DOCUMENT RESUME

ED 186 020 IR 008 386

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TITLE The PLATO Elementary Demonstration Educational Outcome Evaluation. Final Report: Summary and Conclusions.
INSTITUTION Illinois Univ., Urbana. Computer-Based Education Lab.
SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE Nov 78
NOTE 29p.; For a related document, see IR 008 384.

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Case Studies; *Computer Assisted Instruction; *Elementary Education; Elementary School Mathematics; *Mathematics Instruction; *Reading Instruction; *Summative Evaluation
IDENTIFIERS *PLATO

ABSTRACT

This summary report describes the development, implementation, and measured educational outcomes of a demonstration project of beginning reading and mathematics instruction utilizing the PLATO system with groups of elementary school children in Illinois. Extensive descriptions of the experiences and reactions of teachers and students in the classroom as the demonstration developed form the major part of this report. Because of teacher self-selection into the PLATO treatments, this was not a randomized experiment, but rather a naturalistic study in which comparisons could be made; however, a multiplicity of plausible explanations could be offered for differences in outcomes between PLATO and non-PLATO groups, and among classes taught by different teachers. Six case studies, based on observation, interviews, and teacher logs, document the problems of implementation, but also capture teachers' assessments of this developing technology. Demonstration year achievement and attitude outcomes for reading and mathematics are also included, as well as major findings. (RAO)

The PLATO Elementary Demonstration

Educational Outcome Evaluation

Final Report

Summary and Conclusions

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Submitted to the National Science Foundation

November, 1978

Introduction

This is the summary of a longer report of the results of a five-year evaluation of the Elementary Education Demonstration of the PLATO computer-based instructional system. The demonstration was conducted by the Computer-based Education Research Laboratory (CERL) of the University of Illinois, funded by the National Science Foundation. The evaluation was conducted by Educational Testing Service.

The full evaluation final report and a volume of appendices, including means, instruments and preliminary analyses, are available under separate cover.

Summary and Conclusions

The PLATO Elementary Demonstration

The PLATO System consists of a large central computer supporting over 1,000 widely-distributed and technically sophisticated terminals. The terminals are capable of delivering printed, animated graphic, color slide, and (with additional equipment) audio information to students in an individualized manner. Student responses entered via an alpha/numeric keyboard and a touch-sensitive terminal screen, are transmitted to the computer and processed according to the procedures of the particular programmed lesson in which the student is engaged.

The central computer returns feedback to the terminal almost instantaneously. This feedback may consist of judgments of the student's response, hints, new problems contingent on the response, or animated attention directors. Extensive record-keeping facilities make it possible to monitor the performance of each student, and to detect aspects of lessons that may need revision. Each terminal may also be used in the authoring mode, to program new lessons for the system in the TUTOR language; in the instructor mode, to monitor individual performance and to obtain summary information concerning a particular group of students and lessons (a "course"); and as an element in a real-time or in a "mailbox" communication network encompassing all terminals.

With National Science Foundation support, the developers of PLATO, the Computer-based Education Research Laboratory (CERL) of the University of Illinois, placed approximately 100 PLATO terminals and ancillary devices in elementary classrooms in the Champaign/Urbana area. Two groups of curriculum developers prepared lessons in beginning reading for children from kindergarten to grade two and in mathematics for children in grades four to six. The PLATO lessons were designed to supplement, but not to replace, regular classroom instruction.

Over the course of the 1975-76 demonstration year, over 300 students received mathematics lessons via PLATO, and over 700 students received reading lessons.

The Evaluation

This report describes the development, implementation and measured educational outcomes of this demonstration project from the point of view of an external evaluator. Although many of the instruments used were summative, or "bottom line," in design, the continuing evaluation of the projects made it clear that a more formative and process-oriented description of the context of the demonstration was essential for the interpretation of the results of the 1975-76 pilot and demonstration year periods. Thus, extensive description of the experiences and reactions of teachers and students in the classroom as the demonstration developed, form the centerpiece of the report. These observation and case study reports amply document the fact that the PLATO treatment was a collection of treatments, varying with the classrooms in its acceptance, intensity, integration or isolation from the ongoing curricula, and interaction with teacher coverage and style.

Because of teacher self-selection into the PLATO treatments, this was not a randomized experiment, but rather a naturalistic study in which comparisons could be made, but a multiplicity of plausible explanations could be offered for differences in outcomes between PLATO and non-PLATO groups, and among classes taught by different teachers. We have made these comparisons, and have weighed competing explanations to develop our conclusions. We have also attempted to provide sufficient descriptive information to enable others to weigh alternative explanations where appropriate.

As this has been written and reviewed, the PLATO system has continued to evolve with continuing technical and system developments and further development and refinement of the already effective elementary mathematics curriculum. The findings reported here, concerning impact at the end of the 1976 school year, may not estimate the effects of the current mathematics curriculum. Although revision of the PLATO Elementary Reading Curriculum (PERC) has also taken place, the data reported here do not give evidence that techniques for achievement-promoting outcomes were attained in the reading program during the evaluation period. In the absence of successful experience on which to build, it seems as likely that changes could have decreased as increased the effectiveness of the reading curriculum. Thus an argument from positive trend seems plausible for mathematics achievement, but less so for reading.

Implementation

As could be expected of an attempt at simultaneous development and manufacture of a technological medium, of new material for delivery by the medium, and of effective ways of using this resource in classrooms, delays and modifications in any one component led to dislocations throughout the system. In spite of a one year delay in the start of the demonstration, the beginning of the pilot year found neither the system nor the lessons ready to deliver instruction sufficiently reliably to warrant summative evaluation. The generally sympathetic reactions of teachers and students to the demands of the system and to the efforts of the developers to improve reliability and effectiveness offer insights into the resiliance of classrooms. They also point to the problems inherent in relying on feedback directly from volunteer teachers to developers in assessing the complexities and difficulties inherent in installing classroom innovations, or in assessing the effectiveness of such innovations. In the early stages of implementation, the developers appeared to be working so hard and against such frustration, that teachers were reluctant to give anything but positive feedback.

As the system stabilized, and the "early chaos" subsided, more teachers were willing to criticize and to demand more control over lesson selection and sequencing for their students.

During the pilot year, teacher support consisted partly of meetings, printed lesson descriptions and various drafts of terminal accessible and hard-copy student progress summaries. Some supplementary worksheet material was produced in the graph strand in mathematics. The major mode of support, however, was based on classroom visits and interactions with teachers and students by the developers, either in response to teacher requests for help or to the developers' desire to observe students working at the terminals and to diagnose system and lesson problems. This teacher support mechanism had the drawbacks of expense, lack of documentation for export to new sites, and the possible fostering of teacher dependence. Given simultaneous development and implementation, however, this melding of the system with the physical presence of developers in the classroom was not surprising.

During the demonstration year, the system stabilized and the mathematics curriculum began to approximate its planned form. Mathematics developers purposely kept their classroom presence to a minimum, and although delivery of the curriculum did not begin until two months into the school year, a reasonable test of the first-draft curriculum's effectiveness was possible. The reading curriculum, which had appeared to be at too low a level for most students in the pilot year, continued to undergo major revisions at the same time that it expanded its delivery from 15 to 25 classrooms. The demonstration year saw continued problems with hardware, the routing program, and lessons; major modifications were introduced in March of the demonstration year.

Classroom liaison personnel continued to play a major role in the reading implementation throughout the demonstration period.

Classroom Observations and Interviews

Information about various aspects of the implementation was obtained from teacher interviews and questionnaires and from observations of individual students and entire classrooms.

Observations revealed that the physical installation of PLATO terminals in the classroom proved to be relatively trouble-free, although actual operation of the terminals had a somewhat disrupting effect initially, and terminal fans generally raised room noise levels. Frequent system and terminal malfunctions added to disruption in the pilot year and audio device problems plagued the reading project well into the demonstration year.

Students exhibited considerable variation with respect to the amount of time needed to develop familiarity with terminals. The average time needed to develop independent use was about one week, with lower grade level students needing considerably more time than upper level students.

The necessary student orientation was accomplished by CERL staff, teacher aides, and in some cases, by other students who had had previous experience with the system. Student use of PLATO took place primarily within school hours, with equal time usually being given to all students. However, some students used terminals before and after school, and others gained access to terminals at the University on weekends. The volunteer teachers using the system exhibited considerable heterogeneity with respect to their knowledge and expectations of, as well as their interest in, the system. Although all teachers ultimately acquired at least minimal proficiency with terminals, a significant number felt inadequately prepared to deal with terminal problems.

Teachers' familiarity with the format, style, and content of PLATO lessons also varied considerably. Furthermore, teachers showed different preferences for various ways of becoming acquainted with lessons, with some preferring working through lessons themselves and others opting to read the program description book or observe the lessons as their students worked on them.

PLATO activities tended to remain largely independent of teachers' regular curricula, although the introduction of lesson prescriptions in the demonstration year had the effect of increasing integration somewhat.

Generally, teachers' perceptions of PLATO lesson materials were as diverse as the lessons themselves and usually depended on teachers' personal preferences, the curriculum materials they were currently using, and the ability and reactions of their students.

Although teachers were divergent in their views on using PLATO materials, most of them considered PLATO to be an effective means of providing reinforcement, practice, and individualization. The attribution of specific effects on learning, however, was more difficult. Reading teachers most often mentioned increases in the ability to follow directions and the development of listening skills as specific effect of PLATO. Although few teachers mentioned increased knowledge as an effect, several did report more positive student attitudes about subject matter.

Generally, teachers believed that the most able students benefited most from PLATO, largely because they found it easier to master the new method of learning offered by PLATO.

Math teachers were more favorably disposed toward PLATO than were reading teachers. Generally, teachers' approval or acceptance of PLATO was conditional, with many teachers mentioning the need for system and lesson improvement and more adequate implementation.

The classroom observations made during the pilot and demonstration years suggested that the reading classrooms in which PLATO was implemented were not atypical in their functional use of space and their use of various material resources and reading activities, although large-group instruction may have been rarer than the norm in these classes.

In general, reading teachers exhibited a low-to-moderate level of interaction with PLATO. There was generally little teacher use of the system to obtain information about student performance or to change childrens' PLATO assignments.

Extensive observations of a limited number of kindergarten classes during the demonstration year showed some diversity among the classrooms with respect to their organization and activity. As might be expected, these kindergarten classrooms were quite different from the first- and second-grade classrooms observed in the pilot year, especially with respect to their rare use of textbooks and workbooks. As with first- and second-grade classrooms, however, teachers seldom used the terminal to get information about students' work. Students in these classrooms were more often expected to follow the PLATO schedule, with other classroom activities interrupted when students' turns came up, than had been the case in the first- and second-grade classes observed in the pilot year.

The mathematics classrooms observed during the pilot year also varied with respect to physical setting and use of material resources and activities. Generally, the predominant feature of these classrooms was their extensive use of drill and practice of math operations and rules. Mathematics teachers showed only a modest amount of interaction with PLATO, seldom using it to obtain additional information about students or to assign them to PLATO lessons. Generally, mathematics teachers encouraged the use of PLATO, but again, as a classroom resource, PLATO was observed to be more isolated than integrated.

Results of observations of math classrooms during the demonstration year were quite similar to those obtained during the previous pilot year. There was an extremely wide variation among classes with respect to topic coverage and use of various materials. Regarding interaction with PLATO, there was some indication that PLATO scheduling was more strictly adhered to (especially in those classes participating for the first time), with PLATO taking precedence over other activities. Teachers, however, still showed relatively little interaction with terminals and there continued to be little effort devoted to relating PLATO content to regular lessons and little time spent discussing PLATO with students. Despite this relative lack of involvement, however, teachers more often made favorable than critical comments about PLATO's effect on student learning. Likewise, students were much more likely to find PLATO to be enjoyable than frustrating or boring as evidenced by their comments and their willingness to devote non-allotted or unscheduled time to PLATO.

Kindergarten and first-grade students' experiences with the PLATO system were recorded through structured observations and narrative accounts of individual students. These students exhibited various degrees of mastery of the mechanics of the PLATO terminal. Generally, most students used the keyboard effectively and most also showed sufficient facility with the audio unit. This was especially true with the improved second-generation audio devices, although the time needed to change discs was sometimes longer than desired. Microfiche, which was used relatively infrequently by students, was reported to be difficult to use. System (i.e., software) failures were quite rare, while hardware failures were somewhat more frequent and both types were more (indeed, unacceptably) often noted for reading than for math lessons.

Generally, students understanding of system directions was rated quite good, especially for upper grade level students. Their understanding of content, though somewhat lower, was also rated good. Most lessons were judged to be of appropriate difficulty, though a somewhat higher proportion of kindergarten and first-grade lessons were rated to be too easy by observers. Student attentiveness to lessons closely paralleled lesson appropriateness.

Student involvement with PLATO was high at all grade levels, with older students showing somewhat more attentiveness. Moreover, most students seemed relaxed and confident in their approach to PLATO. Some verbalization took the form of requests for help, although the number of requests for teacher assistance was relatively small. Older children were more likely to approach other children, instead of the teacher, for help. Children seemed able to help each other by guiding or giving information rather than by simply giving answers.

PLATO terminals also served as a social setting for students at upper grade levels. Much of the socializing observed was concerned with the content of PLATO lessons and with helping other students. Student interaction with CERL staff occurred through frequent use of the online "notes" option, which added considerable personalization to the PLATO experience.

A math coverage questionnaire showed considerable variation with respect to curriculum emphasis among PLATO and comparison teachers, and time and coverage within PLATO strands. PLATO teachers' emphasis in their regular teaching did not necessarily parallel their PLATO emphases, so that there was as frequently an inverse as a direct relationship between the emphasis associated with on-line and off-line lessons. Furthermore the observed variations in PLATO topic coverage were judged so extreme that PLATO could not be considered to have been a single, uniform treatment, but was used in different ways to either supplement or supplant quite different curricula in different curricula in different classrooms.

Case Studies

Six case studies, based on observations, interviews, and teacher logs, document the problems of implementation, but also capture teachers' assessments of less tangible positive and negative outcomes of opening their classrooms to a still-developing technology, outcomes not easily open to the more objective instruments employed in other components of the evaluation.

Case Study I: describes the experiences of the first-grade teacher who was most heavily involved with the PLATO Elementary Reading Curriculum. Her approach to reading instruction was consistent with the notion of a hierarchy of discrete subskills on which the curriculum was initially based. Partly because of this philosophical compatability, her expectations were high, and her record of encounters, first with the unreliability of the system and of the data it yielded, but increasingly with the lessons and their sequence, is one of growing frustration.

At the end of the pilot year, her summary was, "PLATO needs to give better results... to warrant the time and expense of the program."

During the demonstration year, her stance toward the curriculum became more critical. It was only with the opening up of teacher prescription in March that she began to feel that the system was beginning to justify the effort it required. Even then, the lack of sufficiently challenging lessons led her to conclude that PLATO had not realized the potential she saw for it. She did, however, note positive outcomes in motivation to read and write, in learning to type, in feeling of control over a complex machine. Toward the end of the year, she allowed some children to switch to the mathematics curriculum and reported, "They love it."

Learning outcomes from the reading lessons, however, were seen as occuring in such areas as following directions and taking turns, rather than in more specifically reading-related domains.

Case Study II: This first-grade teacher adopted a less critical stance to the specific value of learning activities, PLATO included. Children's enjoyment of an activity was a more central feature in her evaluation. She was less involved with the PLATO curriculum than was the teacher in Case Study I, but encouraged high usage of the terminals. Although complaining of interruptions, increased time demands for scheduling, and overly easy lessons which did not mesh with her curriculum, she retained a good-humored optimism at the end of the pilot year, feeling that "most children enjoyed it and learned many things," but that; "There is no way to be specific or list the many hidden things learned." As in the previously discussed class, learning outcomes were sufficiently well hidden to yield negative results on the Metropolitan Achievement Test.

In the demonstration year, considerable help (four to six weeks) was required from PERC staff in orienting children to the terminal. This teacher began to question the repetitiveness and heavy phonics orientation of the lessons. When the opportunity to prescribe lessons came, she did not become strongly involved in this activity, in keeping with her preference for personal contact over detailed curriculum analysis and planning. At the end of the demonstration year, in which her students had again logged a large number of hours on PLATO, this teacher was questioning--"What has PLATO done to make a change--I don't know if there is that much difference."

Case Study III: This mixed K-1 room in one of the two traditionally "innovative" schools in the University area, had a very different appearance from the more structured classrooms of the previous two case studies. Whole-group instruction was rare, with individual assignments and a steady flow of children in and out of small groups. The environment was complex, individualized, and occasionally, on the surface, disorganized. This teacher emphasized comprehension over the acquisition of discrete subskills, an approach not consonant with that of the preponderance of the PLATO Elementary Reading Curriculum (PERC) lessons. Many of the children in this class were already reading at the beginning of the school year.

Use of the terminals varied with children's interest, a lassaiz-faire approach to scheduling which made PERC staff uncomfortable. The teacher, in keeping with her use of multiple routes to multiple goals, treated PLATO as another resource which might be of value to some children. Overall usage in the pilot year was average, but with far more individual variation than in most classrooms.

At the end of the year, her class, as with most other PLATO classes, was lower than non-PLATO classes on the Word Knowledge and Word Analysis achievement tests, but above comparison classes on the Reading Test, a measure of comprehension least related to the content of the PLATO Elementary Reading Curriculum.

This teacher's enthusiasm for PLATO was low at the beginning of the demonstration year, partly because of the low difficulty level of the curriculum, and partly because of a feeling that the time demands for proper supervision of children at the terminals were excessive. "PLATO, for the little ones, is not as self-explanatory, not as self-correcting, as they (PERC) would like it to be." However, when the change to teacher prescription came, and with it, the opportunity to emphasize sentence and story-level materials, her involvement and enthusiasm increased sharply, as did that of her pupils. However, this new level of use again underscored the excessive time demands if teacher control over lesson assignment was to be exerted effectively. At the end of the demonstration year, the teacher saw PLATO, when under her control, to be useful for many of her children, but felt she did not have time to monitor each child's progress and prescribe weekly, as she felt she should.

This case illustrates the inferential value of a single case in providing a counterexample to a hypothesis. The senior author had approached early interview and classroom observation issues with the assumption that PLATO would require an "open classroom" environment to gain acceptance, and that more traditional teachers, holding the view that all children should go through similar experiences, possibly differing only in pace, would resent the interruptions and lack of control resulting from sharing responsibility with a stand-alone system. This case demonstrates that a teacher at the more "open" end of the continuum, although perhaps less concerned with control of student movement or form of experiences, was at least as concerned as were her more "structured" colleagues with the <u>content</u> of these experiences and, hence, even more demanding of control over PLATO. Thus the open/traditional dichotomy did not turn out to be useful in interpreting teacher acceptance, mode or amount of use of the resource.

Case Study IV. This sixth-grade teacher, with a group of high ability mathematics students, had 26 years of teaching experience, including experience with an earlier mathematics curriculum development and technology effort. She held high expectations for her students and for PLATO. In what was probably the most formal and didactic of the classrooms in the demonstration, the children, as well as the teacher, kept detailed logs of PLATO lessons, of problems encountered, and assessments of what had been learned. The teacher expressed considerable concern over work missed in other areas during their PLATO time slots, which, except for the graphing lessons at the beginning of the year, were seen as review of material her students had already mastered. She questioned the educational soundness of within-classroom terminal placement, as opposed to a terminal room. She registered concern over students' attempts to skip over the more difficult exercises, feeling that in some instances, "it might have fostered carelessness because it was easier to punch until correct than think out." The theme of concern for wasted time runs through her observations.

The teacher was positive about the general quality of the PLATO lessons, but was disappointed at their low level and lack of relationship to her curriculum, and at the early lack of teacher input in the development of the strands or control and prescription of their use.

At the end of the year, about one third of her students concurred that PLATO had not helped them in math, because it was too easy, but others felt that they had benefited in speed and in understanding of fractions and of signed numbers. The teacher, realizing that her incoming sixth graders in the demonstration year would all have been exposed to PLATO in grade five, and seeing little evidence of the system flexibility or new lesson development that would be required to enable her to choose and to integrate PLATO lessons with her teaching, withdrew from participation at the end of the pilot year. Although she remained positive about the potential of PLATO, the perceived lack of cooperative development by teachers and members of the curriculum team convinced her that the program was not appropriate and would not become appropriate for her students.

Case Study V: This fifth-grade classroom, in which students from two classes were grouped for PLATO mathematics and for science instruction, was taught by an experienced teacher whose first love was science instruction, with an emphasis on first-hand observation. The room and the students' day were highly structured, but characterized by a cooperative and friendly atmosphere. She was sympathetic to an approach to mathematics emphasizing problem-solving with understanding--goals highly consonant with the emphasis of the PLATO mathematics curriculum. She tried to encourage children to think and talk about the process of solving problems, rather than focussing only on one procedure and one answer. However, most mathematics instructional time is still devoted to drill in basic skills. Individual assignments in varying texts and worksheets, pairing for checking work, and individual consultation with the teacher were prominent in the full hour per day devoted to largely independent work on mathematics assignments.

In contrast to the reactions of the teacher in Case Study IV, this teacher found that the graphing lessons with which the pilot year began were too difficult for many of her fifth graders. The frequent requests for assistance with content as well as mechanical difficulties and the need to monitor progress, demanded more time, in class and after hours, than she could give.

With the advent of improved student record formats from the fraction strand, this teacher was able to exert more instructional control, consistent with her technique of allowing children on the terminals during only three hours of the day, and of attempting to utilize PLATO primarily as drill and practice, reinforcing topics already covered in class.

In spite of the tight scheduling, usage was high, and test results suggested that additional mathematics learning indeed had taken place. The demonstration year went smoothly for this teacher, again with positive achievement and attitudinal outcomes.

This teacher was disappointed to find that children with poor work habits carried them over to PLATO, but felt that the tremendous amount of practice provided to middle-achievers could only benefit these students. Her final comment about PLATO was that it was "just like any other method--only as good as the people who use it." In this case, the people who used it for curriculum development who had targeted most lessons at an appropriate level for these children, and their teacher, who used it as a controlled supplement to her curricular decisions, were apparently good enough to yield a positive result in mathematics learning.

<u>Case Study VI</u>: This fourth-grade class is the subject of a separately-published and highly detailed case study prepared by Bernadine Evans Stake. This exceptionally talented teacher was

intensely involved with PLATO, and achieved striking positive student results in mathematics achievement and in attitude toward mathematics.

It is not reasonable to attribute the outcomes in this classroom to PLATO or to the teacher alone, but it is difficult to separate the influence of the two partners. In the case of the graph strand in the demonstration year, for example, this teacher did not use most PLATO lessons, judging them to be too difficult for her fourth graders, but prepared worksheets based on PLATO lessons, with evident positive effect. It is not clear in this case that the teacher would have covered this topic had it been for the PLATO experience. Thus, we do not attempt to summarize this case, nor to generalize from it, but offer the complete study as a detailed description of a particularly successful example of PLATO implementation.

Demonstration Year Achievement Outcomes--Mathematics

Treatment effects were estimated as the difference between observed posttest scores and the scores attained by comparison of children with similar values of covariates (pretest, school, grade, sex, and their interactions). PLATO coverage, reported teacher emphasis, and student characteristics were taken into account in interpreting these results. Significant average treatment effects were found for the following grades and instruments:

• Grade 4	CTBS Level 2 Computation	Subtest	+4.77 points	$p<.0011$
•	Curriculum-referenced test	Whole Numbers	+2.79 points	$p<.01$
•	Curriculum-referenced test	Fractions	+5.36 points	$p<.0001$

(cont'd.)

• Grade 5	CTBS Level 3 Computation	Subtest	+3.42 points	$p<.05$
•	CTBS Level 2 Applications	Subtest	+1.21 points	$p<.05$
•	Curriculum-referenced test	Fractions	+3.21 points	$p<.01$
•	Curriculum-referenced test	Graphs	+2.34 points	$p<.001$
• Grade 6	CTBS Level 2 Computation	Subtest	+1.61 points	$p<.05$
•	CTBS Level 3 Computation	Subtest	+2.87 points	$p<.05$
•	Curriculum-referenced test	Fractions	+2.78 points	$p<.001$
•	Curriculum-referenced test	Graphs	+2.16 points	$p<.001$

Thus, there were significant positive PLATO effects at all grades on a nationally standardized (48-item) test of Computation and on a specially constructed (20-item) test of understanding and representation of fractions, the two higher grades showed significant positive PLATO effects on a test of graphs and linear equations, and grade 4 children exhibited a significant positive treatment effect on a test of understanding of whole number concepts and operations. Such grade-by-treatment interaction is consistent with the level of the strands: the whole number material representing review for many fifth and sixth graders, and the graphs material being quite advanced for many fourth graders.

In addition to these significant overall treatment main effects, significant school-by-treatment interactions were encountered on standardized test results in grades five and six, and on curriculum-referenced tests at all grades. These interactions, which suggested that the apparent treatment effects across different pairs of teachers varied beyond chance limits, were interpreted in the light of information available from process data. In grade four, a discrepantly high PLATO effect on graphs in one school V classroom was attributed to intensive teacher coverage rather than to direct PLATO effects. In grade five, a discrepantly low PLATO effect in school III Level 2 computation and whole numbers was interpreted as resulting from the teacher's decision to greatly reduce his own and PLATO's coverage of these topics on the erroneous assumption that they had already been mastered. PLATO fifth and sixth graders in a mixed grade class in the lowest-achieving school did poorly on CTBS Concepts and on whole numbers, reflecting student problems in reading the lesson instructions, and supporting the conclusion, based on positive treatment-by-pretest interactions, that there was a general tendency for the PLATO experience to most benefit the initially more able students.

Even in the face of these interactions, estimated PLATO effects were positive for all classes in Fractions, for all fourth-grade classes in Whole Numbers, and for all fifth- and sixth-grade classes in Graphs.

An apparent treatment-by-sex interaction in grade six was interpreted as an artifact due to the large number of sixth grade female PLATO students scoring near the ceiling of the CTBS Level 2 posttest.

Examination of reported teacher curriculum coverage showed that treatment effects were greatest on topics which both teacher and PLATO emphasized, but that for the majority of topics in which the PLATO teacher reported less coverage than did her comparison counterpart, treatment effects were still positive. Particularly in these latter cases, it seems reasonable to attribute the additional learning to PLATO.

Attitude Outcomes--Mathematics

Scales of attitudes toward reading and mathematics yielded:

- Significant improvements in attitudes toward reading and mathematics in grade four, with the change being greater in attitude toward mathematics.

- An almost significant (t = 1.80) improvement in attitude toward mathematics contrasting with a significant decrement in attitude toward reading in grade five.

- No measurable impact on attitudes in grade six.

- A less reliable locus of control scale did not yield significant effects at any grade, although there was an almost significant (t = 1.93) tendency for fifth-grade students to become more external in their attributions of responsibility for academic success. The nonsignificant effects at the other two grades were in the direction of increased internality, however.

Although positive, these attitude scale results are not as dramatic as are the mathematics achievement results, nor are they as large as those obtained during the pilot year. However, examination of individual item responses suggests that attitude toward mathematics as a whole may not be as useful a construct as are attitudes toward fractions, decimals, graphs, the latter of which declined in favorableness, in the face of sharply rising popularity of fractions and decimals among PLATO students.

Items concerning PLATO itself revealed great majorities at each grade agreeing that "PLATO is fun" and "helps me like math better," and majorities of fourth and fifth graders (but 49% of sixth graders) asserting that "I learn math more easily on PLATO." However, almost one-third of PLATO fourth and fifth graders and over half of sixth graders also agreed that "PLATO is fun at first but after a while it gets boring." Teachers' observations and evaluator's interviews suggested that a primary source of disaffection among students was a lack of more advanced lessons for children who had completed the existing curriculum.

The majority of students at all grades agreed that "There are a lot of times when PLATO doesn't work," and further that "I get mad when PLATO doesn't work."

Although fifth graders assented to "I like math better with PLATO than with my teacher," by more than two to one (the other two grades being about equally divided), children at all three grades disagreed with "I learn more math from PLATO than from my teacher," by well over two to one, suggesting that many children clearly differentiated enjoyment from learning, and saw PLATO as more strongly related to the former. A clue to one source of this differentiation is in curriculum integration, rather than in the hardware. Approximately one-third of PLATO students at each grade level agreed that "It's hard to see how PLATO math lessons fit together," a considerably larger proportion than agreed with this description of their teachers' lessons.

Demonstration Year Reading Outcomes

Significant negative pilot-year results in a well-controlled study of grade one PLATO Elementary Reading Curriculum outcomes led to a reassessment of evaluation priorities for the demonstration year. The readiness-oriented curriculum and malfunctioning automated management system held first graders in letter-recognition and phonics long after the point at which these skills had been mastered off-line and children were reading.

The reading developers placed their highest demonstration year priority on improving introductory materials, rather than on extending coverage to blending and comprehension content appropriate to the end of grade one. Therefore, it was decided by the National Science Foundation, a congeries of consultants, and the evaluator, that evaluation of the first-grade reading program during the demonstration year should focus on the process data derived from observations and interviews, with resources that had been allocated to securing grade one control groups diverted to strengthening the mathematics evaluation. As the case studies and observations revealed, although most teachers maintained a positive view of the potential of PLATO for teaching reading, and felt that procedural learnings had taken place, few specific reading outcomes from this curriculum were noted. It should be kept in mind that these teachers had a considerable investment of time and effort in the trial of the system, and were to be expected to see the results of PLATO in a rather positive light.

It was possible to conduct a controlled study of kindergarten effects during the demonstration year. Four kindergarten teachers introduced PLATO to their A.M. or P.M. classes in the first semester, and delayed use of the terminals until second semester for their other half-day class. This made possible a first-semester within-teacher comparison of achievement among 68 PLATO and 67 non-PLATO kindergarteners, balanced for morning and afternoon (traditionally, less mature children are tracked into morning kindergarten) exposure to PLATO. At the end of the first semester, PLATO children had averaged only about five hours (30 sessions) on PLATO, and had encountered continuing difficulties with the mechanics of discs, headphones, and the touch panel, as well as with system failures. Phonics lessons, which had been redesigned over the summer, proved to be confusing, and disrupting requests for teacher help were not infrequent.

It is difficult to envisage the mechanism by which this apparently innocuous intervention could have produced a significant effect on individual children, who were exposed to PLATO's ministrations for an average of five minutes per day. Yet, the impact on group achievement was significant and negative, suggesting that the level of classroom disruption may have been greater than was apparent to teachers or observers. The results on midyear standardized tests were significantly negative (4.7 points) for the two PLATO A.M. classes, even more negative (8.7 points) for one PLATO P.M. class, but positive on the average (1.6 points) for the other PLATO P.M. class, reflecting a PLATO by pretest interaction, which balanced a negative effect for initially lower-scoring students with a positive effect for initially more able students. PLATO effects on the curriculum-specific test balanced out, being about -2 for PLATO A.M. students and about +2 for the (more able) PLATO P.M. students.

It thus seemed that the PLATO Elementary Reading Curriculum, in its first-semester form, had, if anything, a negative effect on kindergarten reading achievement. Although the curriculum was again revised in the second semester, it was not possible to assess the effect of these final revisions.

Reading attitudes were assessed in the pilot and demonstration years among first-graders. Although attitudes toward PLATO were clearly positive among the children in both years, there was no evidence that these positive feelings transferred to the activity of reading.

Findings and Conclusions

Two major findings emerged from this evaluation:

1. The PLATO Elementary Mathematics Curriculum, in spite or because of its first-draft form and competing teaching philosophies, was a clear success when delivered in an "add on" mode, and was particularly successful when integrated with teacher mathematics coverage.

The mathematics treatment was associated with large achievement gains in grades four through six and with moderate positive attitude outcomes in grades four and five when it was presenting material that was neither overly familiar nor too far above the students' readiness level. The highly structured fractions strand, although sometimes less fun than whole numbers or graphs, was particularly effective in conveying understanding and skills.

A particularly important outcome was revealed in positive effects on instruments designed to measure students' understanding of and ability to represent concepts and operations, beyond mere facility in manipulation of symbols. The PLATO system here demonstrated that it was capable of <u>teaching</u>, as well as of providing drill and practice of concepts already introduced by classroom teachers.

2. The PLATO Elementary Reading Curriculum demonstrated negative impact on first-grade reading achievement in the pilot year and on kindergarten reading readiness achievement in the first semester of the demonstration year. No effect on attitudes toward reading was found. Additional ancillary hardware (in particular the audio device) with attendent production and implementation problems, and the immaturity of the target population (ages five to seven), were factors in this failure. However, in the opinion of the evaluators, the discrete and slow-moving curriculum, which, in contrast to the mathematics lessons, did not focus strongly on meaning or understanding, was a major contributing factor to this disappointing outcome. The reading development group worked according to an <u>a priori</u> hierarchical theory of reading acquisition which kept curriculum development on its initial path long after it became clear even to most of the reading developers that the approach was not reaching its goal.

In addition to these principal findings, we offer five conclusions, which although grounded in the experience of this project, may generalize beyond this particular demonstration of PLATO:

1. Teacher effects are real, large, and idiosyncratic. Requiring that a program demonstrate impact by swamping teacher variance (i.e., considering teacher effects to be part of the "error term" on the grounds that they are not subject to control and hence are policy-irrelevant) is tantamount to saying that a "treatment" is unitary and that teachers are interchangeable. Neither of these assumptions is tenable, nor is either likely to lead to progress in educational policy.

2. In spite of its apparent replicability, computer-assisted instruction is a treatment which interacts with its setting, and is no better than the curriculum it delivers. The PLATO system is relatively "transparent", in the sense that it imposes few limitations beyond those of the quality of lessons and routing procedures (including teacher decisions) implemented on the system.

3. Elementary teachers demand, and perform more effectively when given, control over curriculum. The data on individual students (particularly false-negative, or "goofing off" data) are not accessible to automated collection, nor do there exist "teacher-proof" algorithms for reducing these data to curricular decisions. The individual trade-offs in foregone alternative activities ("opportunity costs") for students and teachers were not accessible to the evaluation, but nevertheless were real, and important.

4. Simultaneous system and curriculum development is hazardous. In general, <u>much</u> more attention should be devoted to courseware than has been the norm in technological innovation. Preference

should be given to developers who are immersed in the subject-matter, who have extensive teaching experience, and who, ideally, have a track record of successful curriculum development in the subject-matter in other media. Those who are first attracted to the new medium and then begin to cast around for something to teach with it are not likely to develop effective curricula at first pass.

5. Teachers and students were quite positive about PLATO and its potential. We concur, in that the medium is attractive, flexible, highly interactive, and offers immediate feedback to lesson authors. PLATO has demonstrated its potential as a curriculum test bed, for refinement and perfecting of lesson ideas first tried out in the classroom by talented curriculum developers. We would recommend support of such use, for eventual translation to more limited and economical delivery systems. However, without considerable cost reduction, particularly in communication costs, we do not see PLATO IV as an economically viable delivery system for elementary schools, even with lessons as attractive and effective as those developed by the PLATO elementary mathematics groups.