants, including 17 minorities, were known to be functioning at the 8th grade level or below. They were students at an alternative high school in California and ranged in age from 14-18. Both programs taught computational skills and application of mathematical skills.

The researcher found no significant difference in mathematics achievement between the PLATO group and the individualized instruction group on computational or application skills. However, there was a significant difference in the computational skills of the minority students between the two groups.

A comparison study conducted in a large Ohio city (Foshay, 2002) evaluated PLATO results and the statewide results on the ACT Work Keys test. The test was also used as the instrument for measurement in the study. Implemented with a split supplementary-primary strategy, the study had learners under traditional instruction as well as using PLATO for learning new material. Participating students were of high school age and older; they attended one of four citywide vocational career centers. One of the centers also served as an accredited high school.

Researchers found 55% of learners using PLATO gained one level on the ACT Work Keys Applied Mathematics test, versus only 14% of non-PLATO learners. Results for learners in the center’s data processing career track, which used PLATO software as the primary implementation for its core curricula, showed gains on the test up to 44%
while learners in a non-PLATO program experienced a 36% decline on the Applied Mathematics test.

A comparative analysis of PLATO and traditional, individualized instruction was conducted by Barnett (1985). The analysis was completed after an 18-week program (two nine-week treatment periods) at two juvenile correction facilities in Pennsylvania. The program was intended to accelerate the increase in gains that were already being achieved in mathematics prior to the program inception. Participants were academically at-risk juvenile offenders who had been expected to be at high school grade levels (ninth and tenth grades), but were actually found to be at fifth and sixth grade levels in mathematics. They averaged nearly 27.5 hours of PLATO instruction. Consequently, most of the material covered by PLATO and teachers who provided individualized instruction was part of the traditional curriculum for the middle school level. Looking for increased gains beyond those already being earned, the pre- and posttests were given to the juveniles. They were randomly assigned to the two different treatments.

Results showed increases in both the PLATO and traditional, individualized instruction treatments. However, the data for both groups indicated that the juveniles’ gains were not significant.

A comparison study completed at an urban community college in Texas collected data from 81 students in a “Fundamentals of Mathematics I” course over a semester (Dixon, Dessens, Harris, and Neal, 1990). The course was part of a developmental studies math program. The students were low- to average-ability and had an average age near 20, and all had failed the college’s math proficiency test. The study implemented PLATO software for an average of 27 hours on 35 students in the experimental group. The 46
students in the control group received 48 hours of traditional instruction, over six weeks, with required homework. Students were tested with the Arithmetic and Basic Skills test, which is created by the Placement Test Program of the Mathematical Association of America.

The experimental group scored a mean of 15.49 on the pretest, while the control group scored a mean of 14.91. Pretest scores for the two groups were shown to be not statistically different. Mean score improvements on the test for the experimental and control groups were 7.8 and 5.2 points, respectively. The correlation, $r = .27$, between PLATO usage and gain scores was significant at .015 $\alpha$-level.

An experimental study was completed at the University of the West Indies (Anzalone, 1986) to evaluate PLATO instruction. The 47 participants (ages 18-24) composing the experimental group were students in the school’s Human Employment and Resource Training program. They received 28 hours of PLATO instruction over two months. The control group (also 47 students) received 28 hours of traditional instruction over two months. All 96 students scored below 50% on a separate basic skills test used for placement into the program. The study used two forms of the Adult Basic Learning Exam as pre- and posttests.

The evaluation found a significant difference in favor of the students receiving PLATO instruction when compared to the students receiving traditional instruction on the same basic skills. Researchers found that PLATO users outperformed students receiving traditional instruction. In the study PLATO users scored 50% higher than those students receiving traditional instruction.
A study by Mullinix (1980) was designed to investigate whether illiterate adult students’ entry level scores could be used as predictors for: (a) time in the PLATO basic skills program, (b) amount of material studied in the program, and (c) posttest scores. Scores were gathered from four tests, two on reading and two on mathematics. Students’ scheduled hours for study per week were also recorded and analyzed as another possible effect. The program itself was designed to bring the 70 participants to an eighth grade level of achievement. They were enrolled at an adult learning center in Maryland.

The analysis found significant correlations strongest between the Arithmetic Computation and Problem Solving test, which is part of the Adult Basic Learning Examination (ABLE), and predictability of performance on the PLATO learning system. The study provided these results as evidence that students’ success with PLATO, in particular, can be expected to align with performance on a specific pretest, ABLE in this case. This demonstrates the reliability of a pretest/posttest research design in an evaluation of the PLATO program.

A quasi-experimental study conducted at three locations in Louisiana and Mississippi (Reid, 1986) compared PLATO to traditional teaching methods in a context of adult basic education and General Education Development (GED). Pre- and posttests were given before and after the eight weeks of treatments to a total of 30 students. The instruments used for assessment were two versions of the Test of Adult Basic Education. They varied in difficulty, with the pretest labeled medium and the posttest labeled difficult.

Gains were reported in terms of grade levels, according to data gathered from the pre- and posttests. The traditional group showed an average gain of 1.1 grade levels, and
the PLATO group showed an average gain of 1.9 grade levels. Adjusting for the varied difficulties of the two tests, the researcher found no significant difference between the two groups at the .05 significance level.
Chapter Three: Analysis and Discussion

PLATO has been evaluated in many contexts, and the studies presented in the previous chapter represent a sample. In this chapter a synthesis will be attempted. The synthesis will provide a basis on which conjectures will be made about the capacity of the software, specifically its self-pacing, self-mastery, and instructor-as-tutor features. The effectiveness and efficiency of the program are in part attributable to these features.

The PLATO learning system has been implemented commonly using the supplementary and primary strategies. Because the results of the supplementary and primary studies are similar, the synthesis will include findings from both.

Features

A significant consequence of the primary strategy is the change in locus of instruction. Traditional instruction is teacher-centered, while computer-assisted instruction does not require much teacher involvement. Since CAI responds according to programs and input, two new major influences – the programmer and the user – affect the learning environment. The responsibility of instruction is effectively dispersed among three players: the programmer, the teacher, and the learner. The programmer must develop a program based on scientific research and accepted learning theory. Such knowledge guides the programmer’s approach to both presenting the mathematics and developing the software. The teacher facilitates the computer-assisted instruction, by ensuring that students are on task. Teachers help students when CAI is interrupted for any reason, and they should challenge students to demonstrate their mastery understanding in a supportive classroom, in which students are motivated to learn. With PLATO
instruction, the student must carefully monitor his or her own learning, and judge his or her progress. Self-pacing becomes an important aspect of student interactions with CAI.

Self-pacing supports individual needs for timely assessment. That is, the self-mastery feature allows the user to test himself or herself when needed or desired. The program’s capacity for automatic scoring enables the student to reflect on the assessment of his or her work, providing both quantitative and qualitative feedback.

The studies reviewed in this paper show that, because PLATO continuously engages students in instruction and testing, teachers are frequently released from these duties when students use the program. The studies indicate that instructors like using PLATO. Furthermore, because of the nature of the software and the contexts in which it is often used, PLATO is most frequently used with a primary strategy, in which the software is an alternative to teacher-led instruction. This strategy, more than the supplementary strategy, allows the teacher to assist students, giving them individual attention as they work.

The self-pacing, self-mastery, and instructor-as-tutor features come together to create a synergy that enhances student learning. Furthermore, these three features of PLATO are central ingredients affecting the effective and efficient learning of mathematics by students.

Effectiveness and Efficiency

In every study that was reviewed here, students using PLATO performed at least as well as or better than students in traditional classroom settings. This paper asserts that the successes of students are due in part to the self-pacing, self-mastery, and instructor-
as-tutor features of PLATO. In the studies reviewed, success with PLATO occurred as:
(a) significant gains attained over the treatment period, (b) grade levels gained during
 treatment period, and (c) good performances that went unreported due to nonsignificant
gains. As reported by several researchers, these successes, even when nonsignificant
gains were reported, produced desirable outcomes. Post-treatment surveys from the
studies reported students having greater confidence and fewer discipline problems
because of the program. Because students have clearly defined assignments within the
PLATO program, their time on task may also increase.

Time spent using PLATO was limited for students in some experimental groups
and case studies, probably because a school-wide computer lab was being used to access
the software. Although PLATO was accessible, the availability of a lab may have
shortened the length of time students could use the software. In particular, the software
may have been used for a specific unit of study lasting only a few weeks. Findings from
the studies indicate real potential for even greater achievement scores if the students were
given longer periods of time (several months) with their programs and greater frequency
(several times a week) of use. Despite these hindrances, PLATO users in every study
performed well and often in less time compared to the students receiving traditional
instruction in the control groups. Consequently, PLATO seems more efficient than
traditional instruction.

PLATO has also been shown to provide an efficient and accurate means of
assessment. A study conducted in Florida (Trifiletti, 1979) on students, age 8 and 9,
examined the potential of PLATO as a means of assessing a student’s basic operational
skills. The tests results from nine students were graded for accuracy. The data showed
that the computer assessment was 5.7 times faster than the traditional teacher assessment. The two assessments agreed on 91% of skills evaluated, and the computer was more accurate on the remaining disputed skills.

Given adequate time with the program, learners can effectively and efficiently use PLATO. From elementary schools to adult education centers, students using PLATO have performed well. Research has demonstrated the program’s success at different grade levels. This is evidence that supports the use of PLATO in multiple contexts. However, the populations sampled have had high percentages of low-performing students and minority students. Consequently, the conclusions that PLATO is effective and efficient (compared to traditional instruction) are specific to the populations of low-performing and minority students.

**Observations**

Do high-performing students and white students benefit from using PLATO? Asking this question reveals a subtle observation: PLATO seems rarely used strictly in the instruction of high-performing students from the majority population. None of the 22 studies reviewed in this paper were conducted in a context where students were a majority of students were described as high-performing; rather minority groups were highly represented.

CAI programs such as PLATO have inherent power, and are characterized by the self-pacing, self-mastery, and instructor-as-tutor features. Empowered by the self-directing software, students gain some control of their learning environment. Teachers are freed to observe students’ learning. With CAI, students and teachers can attend to
their roles in the classroom: student as learner and teacher as tutor. Students must actively build their knowledge (NCTM, 2000) and, with PLATO, students can take a greater responsibility for their learning. Teachers should challenge and support students (NCTM, 2000) and, with PLATO, instructors can be more intimately involved with students. In short, PLATO enables students and teachers to act out important aspects of the learning and teaching principles established by NCTM.

With the power of a CAI program such as PLATO established, the objective becomes the enhancement of the software to meet the needs of a larger population beyond those of just low-performing students and students from minorities. Certainly, all students would benefit even if PLATO were modified to instruct and to challenge students of all races and ability levels.

PLATO has been underused. High-performing students and students from non-minority backgrounds have not had access to the benefits of PLATO. It seems reasonable that all populations would succeed using PLATO, because of the benefits of the same self-directing structure. Students might benefit from more advanced CAI software equipped with dynamic applets. For two examples, see various applets at ExploreMath.com and the new JavaSketchpad (Key Curriculum Press). These applets allow students to investigate concepts of mathematics. Programmed links within CAI to “outsourced” applications such as Microsoft Excel, TI Interactive!™ (Texas Instruments), Geometer’s Sketchpad (Key Curriculum Press), MicroWorldsPRO (LCSI, Inc.), and Probability Explorer (Stohl, 2002) could empower students with the opportunity to investigate a mathematical concept more deeply. Links within PLATO to applets and applications would capitalize on the pointed objectives for learning outcomes.
that are the specific, specialized goals of those external resources. Therefore, it seems that marrying the architecture of PLATO to the strengths of other software would enhance an already effective PLATO program and make it useful to high-performing students.

CAI software designers should be encouraged to develop programs that meet the needs of all students, no matter what their prior performance may be. These programs would exploit the beneficial features of CAI, computational tools, and microworlds. Such programs are the future of education.
References


Thayer, J. (1992). The effect of the use of computer assisted instruction (CAI) on attitudes and computational scores of developmental mathematics students at two inner-city schools with predominantly black enrollment. (Doctoral Dissertation,


