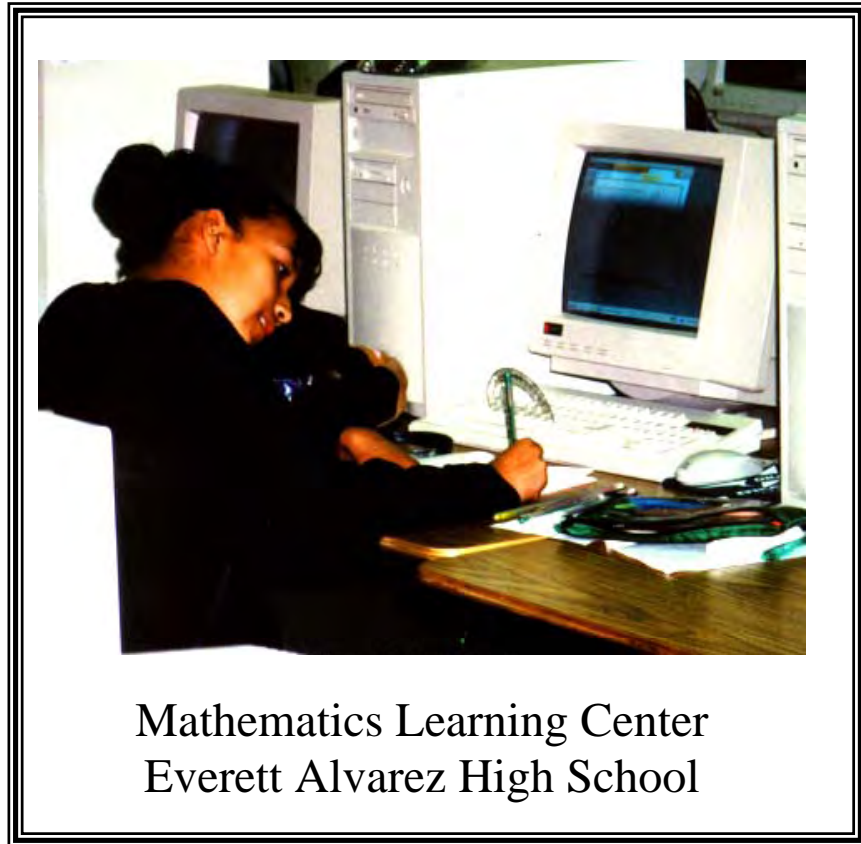


Year Three Report

Implementation and Evaluation of Technology-Based Multimedia Instructional Materials in Mathematics



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Implementation and Evaluation of Technology-Based Multimedia Instructional Materials in Mathematics: Report on the Third Year Field Test in a High School Setting¹

This document reports on the third year of a University—Schools—Business partnership undertaken to evaluate the effects of a comprehensive computer-based multimedia approach to mathematics instruction at the high school level, with support from the California Academic Partnership Program (CAPP).² The partners in this effort are the Everett Alvarez High School of the Salinas (California) Union High School District, the University of California, Santa Cruz, and Academic Systems of Mountain View, California. The instructional materials tested in this project address the skills and concepts of the Algebra curriculum, as well as those required for successful learning in Algebra (pre algebra).

In response to urgent needs to strengthen pre-college mathematics education, Academic Systems developed a new instructional method, called Mediated Learning, which integrates the knowledge gained from research on teaching and learning and on effective uses of technology. Mediated Learning takes advantage of the combined strengths of the instructor, the learner and multimedia technology to create an individualized environment that helps students learn and increases opportunities for instructors to work with individual learners and small groups of students with common needs (as revealed by the system's record-keeping functions).

The model preserves the core elements of traditional instruction, the instructor and printed text, and also integrates computer-mediated instruction, assessment and support. In this environment, the instructor spends less time lecturing and more time directing, modeling, coaching, guiding and mentoring. The system enables the instructor to determine which modules to include in the course and to monitor student progress. The computer engages students actively in every step of learning, and text materials permit them to reinforce and extend skills when they are away from the computer. The skills and concepts included in the software are typically taught at the high school or earlier levels, but to date the Mediated Learning materials have been used primarily for remedial purposes in postsecondary institutions.

This project to evaluate the effectiveness of Academic Systems' Interactive Mathematics materials at Everett Alvarez High School (EAHS) includes implementation and evaluation phases, accompanied by project dissemination activities. This report begins with a description of the setting of the project, and includes sections on implementation, evaluation and dissemination.

¹ This report includes updated versions of selected sections of the second year report.

² CAPP is an intersegmental agency created by the California State Legislature to test and promote activities designed to improve the preparation of all students to attend college. CAPP is administered by the California State University system.

1. The Setting

The Instructional Material

The instructional software to be tested was produced by Academic Systems, this project's business partner. Academic Systems describes *Interactive Mathematics* as computer-mediated instructional materials that are designed to help faculty increase student achievement. Instruction is faculty guided and learner centered³.

Academic Systems focused its marketing of *Interactive Mathematics* initially on two-year and four-year colleges and universities, with the result that hundreds of faculty members and more than 250,000 students have used *Interactive Mathematics*. Both formal evaluation studies and anecdotal reports from these institutions indicate that the company's Mediated Learning model and the *Interactive Mathematics* series are producing noteworthy improvements in student success in mathematics studies. Academic Systems recently has expanded the distribution of the *Interactive Mathematics* series to include limited institutional sales to grades 6–12. The series addresses mathematics concepts that are taught in most high schools and appears to be appropriate for secondary level students. Nevertheless, students, teachers and learning environments of the high school differ in many respects from those of the college or university. For example, a typical class of high school students, when compared to a typical class of college students, presumably will have lower average levels of mathematics achievement, academic motivation, and mastery of the English language.

The School ⁴

The 2000–2001 enrollment of Everett Alvarez High School (EAHS) totals 2,086 students, an increase of 10.8% over the previous year's enrollment of 1,882 students. The current enrollment has the following ethnicity: 74.9% Hispanic, 14.9% White, 4.7% Filipino, 2.1% Asian, 2.7% Black, 0.2% American Indian, 0.4% Pacific Islander, and 0.0% Multiple or No Response. EAHS' enrollment has an interesting anomaly in that females comprise only 48.0% of the total, indicating a possible high dropout rate for girls.

Of the total student enrollment for 2000–2001:

- 6.4% receive assistance through CalWorks; and
- 35.0% are in the free or reduced lunch program.

In 1999–2000 (data for the current year is not available), 43.6% of the students were English Learners; of these, 67.4% were English Language Mainstream students, 25.1% were Structured English Immersion students, and 7.6% were in an Alternative Course of Study.

EAHS currently has 361 computers, of which 331 (92%) have CD-ROM drives. Sixty of the school's classrooms are connected to the Internet and the district's Wide Area Network (WAN). EAHS has a student-to-computer ratio of 5.8:1, which is better than ratios for the district (8.4:1), Monterey County (7.9:1) and California (6.7:1).

The 2000 Academic Performance Index (API) for Alvarez High is 478, reflecting a

³ For more about Interactive Mathematics, see http://www.academic.com/Interactive_Mathematics/Overview.asp

⁴ The California Department of Education web site, [Hhttp://www.cde.ca.gov](http://www.cde.ca.gov)H, is the source of this school data.

decline from the 1999 API of 491. The 2000 API places the school in the 1st decile for all California schools and in the 3rd decile for 100 Similar Schools. The school's 2001 API target is 494. Alvarez High has a numerically significant enrollment of socioeconomically disadvantaged students: 589/2,086 (28.2%). For this subgroup, the API Base is 417 and the 2001 target is 430.

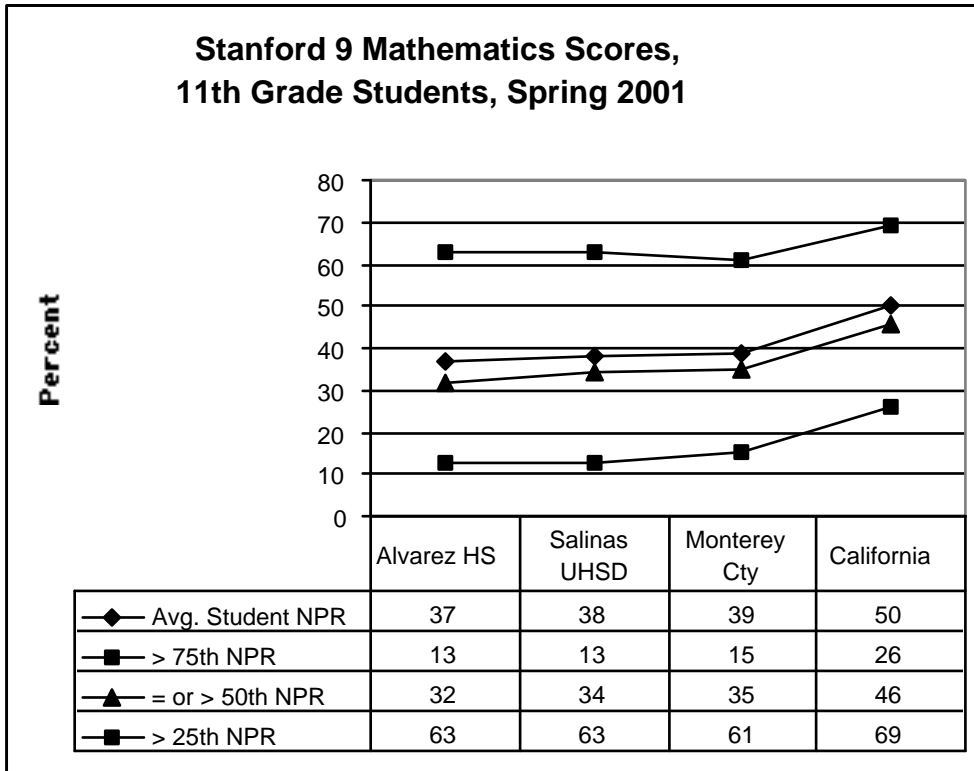
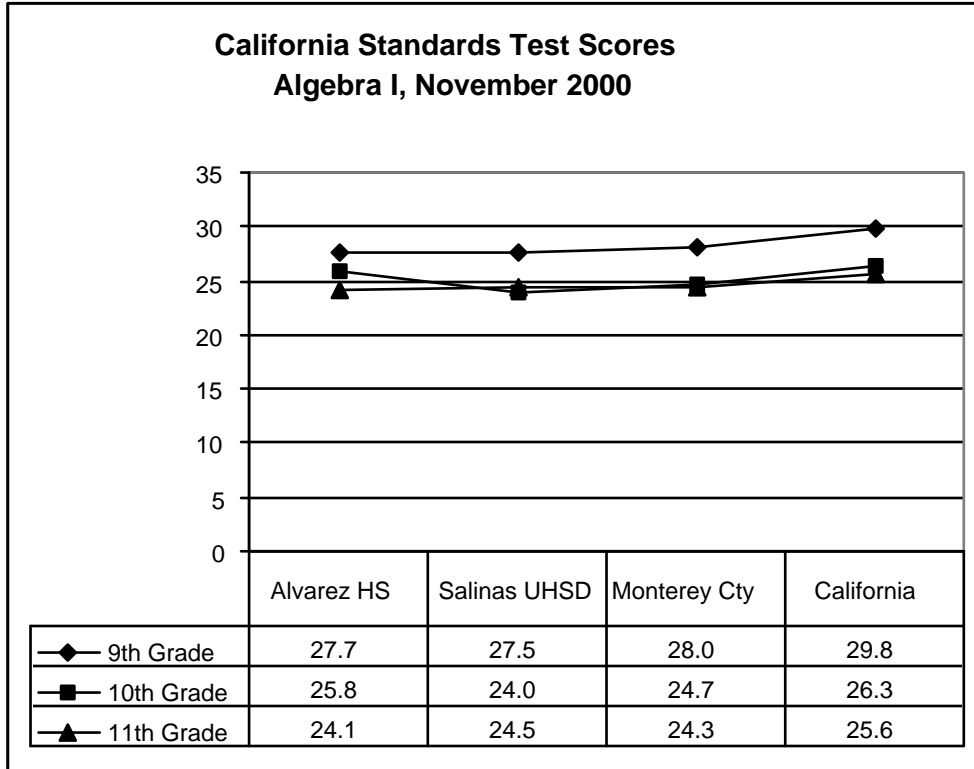
The following two pages present graphical comparisons of mathematics test scores by students at Alvarez High School, the Salinas Union High School District (Salinas UHSD), Monterey County and California.

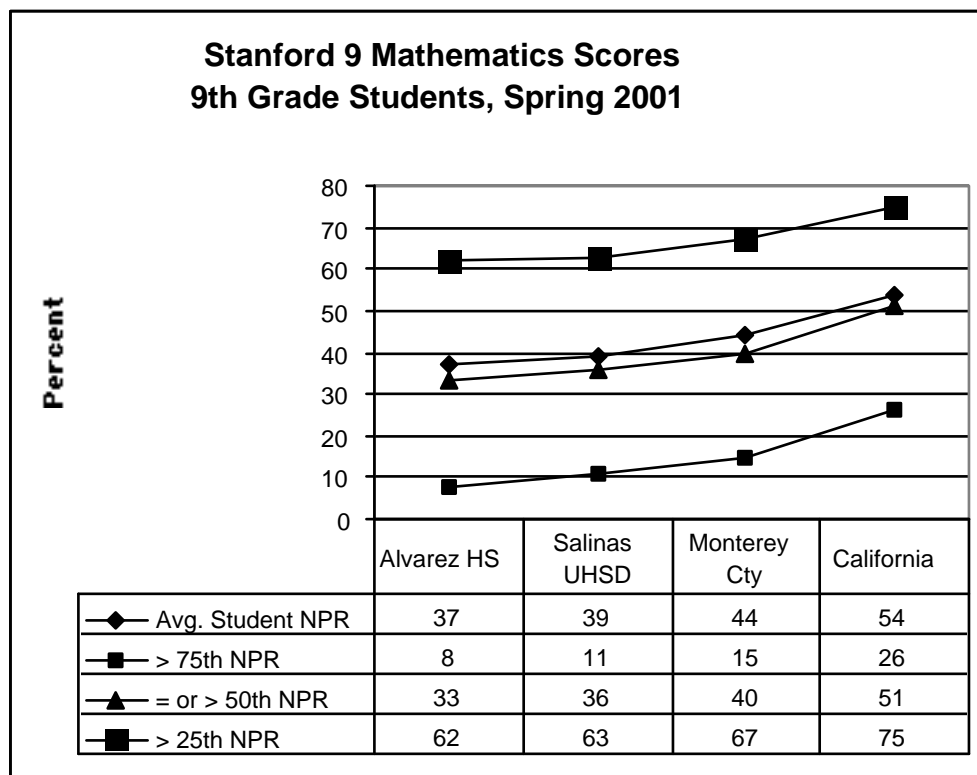
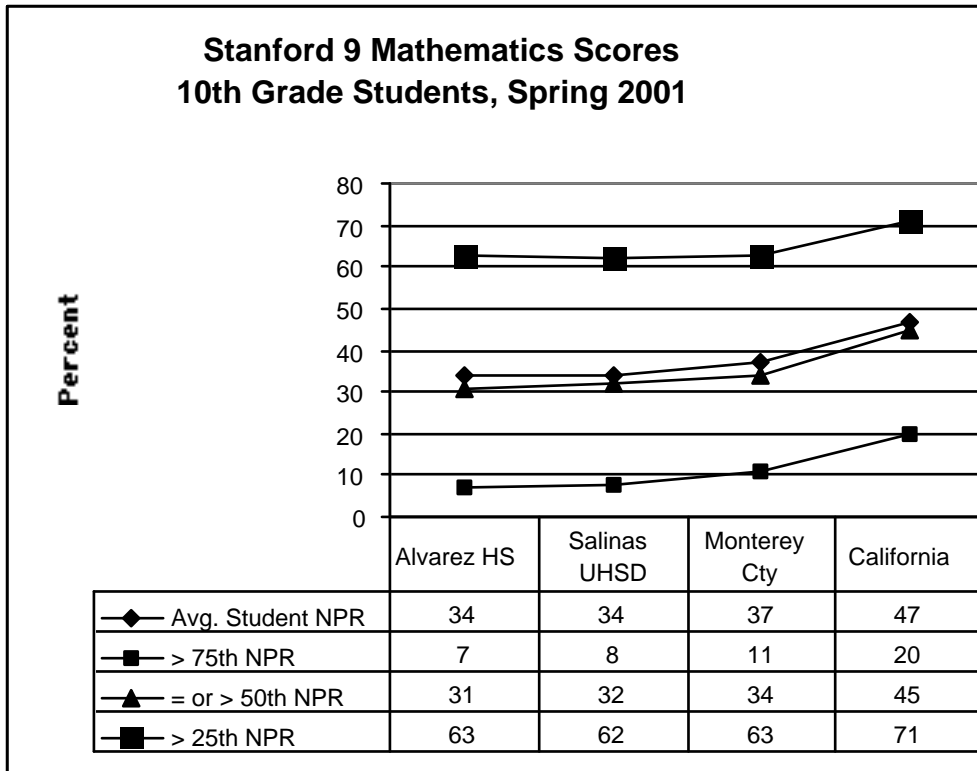
The first graph compares scores from the California Standards Test for Algebra I⁵ for these groups of students in the ninth, tenth and eleventh grades. The maximum possible score on this test is 65. This graph shows that scores for Alvarez High School students are similar to the scores for Salinas UHSD and Monterey County students, and lower than scores for California students. Interestingly, these scores for all groups trend lower as the students advance in the higher grades.

The second graph compares Stanford 9 Mathematics test performance by the same groups of students in the eleventh grade, as indicated by (a) the percent of students at selected levels of the National Percentile Rank (NPR) and (b) the NPR of the average student in each respective group. This graph shows that rankings for Alvarez High School students are similar to the rankings for Salinas UHSD and Monterey County students, and lower than rankings for students in California. For example, 13% of Alvarez High School students exceeded the 75th NPR, just half the percent of California students that exceeded that ranking.

The second, third and fourth graphs present Stanford 9 Mathematics test performance for these groups of students in the eleventh, tenth and ninth grades, respectively. Comparison of these graphs shows that average students at both Alvarez HS and Salinas UHSD achieved little or no improvement in their rankings during these years, while average students in Monterey County and California students actually achieved lower rankings.

⁵ This test is one of the California Standards Tests for mathematics included in California's STAR Program.





2. Implementation

Implementation Goals, Year Three

1. Provide *Interactive Mathematics* for uses in the Mathematics Learning Center during the 2000–2001 school year.
 - 1a. Provide thirty (30) sets of the *Interactive Mathematics* CD-ROMs and Personal Academic Notebooks (PANs).
 - 1b. Provide three (3) copies of the *Interactive Mathematics* Instructor’s Guide.
2. Prepare two (2) or more EAHS mathematics teachers for their instructional uses of *Interactive Mathematics* during the 2000–2001 school year.

Implementation Procedures

Two different courses, Pre-algebra and Algebra, were involved in the project. Scheduling at this school involved an “A-B block scheduling scheme”, with six classes (or blocks) meeting between 54 to 110 minutes per block (see Appendix A).

Unlike the first two years of this project, pre-algebra and algebra classes in the third year have been extended from semester to year-long courses that meet every other day. The schedule was arranged for odd and even numbered blocks to meet every other day for up to 110 minutes except for Wednesdays when all six classes meet between 54 to 60 minutes each. Students were assigned to sections on as random a basis as scheduling considerations in the school would permit.

Project Year Three included eight classes during the entire year. Two sections of the pre-algebra courses received technology-based multimedia instruction (Mediated Learning) and two received Traditional Instruction. For the algebra course, two sections received Mediated Learning and two received Traditional Instruction.

The teachers for both the Mediated Learning and Traditional Instruction classes were selected by the principal, in consultation with the mathematics faculty, as follows:

Teacher of Pre-algebra Mathematics, Mediated Learning (“Teacher B”)

B.A., History; Years of teaching mathematics: 12

Teachers of Survey Mathematics, Traditional Instruction

B.A., Mathematics; Years of teaching mathematics: 1

Teacher of Algebra, Mediated Learning (“Teacher A”)

B.S., Mathematics; Years of teaching mathematics: 6

Teachers of Algebra, Traditional Instruction

B.S., Biology; Years of teaching mathematics: 6

B.S., Mathematics; Years of teaching mathematics: 2

The third year of Mediated Learning instruction at Alvarez High was assigned to two mathematics teachers (“Teacher A” and “Teacher B”), each of whom have had one year’s experience with these materials. These two teachers made some adjustments in their students’ uses of the Mediated Learning software: as they did during Year Two, they limited the pace of the courses by shortening the assignments’ due dates within the range of two weeks. This change had been recommended by the Year One teachers who had encountered difficulties in making frequent adjustments to accommodate students who were progressing at different rates. One of the Year Two teachers felt the new pace made managing her students easier because it provided her with more time to use the software’s tracking system to check on students’ progress and assist them individually.

Another effect of restricting students’ pace was to make possible the inclusion of both short lectures (between 10 to 30 minutes) and practice problems at the beginning of each class session. The lectures were meant to introduce key aspects of the material and to “pre-teach” concepts that student might have difficulty in understanding from the software alone. The practice problems were used to ensure familiarity with solving problems using pencil and paper because some students from the previous year complained about difficulties with taking a written final examination after having used the Mediated Learning software for one semester. These new approaches appear to have addressed some of the challenges that emerged during Project Year One and Year Two.

A graduate research assistant from UC Santa Cruz was on site twice weekly in both the Mediated Learning and Traditional Instruction classrooms. He served as the liaison person with the administration and teachers involved in the project and assisted students who requested help from him when he was present. His work in the classrooms gave him a legitimate role in the school, enabling him to function as a participant observer. He coordinated the testing process, making sure that the appropriate testing materials were provided, keeping records of students who missed tests and arranging for prompt make-up testing.

The teaching assignment during Year Three was greatly compromised by the sudden resignation of a first-year teacher of mathematics. Her departure in the middle of the school year resulted in the need to relocate her students into the existing Traditional Instruction and Mediated Learning courses. In order to provide the needed space for students, the principal and members of the school’s Mathematics Department created study skills courses for students who were failing pre-algebra and algebra. The rates of transfer for all pre-algebra and algebra students out of their original classes and into study skills classes ranged from 20% to 50%. One Traditional Instruction class that had been included in the Year Three study was completely transferred from one teacher to a pre-algebra class taught a newly hired teacher.

Table 1. Total number of students who transferred during the academic year

Category	Number
Students who transferred in or out of Mediated Learning classes	153
Students who remained in the Mediated Learning condition	70
Students who transferred in or out of Traditional classes	193
Students who remained in the Traditional condition	81

3. Evaluation

Evaluation Goals, Year Three

1. Assess the effect of technology-based multimedia instruction in mathematics on the achievement of students in Survey Mathematics (Pre-Algebra)
 - 1a. Pre-test students with the Mathematics Diagnostic Testing Project's *Pre-Algebra Test*.
 - 1b. Post-test students with the Mathematics Diagnostic Testing Project's *Pre-Algebra Test* and the (project-developed) *Course Achievement Test for Survey Mathematics*.
 - 1c. Analyze and report findings
2. Assess the effect of technology-based multimedia instruction in mathematics on the achievement of students in Algebra
 - 2a. Pre-test students with the Mathematics Diagnostic Testing Project's *Pre-Algebra Test*.
 - 2b. Post-test students with the Mathematics Diagnostic Testing Project's *Pre-Algebra Test*. and the (project-developed) *Course Achievement Test for Algebra*.
 - 2c. Analyze and report findings
3. Assess the effect of technology-based multimedia instruction in mathematics on affective characteristics that research evidence has shown to predict future participation in mathematics and mathematics-related courses.
 - 3a. Pre-test and post-test both Survey Mathematics students and Algebra students with the (project developed) *Student Questionnaire*.
 - 3b. Analyze and report findings.

Evaluation Design, Year Three

Figure 1. Testing Sequence for Specific Cohorts and Courses

	FALL TERM	SPRING TERM
	Pretest	Posttest
PRE-ALGEBRA	Algebra Readiness Test Affective Measures	Course Achievement Test Algebra Readiness Test Affective Measures
ALGEBRA	Algebra Readiness Test Affective Measures	Course Achievement Test Affective Measures

We considered it inappropriate to use as a pre-measure a test that addresses the same content as the posttest for the algebra course. Too large a portion of the content and skills would be new and the experience of taking such a test would be frustrating and discouraging to the students. Therefore, the *Algebra Readiness Test* developed by California's Mathematics

Diagnostic Testing Program served as an entry measure (pretest) of mathematics achievement, to be used as a covariate in the analysis of mathematics achievement by algebra students.

Based on a recommendation of the CAPP Advisory Committee, an administration of the *Algebra Readiness Test* was added as a posttest so that it could be used as an additional achievement measure for the survey mathematics groups. This group received both pre and post administrations of the test.

Instrumentation

Achievement Measures:

Mathematics Diagnostic Testing Project's Algebra Readiness Test. The *Algebra Readiness Test*, created by the Mathematics Diagnostic Testing Project (MDTP), is made up of 50 multiple choice items covering topics such as decimals, equations, exponents, fractions, geometry, and integers. The test focuses on concepts and skills known to be essential for success in learning algebra while reflecting changes in curricular emphasis such as the greater attention to conceptual understanding. Students in the algebra and survey mathematics courses completed the test during the first week of the spring semester as a pre test to assess their knowledge of algebra. The same test was administered at the end of the spring semester to the survey mathematics students as a posttest.

Course Achievement Test. This test was developed within the project to measure mathematics achievement over the specific curriculum covered by the instruction in each of the two courses (survey mathematics and algebra). These measures served as a posttest and were administered as the final examination in the appropriate courses. Teachers reviewed Academic System's scope and sequence for the content to be covered in each of the two courses and designated the topics they felt were appropriate for the course in question. Then a mathematician from the business partner, Academic Systems, generated test items to reflect a sampling of the scope and sequence for each of the two courses. The items were then reviewed for appropriateness by teachers of both the Mediated Learning and Traditional Instruction classes. All 40 items on the survey mathematics test and algebra tests called for constructed responses.

The Stanford Achievement Test (9th Edition). High School General Mathematics. The use of the Stanford Achievement Test is mandated by the state of California. The High School General Mathematics sub-test was administered as part of the District's regular testing program. This measure was employed as a posttest, but the results should be interpreted with caution because it is administered early in the spring semester and is, therefore, likely to be rather insensitive to the effects of instruction during that semester. We expect it to be more useful in following students into the subsequent year.

Affective Measures

Mathematics Attitudes. Some research suggests that the attitudes that students hold toward mathematics influence achievement and participation in mathematics (Haladyna, Shaughnessy & Shaughnessy, 1983; McLeod, 1985; Silver, 1985). The expectation that positive attitudes towards mathematics would be associated with higher achievement, and that Mediated Learning would foster more positive attitudes was tested with data from a Mathematics Attitudes sub-scale of a Student Questionnaire. The Mathematics Attitudes sub-scale consisted of 18 items

consisting of statements such as “I really enjoy mathematics.” Students responded on a 6-point scale ranging from *definitely false* to *definitely true*. The sub-scale demonstrated very good reliability with this sample: Cronbach’s alpha was .93 on the pretest and .94 on the posttest.

Mathematics Self-Confidence. A body of research has shown that students’ self-efficacy beliefs regarding their ability to do mathematics is an especially strong predictor of mathematics achievement and participation (Hackett, 1985; Lopez & Lent, 1992; Pajares & Miller, 1995). The sub-scale consisted of 9 items, e.g., “I am quite good at mathematics.” presented in the same response format as described for the Mathematics Attitudes sub-scale. Reliability was acceptable (Pretest alpha = .80, posttest alpha = .70).

Computer Attitudes. Eight items were adapted from the Bath County Computer Attitude Scale (Francis & Evans, 1995) to form a sub-scale for computer attitudes. The items included statements such as “Computers help people to think” and “Computers provide a good way to learn mathematics.” Reliability ranged from .83 (pretest) to .77 (posttest).

Future. Students’ expectation for the future were assessed with a subset of 11 items from the National Education Longitudinal Study. Items consisted of statements such as “I will graduate from high school,” “I will go to college,” and “I will have a job that pays well”. Reliabilities were .89 (pretest) and .89 (posttest).

Global Self-Worth. Many educators believe that students’ general self-concept is affected by their success experiences, in school as well as other settings, and that a positive self-concept may, in turn, facilitate school learning. We used three items from Harter’s Adolescent Self Perception Profile as a measure of general self-concept. Item analysis based on previous samples similar to the present one have shown these three items to have the best psychometric characteristics of Harter’s five Global Self-Worth items. With the present sample, reliabilities ranged from .77 (pretest) to .80 (posttest).

Challenge-Seeking/Persistence. This sub-scale consisting of four items was developed to assess one aspect of goal orientations. Goal orientations have been identified as potentially important contributors to academic achievement in general (Dweck, 1986; Dweck & Leggett, 1988; Elliot & Dweck, 1988), and in mathematics in particular (Peterson, 1988). Students responded to statements such as “I enjoy the challenge of a difficult math assignment,” and “When I have trouble solving a problem, I’m one of those people who tries harder than ever”. Reliabilities with the present sample were .77 (pretest) and .83 (posttest).

Procedures

The *Algebra Readiness Test* was administered to students in both courses on the first week of the fall and spring semesters (late August and January, respectively). The research assistant read the instructions aloud, after which the students were given up to an hour to complete the diagnostic test without using a calculator. Students who were absent on the day of the test made it up within the week. Two weeks before the end of each semester (early January and late May, respectively), students in the six survey mathematics classes took the *Algebra Readiness Test* again as a posttest measure.

The *Student Questionnaire* (affective measures) was administered on the same day as the *Algebra Readiness Test*. Both courses received the *Student Questionnaire* as a pre- and post-affective measure. Students took up to 20 minutes to complete the 53-item survey. Students

responded to each of the items using the following scale: 1–Definitely false, 2–False, 3–More false than true, 4–More true than false, 5–True, and 6–Definitely true. As a means of avoiding a response set on the part of students, some items were phrased so that scoring was reversed, e.g., Definitely true was scored 1, etc.

The *Course Achievement Test* (final examination) was administered on the last week of each semester (early January and June, respectively). Both survey mathematics students and algebra students received a 40–item test. Students were not allowed to use calculators during the exam. The test instructions emphasized the importance of students showing their work on the worksheets so that partial credit could be awarded.

Two research assistants who had been on site during the entire academic year scored the tests. During Project Year One, one of the research assistants collaborated with three of the four teachers to develop the criteria for awarding partial points. The inter-rater reliability was analyzed separately for the survey mathematics and algebra final examinations. The two research assistants achieved a Cohen’s Kappa of .99 for the *Course Achievement Test for Pre-algebra* and .98 for the *Course Achievement Test for Algebra*.

4. Findings

We present here analyses of the achievement and affective outcomes for students who remained in the same treatment (either the Traditional Instruction treatment or the Mediated Learning treatment) throughout the year. Students who transferred in or out of the Mediated Learning treatment were omitted from the analyses. Students who were originally in the Traditional Instruction treatment and later transferred into a different class that also employed Traditional Instruction were not omitted from the analyses because their experimental condition remained the same.

Pre-algebra Classes

Achievement

The pre- and post-test MDTP *Algebra Readiness Test* data of pre-algebra students ($n = 52$) were examined by means of a repeated measures ANOVA with Treatment (Traditional Instruction and Mediated Learning) and Gender (male and female) as factors. The results showed no significant interaction between Treatments. The main effect for Treatment was also not significant. There was no Treatment by Trials interaction, indicating that there were no differences in the pre- to post-test change between Traditional Instruction group and the Mediated Learning group. The main effect for gender and the treatment by gender interaction term were non-significant.

The *Course Achievement Test* (final examination) was analyzed for 51 students by means of an analysis of covariance (ANCOVA) with Treatment and Gender as the factors and posttest (final examination) scores as the dependent variable. MDTP *Algebra Readiness Test* pretest scores served as the covariate. The main effect for Treatment was not significant. The main effect for gender and the Treatment by Gender interaction were not significant.

An additional ANCOVA using students' Stanford 9 test scores ($n = 65$) as the covariate showed a significant main effect for Treatment ($F = 4.33$, $df 1/60$, $p < .05$), with Mediated Learning students scoring higher than Traditionally instructed students (adjusted least squares mean = 18.49 vs. 16.18, respectively).

Affect

Analyses of variance were used to compare pre- and post-treatment scores on the following affective measures: Math Attitudes, Global Self-Worth, Future Involvement in Mathematics, Computer Attitudes, and Challenge-Seeking/Persistence. Independent variables in the analyses were Treatment and Gender.

The only significant finding was for Computer Attitude and Future (students' expectation for the future). The analysis for Computer Attitude ($n=50$) yielded a significant main effect for Treatment ($F = 4.73$, $df 1/46$, $p < .05$). Students in Mediated Learning indicated more positive attitude towards computers (mean = 32.6) as compared to students in the Traditional Pre-algebra course (mean = 29.3).

In general, female students indicated significantly more positive expectations ($F = 8.46$, $df 1/47$, $p < .01$) for their future (mean = 61.9) than boys (mean = 56.7).

Algebra Classes

Achievement

MDTP scores for students who took Algebra during the academic year ($n = 65$) were available only for the pretest. An analysis of variance was employed to determine if students in the Mediated Learning and Traditional Instruction treatments differed in performance on the Mathematics Diagnostic Test. Gender was included in the analysis to determine if the treatments had differential effects on males and females. Both the Treatment by Gender interaction and the main effect for treatment were non-significant.

An analysis of variance was employed to determine if students in the Mediated Learning and Traditional Instruction treatments ($n = 65$) differed in performance on the Mathematics Diagnostic Test. Gender was included in the analysis to determine if the treatments had differential effects on males and females.

An analysis of covariance (ANCOVA), with the MDTP pretest scores as the covariate, the final examination posttest as the dependent variable and treatment and gender as factors ($n=33$) yielded significant main effect for gender on the final examination performance ($F = 10.31$, $df 1/64$, $p < .01$) and a significant gender by treatment interaction ($F = 4.76$, $df 1/64$, $p < .05$).

- Overall, female students in the study scored significantly higher (adjusted least squares mean = 17.42) than male students (adjusted least squares mean = 14.62) on the written course final examination.
- The significant gender by treatment interactions indicate that females in the Mediated Learning condition demonstrated higher course exam scores (adjusted least squares mean = 19) than males students in the same condition (adjusted least squares mean = 13.1) and both males (adjusted least squares mean = 15.6) and females (adjusted least squares mean = 15.7) in the Traditional Instruction condition.

The main effect for Treatment was not significant.

Affect

Analyses of variance were used to compare Algebra students on the following affective measures: Mathematics Attitudes, Math Self-Confidence, Global Self-Worth, Future Involvement in Mathematics, Computer Attitudes, and Challenge-Seeking/Persistence. Dependent variables in the analyses were Treatment and Gender. All results from the analyses of Mathematics Attitudes and Future Engagement in Mathematics were non-significant.

Longitudinal Analyses

One of the objectives of this project was to follow the progress of students as they transitioned from the pre-algebra to algebra Mediated Learning courses. Due to enrollment decisions that made by the Alvarez High School administration (and that were beyond our control), the vast majority of students who were enrolled in the Mediated Learning pre-algebra course did not get assigned to the Mediated Learning algebra course in the following semester. In fact, as of the end of the three-year study period, of the 704 students who had been included in the study, only 15 of the students who studied pre-algebra in a Mediated Learning course were

subsequently placed in a Mediated Learning course to study algebra. The data sample also included a cohort of 40 students who took at least one semester in either Mediated Learning course and a cohort of 26 students who never experienced a Mediated Learning course. An exploratory analysis of covariance was used to examine the achievement of students from these three cohorts. The large majority of the students who were in the study for one semester was later enrolled in other classes and was not tracked for follow-up testing.

An analysis of covariance, with MDTP pretest as the covariate, the MDTP posttest as the dependent variable produced non-significant differences between the posttest scores of the three cohorts. As for their course examination test scores, students from Year One had to be omitted from the analysis because they were administered a 50-problem exam while students from Year Two and Three completed a 40-problem exam. The course examination scores for Year Two and Three students ($n = 10$) were also examined using an analysis of covariance, with MDTP pretest score as the covariate. There were no significant differences between the course examination scores of the three cohorts.

5. Teacher and Student Reactions to the Mediated Learning Approach

In Year Three, added emphasis was placed on collecting descriptive and quantitative interview data from the students.

Teacher Reactions

Both Mediated Learning teachers in Year Three had had a year's experience with the software. Teacher B previously had taught both pre-algebra and algebra with the Mediated Learning material but Teacher A had had no previous experience with the Mediated Learning algebra material. Their continued participation in the research this year minimized the time and training normally necessary as preparation for using the Mediated Learning material.

Both pre-algebra and algebra classroom practices and instructional guidelines were based on the template from Year Two. Lectures and warm-up problems were part of the daily lessons. The pace of the courses remained regulated to keep students on track of the lesson schedules. The greatest difference in Year Three was the new class schedule, which expanded a semester course to one year. During the first half of the year, Teacher B noted a higher rate of missing homework assignments from her students. Although the reasons remain unclear, she suggested that many might have forgotten or put aside the assignment because most of the classes met every other day.

Overall, there were few experiences that distinguished the Year Three teachers from those who taught during the previous two years. One main concern that was not resolved throughout the year was over the technical difficulties that interrupted everyone's progress. One teacher identified the lack of technical support as the most obstructive factor to teaching and learning during the year. The number of failing computers and monitors became a weekly obstacle for teachers and students. Other technical drawbacks included broken headphones and missing mouse track balls, rendering useless both the audio option and the mouse. Despite the continuing difficulties, teachers stated that they were willing to modify their instructional style in the future to take advantage of the potentials of the Mediated Learning software in a high school setting, on the condition that there would be more technical support.

Student Reactions

Many students in the Mediated Learning approach were affected by the resignation of a mathematics teacher in the middle of the school year. As described above (p. 7), the departure of this teacher required the transfer of literally hundreds of mathematics students. Also, for students in Teacher A's Mediated Learning algebra courses, the disruption was more profound after she left school on maternity leave at the beginning of May, seven weeks before the end of the academic year.

Students from both courses were interviewed individually during the last week of school. The following reactions are based on the responses of 19 pre-algebra and 25 algebra students. Due to the informality of the interviews, only frequencies and percentages of student opinions are reported and discussed.

Pre-algebra

The majority of Pre-algebra students (89.5%) enjoyed using the Mediated Learning software to learn mathematics. Some expressed the view that learning mathematics using the software was fun and easier than working with a textbook. Everyone indicated that they liked using computers and most (94.7%) found the Mediated Learning software to be a very well crafted and useful tool. When they were asked to rate their own progress in the class, 79% of the students felt they did better work than expected in this class, as compared to 15.8% who felt they did worse than expected. A student remarked that the math lab provided a learning environment that made distractions almost irrelevant. Unlike the Traditional setting, students who wanted to ignore any distractions (e.g., behavioral problems, other activities, etc.) could do so by focusing on their personal screen and work at a relatively slower or faster pace.

Most students (84.2%) felt the pacing of the course was just right despite the teacher's policy to restrict individual pacing. Like students from previous years, some of these students pointed out that occasionally the pacing might be too fast when the concepts were perceived to be difficult and too slow when the concepts were easy.

Throughout the project much concern has been focused on the classroom arrangement and how the lack of extra workspace may limit students' opportunity to interact with one another. The interview revealed that the majority of the students (84.2%) felt that there was satisfactory opportunity for peer interactions. A few students added that they would like to engage in more group work to make the lessons more interesting.

During the past two years, Mediated Learning teachers have adopted a format that includes lectures of up to 30 minutes in the beginning of each class meeting. This format resembles the usual practice of the Traditional Instruction approach, but the response of students was uncertain. The interviews revealed mixed response: 57.9% of the students felt the software was better at explaining pre-algebra concepts than the teacher while 42.1% preferred the teacher's lectures. Students who preferred the software liked the variety of examples during the explanations, pace of the course, and the opportunity to go back to reexamine concepts that were difficult to understand or solve.

On the other hand, some students felt frustrated over the fact that they couldn't ask the computer questions if the explanations were unclear. The same students also felt that after the teacher's lecture the software's explanation became boring and repetitive. When students were asked if they felt the teacher provided satisfactory personal assistance, 79% of them felt assured that help was available if they needed it.

Finally, students were asked to choose between the two approaches. Early in the interview, they were asked to state a preference for learning algebra the following year between the Mediated Learning and Traditional approach. Seventy-four percent selected to learn algebra using the Mediated Learning approach, 15.8% chose the Traditional Instruction approach and 10.5% reported no preference. At the end of the interview, they were asked which approach they preferred best for learning mathematics. The results were consistent with the previous outcome: 68% of the students chose Mediated Learning while 21% chose the Traditional Instruction.

Algebra

Algebra students ($n = 25$) demonstrated preferences different from those of pre-algebra students. Responses in this section mainly reflect students' experiences with Teacher A. Sixty percent of the algebra students liked using the Mediated Learning software for learning mathematics and 40% of them did not share that view. All but one student liked using computers, 64% felt the Mediated Learning software was a very helpful and easy tool to use, and 36% either disliked the Mediated Learning software or thought it made learning mathematics difficult.

More than half (52%) of the respondents rated their personal performance in the Mediated Learning course as being better than expected (e.g., higher achievement scores and more work accomplished) when compared to their past performances in mathematics courses. The remaining students rated their performance to be lower than (44%) or the same as (4%) past experiences in mathematics courses.

Throughout this interview many algebra students expressed to the interviewer how the departure of Teacher A changed their views about the Mediated Learning algebra class. Before her departure, Teacher A informed her students that future class lectures might not continue in the same manner with the substitute teacher. She encouraged them to rely more on the Mediated Learning software for explanations and request assistance when needed. Although the substitute teacher also lectured at the beginning of each class session, many students did not feel that her explanations and instructions were comparable to those of Teacher A. Algebra students were critical of the short-term substitute teacher and complained how difficult it was to rely primarily on the software for explanations. It was evident that many students had become reliant on Teacher A to explain and instruct class lessons. They wanted new concepts explained in the beginning of class, as had been done since the beginning of the school year. It was difficult for them to learn on their own after receiving lectures and instructions for most of the school year.

Forty-eight percent of the group felt the pace of the class was too fast, 36% thought the pace was just right, and 8% felt it was too slow. Regarding Teacher A, 80% of the students felt that she had provided enough assistance when it was needed. When they were asked to compare their teacher's explanation with that of the Mediated Learning software, 72% stated a preference for the teacher to explain the algebraic concepts and processes. These students liked interacting with the teacher and noted that her explanations were easier to understand because she used examples that were related to their lives (e.g., rephrasing concepts and vocabularies that were easier for them to understand).

There is reason to speculate about the motives behind their reactions when we consider the context of their experiences in the Mediated Learning section. Many students expressed feeling lost when Teacher A left seven weeks before the school year ended and they had to rely more upon the computer for explanations. They were not satisfied with the substitute teacher's assistance and were not accustomed to relying on the software help alone. Interestingly, their reactions did not reflect their decision when they were asked to choose between the two approaches for next year: 52% chose Mediated Learning and 48% chose Traditional Instruction.

6. Summary and Conclusions

Student achievement data from Year Three yielded few statistically significant differences between the Mediated Learning and Traditional Instruction treatments. Still, certain of the findings provoke interest and suggest needs for additional study.

Pre-algebra students in both treatments performed at the same level of proficiency on the MDTP Algebra Readiness test. Review of the final examination scores yielded mixed results depending upon the covariate that was used: when MDTP pre-test scores were used as the covariate, no differences in the final examination scores were found between the two treatments, but when Stanford 9 test scores were used, the Mediated Learning students performed better than the Traditional Instruction students.

During Years One and Two of this study, in the analysis of final examination scores, MDTP pre-test scores and Stanford 9 scores were used routinely as covariates, but did not yield different results. Although the patterns of achievement have not been entirely consistent during the three year period, the findings in Years One and Three suggest that pre-algebra students in the Mediated Learning treatment performed as well or better than pre-algebra students in the Traditional treatment (for complete information, see the Year One report and Appendix B).

The school's A-B block schedule for the 2000–2001 school year provided a good opportunity to examine students' affective responses to their mathematics courses because they were exposed to those courses for the full academic year. Pre-algebra students in Mediated Learning treatment expressed more positive attitudes toward computers than did students in the Traditional Instruction treatment. Despite reported difficulties with the technical reliability of the mathematics laboratory, classroom space limitations and the mathematics terminology used in the Mediated Learning materials, the students' positive attitudes toward computers indicate that they valued and enjoyed their use of computers to learn mathematics.

The affective responses of the female students of pre-algebra in the Mediated Learning and Traditional treatments combined suggest that their expectations for Future Involvement in Mathematics are higher than the expectations of the male students. However, this difference was not supported by achievement differences between female and male students. It would be interesting and potentially useful to identify specific contributors to the differences between female and male students in their future expectations for Future Involvement in Mathematics.

For algebra students, there were no significant differences in mathematics achievement or affect between the treatments. This finding is remarkable for students in the Mediated Learning treatment, considering their teacher's early departure on maternity leave. Many of these students were unhappy with having to adjust to the substitute teacher's different instructional approach but their achievement scores apparently did not suffer as a result. They continued to learn even though they expressed many reservations about the course's new instructional direction during the remainder of the school year.

In their interview responses, these students demonstrated some confusion regarding their experience: while they enjoyed Teacher A's explanations more the Mediated Learning software, more than half of the students felt they benefited more than they expected from the course and would prefer to learn mathematics in the same condition next year. This contradictory pattern of reactions appears to reflect the extraordinary departure of Teacher A in Year Three.

The algebra Mediated Learning software was designed for college students who may have been exposed to some of the concepts during their high school mathematics courses. However, algebra students at Everett Alvarez High School have had little if any exposure to these concepts before their participation in the present project. Accordingly, these students are likely to benefit from the teacher's lectures and problem solving strategies as supplements to the Mediated Learning software. Notably, the combination of the Mediated Learning software, the efforts of Teacher A and perhaps even the efforts of the substitute teacher (although rated poorly by the students) enabled Mediated Learning students to reach achievement levels that were equivalent to those of students in the Traditional Instruction treatment.

Although female algebra students in the Mediated Learning treatment did not show more positive affective responses to Mediated Learning treatment than male students in that treatment, they recorded higher achievement scores than both male students in that treatment and all students in the Traditional Instruction treatment.

During Year Three, several factors might have stimulated negative responses to the Mediated Learning course in algebra, but the environment nevertheless supported learning by all students, and especially by the female students. Did the Mediated Learning treatment tend to offset the reported tendency of teachers to give male students more attention during instruction? Did the treatment reduce the typical competition between males and females? Such possibilities have important implications for mathematics education and are worthy of further study.

In summary, Year Three provided support for the Mediated Learning approach. Both pre-algebra and algebra students in the Mediated Learning treatment consistently expressed both positive attitudes towards the software and a preference to learn mathematics in the future with the Mediated Learning software. The patterns of higher academic achievement for pre-algebra and algebra Mediated Learning students have been consistent during this project. Two exceptions to this consistency occurred in Year Two: (a) pre-algebra students in the Traditional Instruction treatment achieved higher scores than Mediated Learning students on the MDTP test; and (b) algebra students in the Mediated Learning treatment achieved MDTP scores equal to those of students in the Traditional Instruction treatment, but their course examination scores exceeded those of the Traditional Instruction treatment group.

This three-year project has been challenging for all of the participants, but the results indicate that progress has been made to enhance the achievement and the experience of many students in mathematics courses. The Mediated Learning approach for teaching and learning mathematics has yielded positive and useful results in efforts to prepare historically underrepresented students for post-secondary studies in mathematics and science.

Additional studies are needed to investigate other academic dimensions of the impact of this instructional approach. Of particular interest are gender-related differences in both affective response and academic achievement, and the teacher's important role in introducing and explaining concepts in algebra.

7. Dissemination

Dissemination Goals, Year Three

1. Convene the project's advisory committee to (a) facilitate communications among the primary partners and other interested agencies, (b) monitor the progress of the project's activities, and (c) identify opportunities to enhance the project's work.
 - Present the project at CAPP Partners' meetings, as may be requested by CAPP.
 - Present the project at selected educational conferences.
 - Establish a project web site, with information of the project, its progress reports and data, and the evaluation study.

Dissemination Activities

During Project Year Three, UCSC Professor of Psychology Roland Tharp withdrew as principal investigator and co-director in anticipation of his retirement, and UCSC Professor of Mathematics Bruce Cooperstein replaced him in these positions. Because of this transition, the advisory committee did not meet.

On March 3, 2001, the project team hosted a site visit by a CAPP team to Everett Alvarez High School. The following persons participated:

CAPP Team

Dave Jolly, CAPP Statewide Director

Alfred Manaster, Director, Mathematics Diagnostic Testing Project

Martin Martin, CAPP Advisory Committee Member

Project Team

Jennifer Bosco, Student Services Coordinator, UC College Prep Initiative

Bruce Cooperstein, Principal Investigator and Co-director, UCSC

Tom Karwin, Project Coordinator, UCSC

Ed Landesman, Executive Consultant, Academic Systems

Sally Parker, Mathematics Teacher, Salinas High

Phoumy Sayavong, Graduate Research Assistant, UCSC

Murry Schekman, Principal and Co-director, Alvarez High

Jan Story, Mathematics Teacher, Alvarez High

Nina Vasquez, Mathematics Teacher, Alvarez High

On April 3, 2001, the project team met with CAPP Director Dave Jolly, CAPP Committee Member Doug Kirkpatrick and CAPP External Evaluator Jordan Horowitz at San Jose State University. The project team included UCSC Professor of Mathematics Bruce Cooperstein (principal investigator and co-director), Academic Systems Executive Consultant Edward Landesman (project business partner), UCSC Graduate Student Phoumy Sayavong (project research assistant) and UCSC Coordinator of Academic Advancement Thomas Karwin (project coordinator).

At the CSU/ CAPP conference, *California K-16 Partnerships and Student Success*, June 19-22, 2001 at CSU Long Beach, the project was represented by UCSC Coordinator of

Academic Advancement Thomas Karwin (project coordinator), and Graduate Research Assistant Phoumy Sayavong. The project did not respond to the conference's invitation to present its activities.

The project web site <<http://natsci.ucsc.edu/admin/EdAdvance/intmath/default.html>> remained active throughout Year Three, providing information about the project and the evaluation study. We will post our Year Three report on the web site in the near future. As indicated above, information in the *Interactive Mathematics* materials is available on Academic Systems' web site: http://www.academic.com/Interactive_Mathematics/Overview.asp.

8. Future Directions

This project was planned originally to operate for a three-year period commencing October 1, 1998 and ending on September 30, 2001. We have reviewed the project's experience to date with reference to the eight criteria that the U.S. Department of Education's Math and Science Education Expert Panel developed for the evaluation of educational programs in mathematics and science⁶. While all of these criteria are important, most relevant to the present project is the eighth criterion: "The program makes a measurable difference in student learning." The Panel determined that "Promising Programs," in addition to satisfying other criteria, must provide preliminary evidence of effectiveness in one or more sites for at least one of the following six indicators.

1. The program has evidence of gains in student understanding of mathematics.
2. The program has evidence of gains in inquiry, reasoning, and problem solving skills.
3. The program has evidence of improvements in course enrollments, graduation rates, and post-secondary school attendance.
4. The program has evidence of improvements in attitudes toward learning.
5. The program has evidence of narrowing the gap in achievement or accomplishment between disaggregated groups.
6. The program has other evidence of effectiveness or success.

This project has implemented Interactive Mathematics at one site, generated information of potential value to CAPP and the partners and yielded results that would qualify Interactive Mathematics as at least a "Promising Program." We have presented these results in our annual reports and summarized them in our Year Three Report.

The project also has encountered several challenges, as follows:

1. a period of rapid growth for Everett Alvarez High,
2. significant turnover in the teachers assigned to teach with Interactive Mathematics,
3. technical difficulties and insufficient technical support.
4. insufficient space in the mathematics learning center for learning strategies of interest, and

⁶ Math and Science Education Expert Panel (2000). *Exemplary and Promising Mathematics Programs*. (<http://enc.org/professional/federalresources/exemplary/>)

5. two changes of the principal investigator, one due to death and one due to retirement,

With both our results and our challenges in mind, the project team believes that more positive outcomes are desirable and achievable. Accordingly, the project team has reviewed project goals with CAPP Statewide Director Dave Jolly, MDTP Director Alfred Manaster and CAPP External Evaluator Jordan Horowitz and reviewed the possible purposes of program evaluation articulated by Quinones and Kirshstein⁷ as follows:

1. to make decisions on continued funding or recognition,
2. to provide information to program personnel and others on aspects of the program that work well and potential problems,
3. to catch potential problems early in the program so they can be corrected before more serious problems occur,
4. to guide further evaluation efforts (For instance, an evaluation may bring to light issues that need to be examined in greater detail or an initial evaluation of program implementation may be used, in part, to guide a later evaluation of long-term impact.)
5. to provide information on what technical assistance may be needed,
6. to determine what impact the program is having on participants.

This project focused originally on Purpose 6: the impact the program is having on participants, and developed interest in Purpose 4: guiding further evaluation efforts. In particular, we have identified the issues (or needs) that could increase the effectiveness of the courseware, as follows:

- a physical environment that supports peer tutoring and small-group instruction;
- technical support (including replacement parts) that reduces or eliminates technical problems;
- lesson plans that supplement the content of Interactive Mathematics, as may be needed; and
- teaching strategies, e.g., verbalization of mathematics concepts, that enhance learning.

Accordingly, we have proposed a two-year extension of the project period, i.e., to September 30, 2003, to effect changes in implementation of the courseware, revise our evaluation strategy and conduct further analyses of the data gathered during the project's first three years.

⁷ Quinones and Kirshstein (1998). *An Educator's Guide to Evaluating the Use of Technology in Schools and Classrooms*. American Institutes for Research (<http://www.ed.gov/pubs/EdTechGuide/index.html>)

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Attachments

- A. Everett Alvarez High School Bell Schedule for 2000–2001
- B. Excerpt from Year One Report: Summary, Conclusions and Future Directions
- C. Excerpt from Year Two Report: Summary, Conclusions, and Future Directions
- D. Overview of Results: Years One, Two and Three

A. Everett Alvarez High School Bell Schedule for 2000–2001

Attachment B

Excerpt from Year One Report– Summary, Conclusions, and Future Directions

The *Algebra Readiness Test* results for Survey Mathematics reflect very favorably on Mediated Learning. Students who received Mediated Learning made larger pre to post gains than did students who received Traditional Instruction. Performance on the *Algebra Readiness Test* did not differ for males and females. Outcomes indicate that the treatment had an effect that accounted for six percent of the treatment results.

Achievement results on the set of mathematics tasks that were directly relevant to the instructional curriculum, as measured by the *Course Achievement Test* for Survey Mathematics, demonstrated that the Mediated Learning group achieved significantly higher on course content than did the Traditional Instruction group. These results reflect a fairly strong treatment effect, accounting for about seventeen percent of the variance in the achievement of the treatment groups. However the validity of these results is clouded by the fact that some teachers gave their students additional time to complete the test. This was understandable because teachers wanted their students to have an opportunity to perform as well as their skills and knowledge would permit. But it was most unfortunate from an evaluation perspective. The length of the test will be reduced for the second year's testing or, alternatively, a larger block of time provided for all students. The latter of these alternatives is most likely because the final examination is not intended to be a timed test.

With appropriate adjustment to ensure that teachers are comfortable that the testing situation gives students the opportunity to perform at the level of their capability, the need for the assessment to adhere to standardized procedures will be given increased emphasis.

Altogether, the achievement findings for Survey Mathematics suggest that the particular Mediated Learning materials tested in this evaluation may provide an effective approach to teaching the skills and concepts that students will need to succeed in Algebra. The course achievement outcomes must be regarded with caution, but it does not appear that the entire achievement advantage of Mediated Learning over Traditional Instruction is attributable to the fact that some students (in one Traditional Instruction class and two Mediated Learning classes) received extra time to complete the test.

Also, since the materials tested are unique, the results suggested by these data cannot be generalized to other technology-based instructional materials in mathematics.

Next year's study offers the opportunity to see if the current findings comparing Traditional Instruction with Mediated Learning can be replicated, and to a longitudinal follow-up in Year Three.

Affective variables have both theoretical and practical potential for helping us to understand how self-perception and attitudes, such as those examined in this evaluation, influence mathematics achievement and participation. However, the present exploration did not contribute to such an understanding. The analyses of data for the Survey Mathematics course revealed only one significant finding, i.e., the Traditional Instruction group scored significantly higher on Challenge-Seeking/Persistence than did the Mediated Learning group. Since there was no treatment by trials interaction, these results, probably reflect pre-existing differences on this variable. There were no significant pre- to post-test changes among Survey Mathematics students on this or any other of

the affective variables.

Multiple regression analysis of data for Survey Mathematics students indicated that, together, the measures of Mathematics Self-Confidence and Challenge-Seeking Persistence predicted course achievement ($R = .35$). The finding suggests that these self-perceptions variables influence mathematics performance. On the other hand, they were unaffected by differences in instructional treatment. A multiple regression analysis of affective variables for students in the Survey Mathematics course did find that Mathematics Self-Confidence and Challenge-Seeking/Persistence, together, provided a fairly strong prediction of outcomes on the final examination. Together with the teachers, we will consider ways in which instruction might be arranged to contribute to these self-perceptions and, more importantly, to the behaviors that should be associated with them.

It is possible that some of the items included in the measures do not reflect unified constructs for the variables the sub-scales are intended to measure. Follow-up correlation and factor analytic studies will be conducted to determine if the measures can be improved for use in the second-year study.

Unlike the Survey Mathematics course, we did not find treatment effects on achievement variables for students in Algebra classes. At this point, the explanation for different results for the two different courses is open to conjecture. The fact that both treatments were taught by the same teacher could be a factor. The teacher was not certified to teach mathematics. Nevertheless, he appeared to be competent and he was certainly dedicated and hard working. Given his inexperience in teaching Algebra we might have expected there to be an advantage for his Mediated Learning class because outcomes would be somewhat less dependent on teacher experience and expertise than in the Traditional Instruction situation.

It is also possible that the Mediated Learning materials are more effective in teaching lower-level concepts and skills to students whose education has not prepared them to take Algebra immediately upon entering high school than to students who do come prepared for Algebra. Data from Project Year Two will help us to see if these findings are replicated.

On the affective side, there were a number of significant interactions between treatment and trials. On Global-Self -Worth we saw declines on this variable among students who received the Traditional Instruction treatment, but not for students who received Mediated Learning. Students in the Traditional Instruction treatment also registered declines in scores on the Challenge-Seeking/Persistence measure.

Interestingly, Computer Attitude scores for students in the Mediated Learning condition were marked by a decline between the pre and post measures. It might be the case that working on computers on a daily basis leads to less enthusiasm for computers.

Variables for a multiple regression analysis were selected on the basis of an exploratory stepwise multiple regression analysis. The selected variables (Future, Mathematics Self-Confidence, and Global Self-Worth) were used as predictor variables in a multiple regression analysis. The analysis yielded a multiple R of .64, indicating that among the Algebra students, this variable accounted (statistically) for 35 percent of the variance in course achievement.

For reasons entirely unrelated to the experience with Mediated Learning, none of the teachers who were involved in the Year One effort will be returning for Year Two. One teacher retired, one moved on to teach another subject in order to fulfill requirements for a teaching credential, and one had an opportunity to teach in a situation more related to her interest. Teachers did express a desire for some intensification of training, and for modifications that would designate a specific portion of classroom time for Traditional Instruction lectures. We are currently considering ways to accommodate these recommendations.

Finally, our plans for Year Two include the development of a direct response to the CAPP Advisory Committee's expressed interest in the affordability of Mediated Learning. In our Year Two report, we will provide a return-on-investment analysis using cost information from Year One (already compiled) and Year Two, and our findings regarding student outcomes.

Attachment C: Excerpt from Year Two Report– Summary, Conclusions, and Future Directions

Survey Mathematics Classes

Algebra Readiness Test results for Survey Mathematics indicate that students who received Traditional Instruction made larger pre to post gains than did students who received Mediated Learning instruction. The significant treatment effect also showed higher achievement scores for the Traditional Instruction group than the Mediated Learning group. This result does not support the finding from year one, which showed that students in the Mediated Learning treatment recorded greater gains on the *Algebra Readiness Test*. It is possible that the decision to restrict the pace of the Survey Mathematics Mediated Learning groups may have affected students' experience in the class. The new pace may have limited students from taking advantage of alternative explanations from the software's four "virtual assistants", who were very popular with students in the previous year. Also, the time teachers spent on daily lectures and exercise problems may have promoted more dependency on the teacher for explanations and assistance rather than the Mediated Learning software.

Achievement results on the set of mathematics tasks that were directly relevant to the instructional curriculum, as measured by the *Course Achievement Test* for Survey Mathematics, did not differ between the two treatment groups. Performance on the *Course Achievement Test* yielded a significant main effect between female and male students. As a group, females demonstrated higher *Course Achievement Test* scores than male students. When the two genders were compared across treatment groups (e.g., females in Mediated Learning group versus males in Traditional Instruction group and vice versa), there were no differences in their *Course Achievement Test* scores.

In addition to non-significant differences between *Course Achievement Test scores*, the non-significant results from the affective measures did not contribute any potential predictors of mathematics achievement to explain differences in their *Algebra Readiness Test* results. Students in both treatment groups have maintained similar patterns of attitudes toward the mathematics, global self-worth, future involvement in mathematics, computers, and challenge-seeking/persistence throughout their Survey Mathematics courses. Perhaps the period of exposure (one semester) did not allow enough time for students to develop new attitudes that reflect their experience in the Mediated Learning group. It will be interesting to see if longer exposure to mathematics instruction in the computer lab will dramatically influence students' attitudes. The new year long curriculum schedule in Year Three will allow us to test this idea.

Overall, the achievement findings for Survey Mathematics showed that achievement scores between the two treatment groups were not consistent across exam types. Results from the *Algebra Readiness Test* favored students in the Traditional Instruction group but their *Course Achievement Test* scores were not different from students in the Mediated Learning group. The explanations for these inconsistent achievement patterns are unclear and continue to be open to conjecture. The degree to which students in both groups viewed how the two test scores (*Algebra Readiness Test* and *Course Achievement Test*) would influence their permanent grade could be a factor because when their scores mattered, their achievement scores were not different.

Algebra Classes

Student performance scores on the *Course Achievement Test in Algebra* showed that student in the Mediated Learning group received higher scores than the Traditional Instruction group. This outcome differs from the previous year in which no differences between the two treatment groups were found. The fact that one of the Mediated Learning Algebra classes included all transitional bilingual students supports the notion that Mediated Learning instruction can be beneficial to English language learners as well as mainstream students who are proficient in English. This outcome has also provided some support that suggests the adjustments made to the Mediated Learning instruction were not only appropriate but also effective for teaching the skills and concepts that students needed to succeed in Algebra. Results from the affective variables did not yield any significant pre- to post-test changes between the two treatment groups and therefore did not provide us with variables that could influence students' mathematics performance.

Future Directions

The original plan for Year Three of this project consisted of a longitudinal follow-up study of students who used the Interactive *Mathematics* materials during Years One and Two. We still intend to monitor these students during Year Three, and to re-analyze the Year Two data to compare the achievement levels of (a) Algebra students who used the *Interactive Mathematics* materials in both their Survey Mathematics and Algebra courses and (b) Algebra students who used these materials in only one or the other of these courses.

In addition, we wish to address issues that arose during Years One and Two and to extend and refine our implementation and evaluation of these materials.

The first and most important issue is the inconsistency of outcomes, as follows:

During Project Year One at Alvarez High, Survey Math students using the Mediated Learning materials made larger gains as measured by the *Algebra Readiness Test* than did Survey Math students in the Traditional Instruction treatment. Survey Math students in the Mediated Learning treatment also scored higher on the *Course Achievement Test* than students in the Traditional Instruction treatment (see Attachment D for qualifications of this finding). For Algebra students in the Mediated Learning and Traditional Instruction treatments, there was no significant difference in the *Course Achievement Test* scores.

During Project Year Two, Survey Math students in the Traditional Instruction treatment made larger gains as measured by the *Algebra Readiness Test* than did Survey Math students in the Mediated Learning treatment. Algebra students in the Mediated Learning group received higher scores on the *Course Achievement Test* than the Traditional Instruction group.

These results, although inconsistent, could be interpreted as a successful trial of the Mediated Learning approach: despite the teachers' and the students' unfamiliarity with the technology and the *Interactive Mathematics* materials, student achievement was comparable to that of students in the Traditional Instruction treatment. While the first uses of a new approach to instruction rarely are successful, these results are generally positive. However, since many postsecondary institutions have had good results with *Interactive Mathematics* (which addresses concepts that are commonly taught in high schools), we believe that further refinement of the implementation of the Mediated Learning approach could support higher levels of achievement by secondary students using these materials.

As we analyze the experiences to date to identify factors that might be limiting the achievement of students using *Interactive Mathematics*, we should consider ways in which we might modify the implementation of these materials during Year Three to reduce or eliminate the effects of such factors.

Factors that warrant examination include the following:

Teacher practices

- Are teachers using Interactive Mathematics as Academic Systems intended it to be used?
- Assuming they are not, what additional training would encourage and prepare teachers to use the material as intended?
- Assuming that training would change teacher's practices in the desired manner, would student performance be improved?

Classroom Configuration

- Does the arrangement of student workstations in the Mathematics Learning Center inhibit student interaction, i.e., peer tutoring?
- Would a different arrangement of student workstations, plus related instructions by the teacher, encourage and facilitate higher levels of course-related student interaction?
- Would higher levels of course-related student interaction allow teachers to use their time more productively and improve student performance?

Hardware Options

- Would Interactive Mathematics run on "server plus thin client" hardware systems, as successfully as on "server plus general-purpose PC" systems as originally designed?
- Would the use of "server plus thin client" systems reduce instances of student misbehavior and operational problems, without negatively affecting cognitive or affective results?
- Would the use of "server plus thin client" hardware systems reduce capital and operating costs to levels that would enhance the affordability and cost-effectiveness of Interactive Mathematics, and by implication other technology-based multi-media materials?

We have planned activities for Year Three in the context of three noteworthy changes.

First, the University of California College Preparatory Initiative (UCCP) has agreed to fund the licenses for a third year of use of Interactive Mathematics. (Academic Systems provided these licenses for Years One and Two at no cost.)

Second, Alvarez High has adopted a new schedule for 2000–2001, such that the Survey Mathematics and Algebra courses extend over the school year, rather than a single semester. (During Years One and Two, Alvarez High employed a block scheduling scheme, with each class meeting for the equivalent of two periods (100 minutes) per day to cover the content of a year long course in a semester of instruction.)

Third, Salinas High School has expressed interest in implementing *Interactive Mathematics* in its new "thin client" mathematics laboratory, and UCCP has agreed to fund the licenses for this

implementation.

Accordingly, we are considering the following changes during Year Three:

In addition to implementing the longitudinal follow-up study, as planned, we will continue to measure student achievement and affective change during Year Three, following the same evaluation design we employed during Years One and Two.

We will seek to move the Mathematics Learning Center to a larger room, to make possible a rearrangement of student workstations to facilitate peer tutoring. Alvarez High has identified a larger room that is available for this purpose. We are working currently to determine if (a) the room is in fact large enough to support the desired arrangement of student workstations and (b) the move would be affordable. If these conditions are met satisfactorily, we would relocate the Center during the holiday break in December.

We will seek to implement *Interactive Mathematics* at Salinas High School during the spring semester, and to measure student achievement and affective change in the respective courses, following the evaluation design we are using at Alvarez High School.

D. Overview of Results: Years One, Two and Three

YEAR 1

Pre-algebra

- Mediated Learning students scored higher on MDTP; also made more pre to post gains.
- Mediated Learning students scored higher on final exam also.
- Traditional Instruction students scored higher on Challenge-seeking/Persistence
- Traditional Instruction students had more positive attitudes towards computers than mediated students

Algebra

- No difference between the two groups
- Global Self-Worth scores for the Traditional Instruction treatment declined from pre- to post-testing, whereas scores of the Mediated Learning group were essentially constant.
- Traditional Instruction students declined more than Mediated Learning students in Challenge-Seeking/Persistence.

YEAR 2

Pre-algebra

- Traditional Instruction students demonstrated higher achievement and made greater pre- to post-test change than Mediated Learning students.
- No difference in final exam scores between the two treatment groups
- No differences in affect between the two treatment groups

Algebra

- Mediated Learning group scored higher on the final exam
- No differences in affect between the two treatment groups

YEAR 3

Pre -algebra

- No difference in achievement as measured by MDTP scores
- Final exam scores were the same for both treatment groups when the MDTP pre-test scores were used as the covariant but significantly different when Stanford 9 scores were used as the covariant. In this case, students in the Mediated Learning treatment scored higher on the final examination. (This is the first time during the project's three years that the two covariates yielded difference results.)
- Students in the Mediated Learning treatment demonstrated more positive attitudes towards computers.
- Female students in both treatments were more positive about their future involvement in mathematics than male students.

Algebra

- There were no significant differences between the two treatments in either achievement or affect.
- Female algebra students in the Mediated Learning treatment recorded higher achievement scores than male students within that treatment and all students in the Traditional Instruction treatment.
- Female students in the Mediated Learning treatment scored higher than males in same treatment and higher than both males and females in the Traditional Instruction treatment.