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ABSTRACT

This paper summarizes a formative evaluation of a developmental project designed to maximize the potential use of computers in mathematics instruction through the use of volunteers. The project was conducted using a 7th-grade class at an intermediate school in Utah. Data were analyzed for 12 students in a special class for students not having the necessary basic mathematics skills to enroll in a regular class. Students used math computer lab twice a week. The volunteers determined what mathematics skills each student needed to practice by referring to the student files, determined what software program would be appropriate for the student, and managed all the necessary student data. Both quantitative and qualitative data were analyzed for: (1) achievement; (2) attitude about mathematics; (3) mathematics anxiety; (4) study habits; (5) positive reinforcement; and (6) individual help from an adult. Qualitative data collected through personal interviews, volunteer tutor activity sheets, and field notes were analyzed to identify participants' perceptions of the strengths and weaknesses of the project. (Author/YP)

An Evaluation of an Innovative Use of Computers and Volunteers in 7th Grade Math Instruction

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California Educational Research Association

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An Evaluation of an Innovative Use of Computers and Volunteers in 7th Grade Math Instruction

This paper summarizes a formative evaluation of a developmental project designed to maximize the potential use of computers in math instruction through the use of volunteers. The report focuses on concerns, issues and questions a practitioner should examine when replicating a similar project. The following paragraphs present a rationale and description of the project.

One of the most effective uses of computers in the instructional process is during student practice. Computers can be used to ensure a very sophisticated drill and practice session, much more sophisticated than a teacher could implement. Computers are very efficient and effective at managing student practice. They can keep track of the number of times students have tried an item, how often they have reviewed an item, give students a small working pool of items consisting of new and review items, eliminate the sequential learning effect by randomly rearranging items, and many more tasks that a teacher cannot possibly manage or remember for 25 students or more (Merrill, 1986). In addition, computers can foster or maintain a high degree of learner attention and motivation because of the novelty and the gaming properties computers can build into a practice session.

Another strength of computers in assisting in the instructional process is giving immediate feedback to the learner during practice. Teachers cannot give individual feedback to 25 or more students in a class consistently and frequently during student practice. Due to the interactive capabilities of the computer, however, students can receive immediate feedback on all their practice exercises. In fact, some software programs will give remedial help to students if their answers were not correct.

Despite the strengths computers have in assisting instruction, some public schools have not maximized the use of the computers in their math instruction. Some schools use computers in their math instruction; however, they lack a management system which ensures that students are executing math programs commensurate to their particular math deficiencies. In some schools teachers send part of their class to the computer lab to practice math exercises, however, students frequently end up playing math games which do not map to their math deficiencies or the practice they need. Usually the computer specialist supervising the computer lab doesn't know what specific programs each student should execute to meet his or her instructional needs. It is almost impossible to expect a teacher to manage some students practicing in the computer lab while other students are doing individual work in the classroom. Usually the teacher cannot send all the students at one time so he or she must remain in the classroom with the students who cannot go the computer lab. Even if a teacher has a small class and there are enough computers for each student in the computer lab, one teacher cannot effectively manage the lab. In short, some schools are not maximizing the computer because they do not have an effective management system which ensures that the students execute appropriate software for their particular learning needs.

The main focus of this project was to use community volunteers to ensure that an appropriate management system was functioning so that students could practice appropriate math skills for their particular math deficiencies. In other words, through the use of an effective management scheme, the full potential and power of the computer would be maximized in helping students practice basic math skills.

This project was called the Productivity Math Project. The project was implemented at an Intermediate school in Utah. The primary stakeholder was a district Supervisor of Educational Support Services.

FUNCTION OF THE EVALUATION

The object (evaluand) of this evaluation was the Productivity Math Project. The function of this evaluation was formative. In other words, the purpose of the evaluation was to provide information that would be used to improve the program. The data from this pilot class were not used for summative purposes, such as comparing the results from this pilot study to other programs to see which programs did better. The results from this study were used in working out the bugs in the project and developing the best possible program. Conclusions and recommendations focus on how the project can be improved so that the best possible program can be implemented in the future.

EVALUATION QUESTIONS

The evaluation addressed the following questions:

1. To what extent was the Math Productivity Project implemented according to the implementation design?
   a. How was the project designed to be implemented?
   b. What actually happened in the implementation of the project?
2. What impact did the project have on the students?
   a. To what extent did students achieve basic math computational skills (addition, subtraction, multiplication, and division)?
   b. To what extent did the project influence the students in terms of:
      (1) Their attitudes towards math?
      (2) Their anxiety towards math?
   c. To what degree did the project affect math homework study habits of the students?
   d. To what extent did the project provide students with positive reinforcement?
   e. To what extent did the project provide students with individual help from an adult on their math problems?
3. What were the strengths and weaknesses of the project as perceived by the participants and what suggestions did they have concerning how the project can be improved? (Participants included the volunteers, the teacher of the pilot class, the volunteer coordinator, The Intermediate School Vice-Principal, and students in the pilot group.)

EVALUATION METHODS AND PROCEDURES

Subjects

This pilot study was conducted using a 7th grade class at an Intermediate School in Utah. The class was one of eight basic math classes being taught at the school for students who did not have the necessary basic math skills to enroll in a regular seventh or eighth grade math class. As mentioned previously, these students were identified by one or more of the following criteria to be enrolled in a basic math skills class:

a. Their results on the Metropolitan Achievement Test. This test was given in the spring of 1986. Students who scored at least two grade levels below the normal grade level were placed in the basic math classes.
b. Their results on the California Achievement Test. This test was also given in the Spring of 1986. Students who scored a least two grade levels below the normal grade level were placed in the basic math classes.
c. Their results on the WRAT Test. This test is given to incoming students not having a current test score. Students scoring low on this test were placed in the basic math classes.

d. As a result of teacher, counselor, and/or parent recommendations, students were placed in the basic math classes.

Data were collected from 18 students in the class. However, data from six students were not used in the data analysis because these students either quit school early and we could not obtain posttest results, or students were added to the class halfway through the study and we could not obtain pretests results. The data analysis was conducted using data from 12 of the 18 students.

Instrumentation

A number of various instruments were used to collect the appropriate data necessary to answer the evaluation questions. Each instrument used will be discussed in the following section.

The evaluators developed interview schedules designed primarily to obtain qualitative data for answering the first and the last evaluation questions. These interview schedules were used by the evaluators in personal interviews with the volunteers, students, and school personnel. In addition, a few of the questions were designed to obtain perceptions from those interviewed about the achievement and learning gains of the students involved in this project.

The evaluators developed the "Volunteer Tutor Activity Sheet" to obtain information concerning what type of daily activities or tasks the volunteers performed while they worked at the school. This instrument was designed to give information to determine to what extent the project was implemented according to the original design. The volunteers were requested to report their daily activities on one of these sheets before they left the school.

The evaluators collected additional qualitative data necessary to answer the evaluation questions through conducting field notes. A limited number of observations were conducted at the site (the computer lab and the classroom) to help give the evaluators a better understanding of what was happening during the study. Only a few observations were scheduled due to budget constraints.

Four criterion-referenced tests were used in the study, each containing multiple domains defined as units in the tests. These tests measured simple addition and subtraction skills (Beginning Mathematics 1), simple and complex multiplication and division skills (Beginning Mathematics 2), basic computation skills in solving fractions (Beginning Fractions), and basic decimal computation skills (Beginning Decimals). These tests are referred to throughout the report as the Metra tests because they were published by Metra Publishing Company.

An instrument developed by Richard Sudweeks called "My Feelings about School Subjects" was used to measure student attitudes about math. Dr. Sudweeks, Assistant Professor of Instructional Science at Brigham Young University, developed this instrument while he was working at Syracuse University in New York. The results of this instrument have been tested previously with students to ensure a high degree of validity and reliability. The instrument includes items measuring student attitudes about Math, English or Language Arts, Social Studies and Science. Scales measuring other subjects were included to ensure that if math attitude changed, it was independent of other school subjects, and not the result of a change in attitude about school in general.

The Syracuse Math Anxiety Scale was used to measure student anxiety towards math. This instrument was developed by Sudweeks and Stroller at Syracuse University. The scale was originally designed f r upper high school students. In consultation with Dr. Sudweeks about using this instrument with seventh and eighth grade students, he felt the instrument would not need to be revised, even though it was designed for high school students.

A questionnaire was developed by the evaluators to determine students' homework study habits, individual help they received during the intervention, and other important information to answer the evaluation questions. The evaluators developed this instrument in consultation with the district Supervisor of Educational Support Services and the school administrators.

The R.A.T. standardized test was used to measure pretest and posttest results in math achievement.

Procedures

The data collection phase of the evaluation was conducted from January to August, 1987. The students began using the Math Computer Lab by the second week of January. In addition, the volunteers became involved with the students about the second week of January.

To obtain the necessary information to answer the evaluation questions, pretests and posttests were administered to determine what affect the project had on the students. The Metra tests were administered by the volunteers. In an orientation meeting held in December 1986, one of the evaluators trained the volunteers on how to administer the criterion-referenced tests to the students. This orientation meeting was held in December so the volunteers could administer the tests the first two weeks of the second semester. Although much of the testing was done in the first two weeks of school, some testing was not completed until the first week in March.

The Syracuse Math Anxiety Scale, the Attitude About School Scale, and the Student Questionnaire were administered to the students by one of the evaluators on January 23, 1987. It took about 50 minutes to administer these three instruments. These instruments were administered about two weeks after the project began due to changes in the proposal and evaluation design. The students were asked to fill out the questionnaire assuming it was the first day of school and not the 23rd of January. That is, they were asked to fill out the questionnaire as if it had given to them on the first day of class of the second semester. This request of the students was necessary so the first two weeks of the second semester would not influence their responses concerning what previous experience they had had with a computer and individual feedback and reinforcement they had previously received from adults in their math class.

We conducted a few observational sessions at the site. Only the volunteer coordinator was told ahead of time that we were coming to the Math Computer Lab to observe so that the project could be observed as it was naturally occurring. In addition to observational field notes, we informally interviewed some of the participants in the project, such as volunteers, the teacher, and some of the students. The observations and informal interviews were conducted to determine how the project was actually being implemented. In addition to the observations and interviews, we also attempted to determine to what extent the project was being implemented by asking the volunteers to record what type of things they did everyday at the school on the Volunteer Tutor Activity Sheet. Also, document analysis was also conducted during the project on various documents available.

All of the posttests were administered on May 5, 1987. The Syracuse Math Anxiety Scale, Attitude about School instrument, and the Student Questionnaire were administered by one of the evaluators to the students during the normal class period (50 minutes). These three instruments were exactly the same as the instruments administered in January, no revisions had been made to them. The Metra posttests were administered throughout the entire day. Instead of having the volunteers give the posttests as they had done in the pretests, we decided to collect all the posttest data in one day. This way the data collection would not continue over multiple weeks as it had done in the pretesting. To accomplish the task of collecting all the Metra posttest data in one day, five evaluators conducted the testing until all the testing was completed. All of the evaluators were trained how to administered the tests before testing the students. All four Metra tests were given to each student. It took about an hour to an hour and a half to test each student.

On May 21, 1987, we conducted interviews with the students and the teacher of the pilot group. We used the interview schedules to guide the interviews. Each of the student interviews took about 20 minutes and the teacher interview lasted about an hour. Other interviews with school personnel and all six volunteers were conducted over the phone.

R.A.T. standardized tests scores of student achievement were collected from the teacher a few months after school was out for summer. These data were collected because school personnel felt that these data showed significant learning gains between pretests and posttests results.

FINDINGS

How the Project was Implemented

The Original Design of the Project

The main focus of this project was to use community volunteers to ensure that an appropriate management system was functioning so that students could practice appropriate math skills for their particular math deficiencies. In other words, through the use of an effective management scheme, the full potential and power of the computer would be maximized in helping students practice basic math skills. The following items describe how this purpose or focus of the project was to be achieved in the original design of the project.

- One of the first tasks is to determine the classroom management organizational plan. This plan involves determining the class instructional objectives, activities that need to be conducted to achieve the instructional objectives, identify who is responsible, and determine what materials are required.
- Once the instructional objectives (for basic math computational skills) for the class are determined, appropriate computer software needs to be identified and purchased which maps (matches) directly onto the instructional objectives. The software should be appropriate drill and practice applications, not just flashy, whistles and bells math games.
- Appropriate criterion-referenced tests which also map directly to the instructional objectives need to be purchased. These tests will be used to determine what math skills students are deficient. These tests will also be used in conducting pretests and posttests to determine achievement gains of the students in the pilot study.
- The teacher will provide the volunteers with the information concerning what basic computational skills the students are weak in or lack mastery level skills. The teacher will obtain this information from the results of the criterion-referenced tests. A file should be kept on each student in the class. This file should contain information concerning what math skills students needs to practice and reports on how they are progressing, both from the teacher and the volunteers.
- The student files will be placed in the Math Computer Lab so that volunteers can determine what math skills the students need to practice. The heart of the project involves the volunteers determining (referring to the student files) what math skills each student needs to practice, and then helping the student execute the appropriate drill and practice software. When a student comes into the Math Computer Lab, the volunteer should first refer to the student's file to determine what math skills that student needs to practice. After the volunteer has determined what skills the student should practice, the volunteer should then determine (from a chart discussed in the following paragraph) what software program would be most appropriate for that student to execute. The Volunteer should help the student start the program and then allow the student to run the program with his partner.

- As mentioned previously, software will need to be obtained which maps directly onto the instructional objectives and criterion-referenced tests. A chart will need to be developed that maps the basic math computational skills to the appropriate software to practice for that math skill. This way, when the volunteer determines what skills a student needs to practice, he will refer to this chart and immediately determine which software program he will help the student execute to practice that particular program.
- Volunteers will be available during the computer lab session to help students individually after they help each student execute the appropriate software program for their instructional needs. There should be at least two volunteers supervising the computer lab.
- Twelve students will go to the Math Computer Lab twice a week. Since there are more than 12 students in the class, students will have to rotate going to the lab. Because there are only six computers in the lab, two students will work with one computer. Students will receive direct instruction from the teacher twice a week in the classroom. One day a week will include testing or review in the classroom. The teacher will update the student files on their practice needs according to the results of frequent testing.
- The Math Computer Lab will be made available at 2:10 pm on Tuesdays, Wednesdays, and Thursdays during the 8th hour. The eighth hour is an optional class time for students to catch up on homework and other necessary things they need to do. Volunteers will supervise the lab during these hours for students to execute software programs and receive tutorial help.
- The volunteers will manage the record keeping system in the computer lab. Appleworks and M.E.C.C. software management systems will be used to record and manage all the necessary student data. If the volunteers cannot perform this task, a resource aide will be hired to manage the record keeping system. This record keeping system will record such data as when students have achieved mastery of math concepts and skills, what software programs they have executed, what individual help the students have received, etc.

What Actually Happened in the Implementation

The project was not completely implemented as it was designed. In fact, the key components of the project never did occur. The key components were that the volunteers would select the appropriate software programs which each student should execute to give him the necessary practice and feedback to meet his instructional needs. Each of the components of the project design explained in the previous section will now be addressed concerning what actually happened to those items in the actual implementation of the project. These findings were determined from data collected from interviews, observation and document analysis.

- School personnel did develop a classroom management organizational plan. This plan consisted of a one page sheet summarizing the activities that needed to be conducted to achieve the instructional objectives, identified who was responsible, and determine what materials were required for each of the major instructional objectives. In addition, the plan included attached sheets which listed the specific math concepts to be taught (for the scope and sequence of the class) and for each specific math concept, a section on the activities, who is responsible and materials needed. In addition, the plan also included some attached sheets showing the CAI Software programs and curriculum match. These sheets listed software programs and then match the appropriate math concepts that these software programs addressed. These sheets identified most of the math concepts that were to be taught in the class; however, some math concepts were not identified.

- As mentioned previously, school personnel identified many software programs which matched the specific math concepts and instructional objectives for the class. However, their CAI Materials and Curriculum Match chart was incomplete, because some of the math concepts did not match any of the software identified. Even though many software programs were identified, very few software programs were purchased by school personnel. At the beginning of the project, five disks were available in the Math Computer Lab. By the end of the project, 10 disks were available.
- As was mentioned previously in the report, appropriate criterion-referenced tests which matched the math concepts and instructional objectives of the class were not purchased by the school personnel. Criterion-referenced tests published by Metra were decided to be used at the last minute. These tests did not completely match the math concepts of the class; nevertheless, because they did measure basic math computational skills, they were used in the study.
- Information concerning individual student weaknesses and instructional needs were not provided to the volunteers. The teacher did record students' instructional needs as a result of the criterion-tests administered to the students; however, the volunteers did not have access to these records in the Math Computer Lab. If a volunteer was available to tutor a student, the teacher would review with the volunteer what skills the student needed to practice and give the volunteer the student file to refer to while tutoring the student. The volunteer then returned the student file to the teacher following the tutoring session.
- The main component of the project was not implemented. That is, the volunteers did not select appropriate software for each student to execute, depending on the student's individual instructional needs. However, the teacher did try to execute appropriate software for each student at the beginning of the lab session. The teacher would normally take 12 students to the lab on Tuesdays and Thursdays. She would allow students to pair up with a friend using one computer. She would then give each student appropriate software for their particular instructional needs. After she started all the students on the software programs they should have executed for their instructional needs, she would go back to her classroom and work with the other students in the classroom. Some of the students told us during our interviews that many students would wait for the teacher to leave, take out the disk she had given them and insert their favorite game disk. Apparently the volunteers supervising the lab either did not care if the students switched disks or were unaware of what the students were doing, according to some of our informants.
- The volunteers did not refer to a student file to determine what math skills a student needed to practice, nor did they refer to the match chart showing the match between math skills (or concepts) and appropriate software because these resources were not available to them. Midway through the project, the evaluators recommended to the school personnel that if they performed the following three tasks, it would have a significant influence on the project: 1) copy the teacher's student files she had documented listing the specific math deficiencies of each student and make these files available in the Math Computer Lab, 2) have someone who was computer literate review all the software programs in the lab and match each of the programs with the scope and sequence instructional objectives (and if he or she had time, to purchase more math drill and practice software which would match to the class objectives), and 3) train each of the volunteers basic computing skills so they could manage the lab on their own. These suggestions were not implemented.
- Even though the volunteers were not able to help the students load and execute their programs, they did help and tutor the students upon request in the lab. From observational and interview data, it appears that the volunteers spent most of the time in the lab watching over the shoulders of the students and helping them when they asked for help. Some of the students said during the interviews that the volunteers

were very helpful when they couldn't understand how to do a math problem. At the beginning of the project, there were usually at least two volunteers supervising the lab on Tuesdays and Thursdays during the regular class period. However, about midway through the project had to drop out of the study, which left one volunteer supervising the computer lab by himself. More will be discussed concerning the activity of volunteers in the "Other Implementation Issues" section.

- The students attended the lab twice a week (unless they had to rotate since there were more than 12 students in the class) and had direct instruction with the teacher in a traditional classroom situation three times a week. A few of the volunteers never did supervise students in the computer lab. These volunteers came to class during the regular class time and tutored students. The teacher would determine which student needed the most individual help that day and send that student with the volunteer to be tutored during the entire class period.
- The 8th hour did not involve students practicing math skills on the computer to the extent it was envisioned in the original design. Students usually attended the 8th hour because they were required to by their teacher. The volunteer who usually worked the 8th hour said that most of her time was spent administering the Metra tests, and once in a while tutoring a student.
- Appleworks or another similar M.E.C.C. database program were not used in the project. The software was never purchased for the project and the volunteers wouldn't have known how to use it even if it was available.

Impact of Project on Students

This section of the evaluation report will identify specific evaluation questions concerning what impact the project had on students, the methods used to collect data to address those questions, and a summary of the findings of the data analysis. In analyzing the quantitative data, we used the statistical packages SPSSX and LIKERT on the BYU Vax 8600 computer. Qualitative data (collected from interviews with students, volunteers and school personnel) were analyzed and categorized. Each of the following sections on how the project impacted students will be discussed in terms of quantitative data analysis and qualitative data analysis.

Achievement

To what extent did students achieve basic math computational skills? Quantitative data to address this question were collected using the four criterion-referenced tests and student R.A.T. scores collected by the teacher. Qualitative data to address this question were collected through interviews.

Quantitative Analysis. Table 1 compares the means and standard deviations of the student's scores on the four criterion-referenced tests given preproject and postproject. A dependent T-test was administered to determine if there was a significant difference between the pretests and posttests results. The analysis indicated a significant change in the students' performance on the Fractions test, significant at the .003 level. However, the students' performance did not change on the other three tests.

Table 1

T-Tests Comparison for Pretest and Posttest Scores on Metra Tests

Metra Test	Mean	Standard Deviation	T Value	Level of Significance
Math 1 Pretest	70.23	2.61	.16	.872
Math 1 Posttest	70.46	1.81		
Math 2 Pretest	56.33	12.94	1.14	.280
Math 2 Posttest	61.08	8.90		
Fractions Pretest	21.50	8.52	3.72	.003
Fractions Posttest	30.00	9.32		
Decimals Pretest	21.08	6.45	.75	.467
Decimals Posttest	19.75	5.88		

Table 2 lists the students' scores for the pretest and posttest on each of the four Metra tests. The first number is the actual score. The second number in parenthesis is the percent correct of the total possible. The total possible points for the pretest and posttest for Math 1 test were 74, Math 2 were 85, Fractions were 53 and Decimals were 36. Some of the test units and individual questions were deleted from the score possible because the students nor the testors did not understand the questions.

Table 2

Individual Student Scores (including Group Averages) and Percent Correct of Total Possible Points on Metra Tests (percent correct scores are in parenthesis)

Student	Math 1 Pretest	Math 1 Posttest	Math 2 Pretest	Math 2 Posttest	Fractions Pretest	Fractions Posttest	Decimals Pretest	Decimals Posttest
1	71(96)	69(93)	78(92)	52(61)	19(36)	29(55)	11(31)	20(56)
2	71(96)	72(97)	59(69)	69(81)	38(72)	47(89)	27(75)	26(72)
3	65(88)	70(95)	53(62)	64(75)	14(26)	38(72)	21(58)	29(81)
4	68(92)	72(97)	69(81)	65(76)	22(42)	30(57)	23(64)	23(64)
5	69(93)	72(97)	34(40)	52(61)	18(34)	22(42)	18(50)	16(44)
6	72(97)	73(99)	66(78)	75(88)	27(51)	40(75)	36(100)	28(78)
7	70(95)	72(97)	42(49)	54(64)	26(49)	18(34)	19(53)	11(31)
8	73(99)	68(92)	68(80)	68(80)	31(58)	33(62)	18(50)	16(44)
9	68(92)	70(95)	43(51)	68(80)	5(09)	19(36)	14(39)	16(44)
10	74(100)	68(92)	60(71)	46(54)	16(30)	22(42)	19(53)	17(47)
11	72(97)	69(93)	56(66)	55(65)	19(36)	24(45)	25(69)	13(36)
12	MD*	66(89)	48(56)	65(76)	23(43)	38(72)	22(61)	22(61)
Average for all Students	70(95)	70(95)	56(66)	61(72)	22(41)	30(57)	21(59)	20(56)

* MD means missing data.

Table 3 compares preproject student scores on the standardized R.A.T. test with postproject student scores. The mean score is the average grade level for the pretest and posttest results. As the table shows, there was a significant difference between preproject and postproject grade level scores. Students increased a little less than a full grade level during the school year.

Table 3

T-Tests Comparison for Pretest and Posttest Scores on the R.A.T. Standardized Test

Metra Test	Mean	Standard Deviation	T Value	Level of Significance
R.A.T. Pretest	4.88	.55	2.36	.046
R.A.T. Posttest	5.52	1.24		

Qualitative Analysis. Most of the students (9 out of 11) felt that they had learned more about math and how to do math in this program vs. the previous semester without the intervention of volunteers and computers. One student commented that she had learned additional math skills from the computers not taught in the class, such as measurement skills. However, another student indicated that he had learned more in the previous semester because the books were used more than in this project.

It was difficult for the volunteers to determine whether or not the students learned the math skills they were suppose to learn because the volunteers did not know for sure what was required of the students. In addition, two of the volunteers said that they did not work with enough students to make a judgement. One volunteer felt that the students did not learn what they could have learned, mainly because the of the disorganization of the program. Another volunteer simply indicated yes the students learned what they were suppose to learn, but didn't give any rationale for his response.

Both of the school personnel interviewed indicated that they thought students learned more basic math skills as a result of this intervention than the tradition math class approach used the previous semester.

Attitude about Math

To what extent did the project influence the students in terms of their attitudes about math? Quantitative data to answer this question were collected using the Attitude About School Scale. Qualitative data to address this question were collected through interviews.

Quantitative Analysis. Table 4 compares the means and standard deviations of the students' responses to the preproject and postprcject measures of attitude. The pretest and posttest means for all school subjects are very close. These results suggests that there was no measurable change in student attitudes as a result of the project. Apparently, the intervention did not have a positive or negative affect on the students' attitudes about math. One thing we can learn from these results is that the project did not cause negative feelings towards math. These results also indicate that there was not a general attitude change during the study towards school in general.

Table 4

T-Tests Comparisons of Students' Preproject and Postproject Attitudes Toward Math, English, Social Studies, and Science

Attitudinal Object	Mean	Standard Deviation	T Value	Level of Significance
Math Pretest	34.73	8.1	.37	.720
Math Posttest	34.18	8.6		
English Pretest	35.82	2.52	.27	.793
English Posttest	36.27	8.36		
Social Stu Pretest	33.64	10.11	.33	.747
Social Stu Posttest	32.91	12.60		
Science Pretest	28.37	7.33	1.55	.152
Science Posttest	26.46	5.61		

Table 5 lists the number of items, potential range of scores, and the reliability estimates and for each of the affective scales. The higher the score, the more positive a student's attitude was about math, and visa versa, a lower the score meant a student had more a negative attitude about math.

Table 5

Reliability Estimates for Affective Measures

Scale	Number of of Items	Potential Range of Scores	Coefficient Alpha Index of Reliability
Math Pretest	14	0 - 56	.847
Math Posttest	14	0 - 56	.897
English Pretest	14	0 - 56	.792
English Posttest	14	0 - 56	.878
Social Studies Pretest	14	0 - 56	.895
Social Studies Posttest	14	0 - 56	.931
Science Pretest	14	0 - 56	.702
Science Posttest	14	0 - 56	.633

Table 6 lists the students' scores for the pretest and posttest results on each of the attitude scales about school subjects. The students' scores on each of the pretest scales ranged from: Math 22 to 53; English 18 to 51, Social Studies 16 to 46; and Science 17 to 44. Their scores on the posttests ranged from: Math 25 to 50; English 29 to 52; Social Studies 14 to 50; and Science 18 to 44.

Table 6

Individual Student Scores (and Group Averages) Toward Math, English, Social Studies, and Science Affective Scales

Student	Math Pretest	Math Posttest	English Pretest	English Posttest	Social Stu Pretest	Social Stu Posttest	Science Pretest	Science Posttest
1	32	30	37	33	29	23	30	26
2	38	42	36	32	38	31	27	24
3	37	41	42	44	44	50	31	31
4	37	40	39	41	38	39	28	31
5	35	23	39	45	17	14	29	26
6	37	33	18	31	40	28	19	19
7	28	25	33	25	30	28	17	18
8	53	50	51	52	46	50	44	36
9	40	48	40	50	40	50	32	44
10	22	26	39	38	41	37	24	29
11	37	38	31	29	31	46	28	21
12	26	28	29	29	16	16	35	30
Average for all Students*	34.7	34.2	35.8	36.3	33.6	32.9	28.4	26.5

* These averages exclude student no. 9 (see Threats to Validity section).

Figure 1 shows how the previously listed affective scores fit on the affective continuum underlying the different school subjects. For example, the average score for students' responses on the math posttest scale was 34. This score would fall in the Neutral Attitude zone, however, it is very close to the Positive Attitude zone. We can conclude from these results that at the completion of the project, the students generally had somewhat of a neutral attitude towards math, with a tendency towards the positive direction.

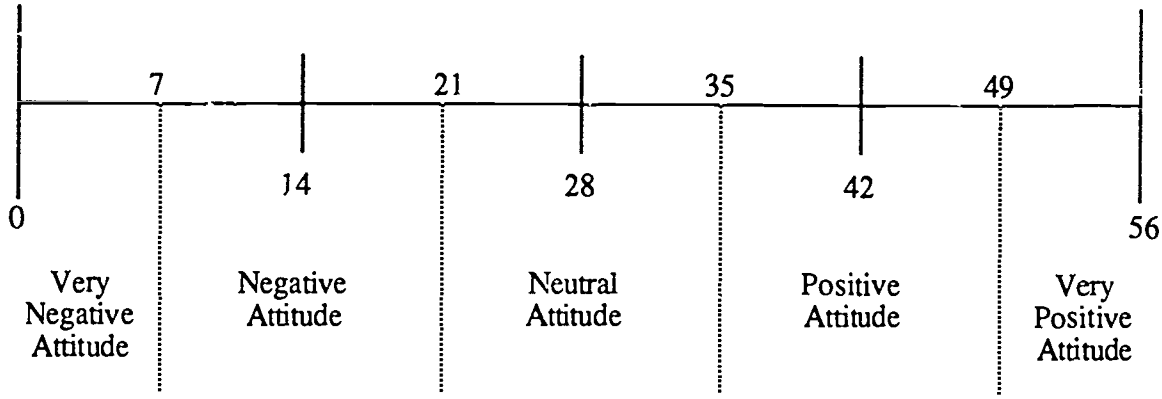

Figure 1

Continuum of Students' Attitudes Toward School Subjects

Qualitative Analysis. All of the students except three said that their attitude towards math has become more positive as result of this project. Three students said their attitude has stayed the same. From the student responses, the project did not have a negative affect on the students' attitudes towards math. One of the more positive responses was, "More positive attitude. I use to hate math. Now I feel better about being in the class."

Most of the volunteers indicated that they thought students attitudes about math were more positive as a result of the project. One volunteer indicated that students didn't like being required to go to the eighth period. Another volunteer responded by saying that he didn't really know and couldn't identify any general trends among the students.

Both of the school personnel who responded indicated that they noticed a change in students' attitude about math. They felt students were more positive about math as a result of the intervention. One commented, "Yes. Pats on the backs from volunteers helped. The situation was less stressful to the students because of the project."

Math Anxiety

To what extent did the project influence the students in terms of their anxiety towards math? Quantitative data to answer this question were collected using the Math Anxiety Scale. The questions in this instrument assessed the students' feelings and fears about math. Qualitative data to address this question were collected through interviews.

Quantitative Analysis. Table 7 compares the means and standard deviations of the students' responses to the preproject and postproject measures of math anxiety. The pretest and posttest means are very close. These results suggests that there was no measurable change in students' anxiety towards math as a result of the project. Apparently, the intervention did not have a positive or negative affect on the students' anxiety towards math. As the case with attitude about math, these results indicate that this project did not increase students' anxiety towards math.

Table 7

T-Tests Comparisons of Students' Preproject and Postproject Anxiety Toward Math

Attitudinal Object	Mean	Standard Deviation	T Value	Level of Significance
Math Pretest	26.72	11.63	.34	.739
Math Posttest	27.64	13.38		

Table 8 lists the number of items, potential range of scores, and the reliability estimates and for the pretests and posttests Math Anxiety scales. The higher the score, the more anxiety a student felt about math, and visa versa, the lower the score, the less anxiety a student felt about math.

Table 8

Reliability Estimates for Math Anxiety Measures

Scale	Number of of Items	Potential Range of Scores	Coefficient Alpha Index of Reliability
Math Pretest	18	0 - 72	.879
Math Posttest	18	0 - 72	.931

Table 9 lists the students' scores for the pretest and posttest results on each of Math Anxiety Scale. The students' scores on the pretest scale ranged from 11 to 49. Their scores on the posttest ranged from 7 to 60.

Table 9

Individual Student Scores (and Group Averages) on the Math Anxiety Scale

Student	Math Pretest	Math Posttest
1	23	31
2	18	16
3	19	18
4	20	24
5	30	46
6	18	22
7	40	42
8	11	7
9	17	60
10	49	49
11	27	30
12	39	19
Average for all Students*	26.7	27.6

* These averages exclude student no. 9 (see Threats to Validity section).

Like figure 1, figure 2 shows how the previously listed anxiety scores fit on the anxiety continuum underlying this construct. For example, the average score for students' responses on the math anxiety posttest scale was 27.6. This score would fall in the Neutral Attitude zone, however, it is very close to the Low Anxiety zone. We can conclude from these results that at the completion of the project, the students generally felt neutral anxiety towards math, with a tendency towards the low anxiety direction.

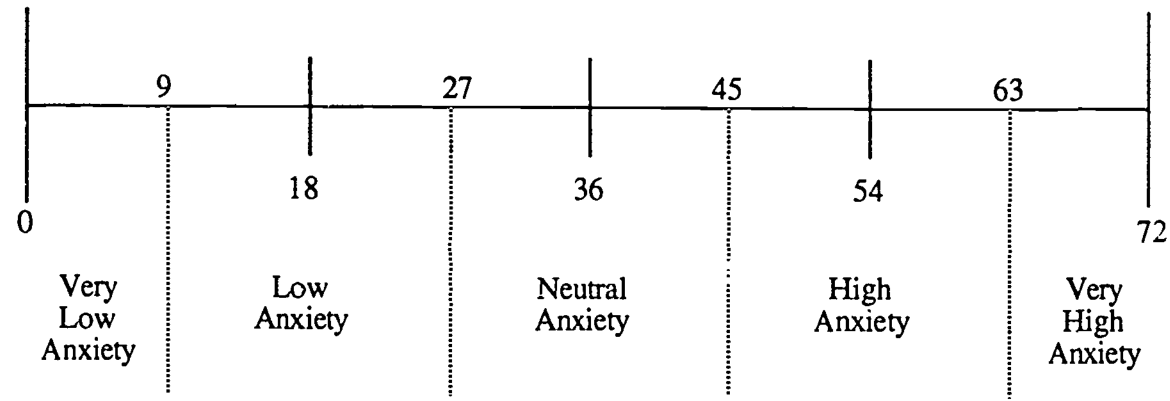

Figure 2

Continuum of Students' Anxiety Towards Math

Qualitative Analysis. Students were not asked if they thought their anxiety towards math had decreased as a result of the project. We thought the volunteers and school Personnel would be the best judges of this construct.

Either the volunteers didn't want to make a judgement on this construct or they thought the students' anxiety had decreased from the beginning of the semester. Two volunteers felt that they could not judge. Three felt that students' anxiety had decreased. One reported that he saw very little anxiety among students at all. One of the more positive comments were, "Yes. One kid in particular. I heard him talking about his lack of fear of math this semester."

The two school personnel who responded to this issue gave conflicting responses. One responded, "Yes. Some drastic, some small amount. Some were paranoid about certain areas of math." The other said, "No, probably not."

Study Habits

To what degree did the project affect math homework study habits of the students? Quantitative data to answer this question were collected using the Student Questionnaire. This questionnaire asked the students three questions concerning their study behavior habits. Qualitative data to address this question were collected through interviews.

Quantitative Analysis. Table 10 lists the students' responses to the first question on the questionnaire, which asked, "How often do you work on your math homework (outside of your math class)?" The results show that most of the students do homework about 1-2 times a week. There is not a significant change from the pretest and posttest results; however, it appears that a small shift occurred towards some students studying less after the project than before.

Table 10

Students' Responses on How Often They Do Homework Outside of Their Math Class

Response Categories	Pretest Results Number of Respondents	 Percentage of Respondents	Posttest Results Number of Respondents	 Percentage of Respondents
Everyday	1	8%	0	0%
3-4 times a week	1	8%	0	0%
1-2 times a week	9	75%	8	67%
1-2 times a month	1	8%	2	17%
Don't do homework	0	0%	2	17%
Total	12	99%	12	101%

Table 11 list the students' responses to second question on the questionnaire, which asked, "On average, about how much time do you spend working on your math homework during the week?" These results indicate that most of the students study 1-2 hours per week on math homework. The project did not significantly affect the amount of time students spend on math homework. It appears from the data that a minor shift in behavior took place during the project, with a few students studying less time than at the beginning of the project.

Table 11

Students' Responses on How Much Time They Spend Working on Math Homework During a Normal Week

	Pretest Results		Posttest Results	
Response Categories	Number of Respondents	Percentage of Respondents	Number of Respondents	Percentage of Respondents
None	2	17%	3	25%
1-2 hours	7	58%	8	67%
3-4 hours	2	17%	1	8%
5-6 hours	1	8%	0	0%
7-10 hours	0	0%	0	0%
More than 10 hrs a week	0	0%	0	0%
Total	12	100%	12	100%

Table 12 lists the students' responses to third question on the questionnaire, which asked, "How often do you study math during the eighth hour?" The purpose of this question was to determine whether students came in to study math on their own initiative as a result of the project. The results show that most of the students study 1-2 per week during the eighth hour. The project did not significantly affect the amount of time students study their math homework during the eighth hour. An analysis of the pretest and posttest results show a slight shift towards less time being spent studying during the eighth hour at the end of the project.

Table 12

Students' Responses on How Often They Study Math During the Eighth Hour

	Pretest Results		Posttest Results	
Response Categories	Number of Respondents	Percentage of Respondents	Number of Respondents	Percentage of Respondents
Everyday	1	8%	0	0%
3-4 times a week	1	8%	1	8%
1-2 times a week	6	50%	5	42%
1-2 times a month	3	25%	4	33%
Don't do homework	1	8%	2	17%
Total	12	99%	12	100%

Qualitative Analysis. Eight students indicated that their study habits improved as a result of the project. One student commented, "Yes. I was failing before, now I'm doing real well. I do a page of math every night." Three students said their study habits have not changed. Another student said, "Not really. I find more opportunity to goof off."

One of the school personnel responded to the question of whether or not the students' study habits have been improved by saying, "Yes. They do their homework better than they did before. They are more confident in their homework because they have had a lot more practice because of the computer." Only one person from the school was asked a question about his or her perceptions on study habits.

Positive Reinforcement

To what extent did the project provide students with positive reinforcement? Quantitative data to answer this question were collected using the Student Questionnaire. This questionnaire asked the students the following question, "How often in the past week has an adult at school told you that you have done well in math?" Qualitative data to address this question were collected through interviews.

Quantitative Analysis. Table 13 lists the students' responses to this question. The results indicate that most of the students never received positive reinforcement from an adult (during the previous week that they responded to the questionnaire) about their performance in math. The pretest and posttest comparison shows that four students responded in the pretest that they received positive reinforcement often or very often. However, none of the students responding in the posttest indicated that they had received often or very often positive reinforcement.

Table 13

Students' Responses on How Often They Received Positive Reinforcement from an Adult

	Pretest Results		Posttest Results	
Response Categories	Number of Respondents	Percentage of Respondents	Number of Respondents	Percentage of Respondents
Never	6	50%	7	58%
Sometimes (1-2 times/wk)	2	17%	5	42%
Often (about once a day)	2	17%	0	0%
Very Often (many times a day)	2	17%	0	0%
Total	12	101%	12	100%

Qualitative Analysis. All of the volunteers said that they tried to give positive reinforcement to the students. Some volunteers said they gave the students positive reinforcement everytime time they worked with a student.

One of the school personnel responded to the question of whether or not the students' received more positive reinforcement in this project than the previous semester by saying, "Yes. Most definitely. Volunteers were great in giving the students praise. They were always telling me how good the students were doing." Only one person from the school was asked a question about positive reinforcement.

Individual Help from an Adult

To what extent did the project provide students with individual help from an adult on their math problems? Quantitative data to answer this question were collected using the Student Questionnaire. Two questions were asked students concerning to what extent they received help from adults. Qualitative data to address this question were collected through interviews.

Quantitative Analysis. Table 14 lists the students' responses to a question which asked, "How often do you receive individual help from an adult at school to solve math problems?" Most of the students sometimes (1-2 times a week) receive help from an adult to solve their math problems. The pretest results indicate all of the students receive help from an adult at least weekly. However, the posttest results indicate that two of the students felt like they never had adult help in solving math problems.

Table 14

Students' Responses on How Often They Received Individual Help from an Adult to Solve Math Problems

	Pretest Results		Posttest Results	
Response Categories	Number of Respondents	Percentage of Respondents	Number of Respondents	Percentage of Respondents
Never	0	0%	2	17%
Sometimes (1-2 times/wk)	8	67%	6	50%
Often (about once a day)	3	25%	4	33%
Very Often (many times a day)	1	8%	0	0%
Total	12	100%	12	101%

Table 15 reports the results of a similar question to the previous question, however, with a little different emphasis. This question asked, "How often do you have problems with math that you cannot solve by yourself and don't receive help from an adult at school?" The information we wanted from this question was the frequency when a student couldn't solve a problem and obtain help from an adult. These results show that most of the students are never faced with such a situation that when they are faced with a math problem they cannot solve, they cannot find help from an adult to assist them in solving the problem. There doesn't seem to be a significant change from the pretest and posttest results. However, the posttest results seem to be somewhat more positive than the pretest in that the pretest results had more students who had the situation occur more frequently.

Table 15

Students' Responses on How Often They Cannot Solve Math Problems and Cannot Receive any Help from Adults

Response Categories	Pretest Results: Number of Respondents	Pretest Results: Percentage of Respondents	Posttest Results: Number of Respondents	Posttest Results: Percentage of Respondents
Never	6	50%	6	50%
Sometimes (1-2 times/wk)	3	25%	5	42%
Often (about once a day)	3	25%	1	8%
Very Often (many times a day)	0	0%	0	0%
Total	12	100%	12	100%

Qualitative Analysis. The volunteers indicated that they did not give a lot of individual help to students. Three students came to the school one day a week, in which they helped students during that period. Two other volunteers said that they didn't tutor much or not that often. The last volunteer said that he tutored about 15 percent of the time that he was at the school.

One of the school personnel responded to the question of whether or not he or she thought the students received more individualized help in this project than the previous semester using the traditional approach by saying, "Yes. Most important thing that the students got from the project. This was the best component of the project. The pilot group is near the normal 7th grade level math class. All the 7th graders in the class will go into the normal 8th grade class next year except one. One student will go into Pre-algebra." Only one person from the school was asked a question about individual help.

Participants' Perceptions of the Project

What are the strengths and weaknesses of the project as perceived by the participants and what suggestions do they have concerning how the project can be improved? Qualitative data collected through personal interviews, Volunteer Tutor Activity Sheets, and field notes were analyzed in this section of the report to identify participants' perceptions of the strength and weaknesses of the project. In addition, suggestions from participants are also listed.

Weaknesses of the Project

The students were not nearly as specific as the volunteers or school personnel about the weaknesses of the program. Six students said either "nothing" or "I don't know." Two students said a weakness of the program was not having more time in the lab. One student had a difficult time getting along with some of the volunteers and the other student did not like doing math problems.

The volunteers were very specific about some of the weaknesses and frustrations of the project. The following weaknesses were listed by the volunteers.

- The disorganization of the project.
- Didn't get to tutor students one-on-one.
- The school's rotating class schedule.
- Sitting around waiting for something to do.
- Difficult to supervise students in the lab with only one volunteer.
- Volunteers were not trained or oriented on what they should be doing in the project.
- Poor training and orientation. Volunteers were not trained on how to tutor students and run the computers.
- Software programs didn't match the learning objectives of the class.
- No management system so that they could know what programs students should run.
- Vast majority of software programs didn't help much, there were more games than instructional.
- The students really were not learning anything new, just playing around. The students were not progressing as fast as they could have.
- The achievement tests used did not match the software or the learning objectives of the class.
- The volunteers had a misconception about the entire project because an appropriate orientation and overview wasn't conducted. Not having a real concept of what we were trying to do in this project or what we were suppose to do as volunteers.
- Poor software in the computer lab.
- There weren't enough people involved in the project to run it and make it systematic and organized.
- Not much support from the school staff.
- Lack of communication.
- School should have communicated things better.
- Very advanced students running simple math and fractions software games.

The school personnel identified some of the same weaknesses as those listed previously. The following list identifies weaknesses which were not addressed in the previous list by the volunteers.

- Trying to run the computer lab without volunteers supervising the lab.
- School Administration conducts a last minute thing, like an assembly or something, and throws the tutoring and computer lab schedule completely off.
- District support not complete.

Strengths of the Program

To determine what students thought were some of the strengths of the project, we asked them, "What did you like most about this program?" Seven students said they liked using the computers. Two students said they really liked the variety the program offered. One student indicated that he liked getting out of class the most. The last student commented, "The volunteers taking the time for us to help us out."

The volunteers were asked, "What did you like most about this program?" Four of the six volunteers responded by saying they liked the association of the students. Another volunteer said he liked the to see the students having a positive experience with math. The last volunteer said that he liked the "theory or concept of the whole idea. It is a worthwhile idea to try out and develop a program."

Two of the school personnel were asked what they liked most about the project. The first responded, "Volunteers, they were the strength of the program. The volunteers were very willing. Without them we wouldn't have had the computer lab. I wouldn't have a computer lab without volunteers." The second person said, "Other teachers feel better about using volunteers in their classroom because of the results of this program."

Suggestions to Improve the Project

To determine what suggestions students had to improve the project, we asked them, "What suggestions do you have to improve this program?" Five students suggested purchasing better software for the lab. For example, one student said, "Get joy sticks for the computers. Purchase better games, it is a drag using the keyboard when you could use joy sticks." Two of these five students mentioned specifically purchasing better games for the lab. One student suggested that the lab needed to be better supervised. She said, "The teacher should stay in the classroom, when she doesn't, the volunteers don't manage the lab properly. Students change the programs that she tells them to run as soon as she leaves the computer lab." Two students suggested having more volunteers to help students. Three students said that they couldn't think of anything. The last student thought the math problems on the computer should be harder.

The volunteers were asked, "What suggestions do you have to improve this program?" The following list is a summary of their suggestions.

- Better organize the whole project. This item was mentioned by almost every volunteer.
- Have a programmer write software programs which map onto the achievement tests and learning objectives for the class.
- Properly instruct and train the tutors. Train them how to use the computers and tutor students. This item was mentioned frequently by almost all volunteers.
- Give the volunteers a better overview and focus of the concept of what the project is about. Need more and better orientation for volunteers.
- Give volunteers more responsibilities. Teach them how to properly evaluate students progress and give them more responsibility for student learning and progress.
- Map the achievement tests to the learning objectives. Then map the software onto the achievement tests and learning objectives.
- Get better achievement tests.
- Have more than one volunteer in the computer lab at one time.
- Give the volunteers the same text that the students are using (or better yet a teacher's guide with the answers in it) so they can be prepared for the type of things the students will ask them.
- Give the volunteers a list of the students' names so they can call them by name and become more personable with them.
- Train the volunteers on the math content going to be covered that semester or year before school starts.
- Establish goals with each student so they can be part of the process.
- Hire someone full-time to run the computer lab. This person should take pride and full responsibility for the program and the computer lab.
- Get better software.

The school personnel were asked to list the suggestions they thought would improve the project. The first person suggested, "Get more and better software for the computer lab. Need to get diagnostic programs to determine in what areas students are weak. Then have student run that program where he will practice the math skills in which he is weak. Have the volunteers really control the computer lab." The second person responded, "Hire someone to run the computer lab 5 hours a day. This person will take full responsibility to make sure the project is implemented completely and has full charge of the lab. Take a year to get the software mapped out according to the objectives. Ideally, the teacher would send the student to the computer lab with a note indicating what math skills he needs to practice, and the lab supervisor would then give him the appropriate software to practice those skills." The third person said, "More communication is needed between the volunteers and the teachers. Need to have an up-to-date file on each student. Volunteers should sign in and then get right to work, no waiting time. Need much better organization."

DISCUSSION

This section of the report will address threats to internal validity of the study and discuss issues and implications concerning the major three evaluation questions.

Limitations of the Study and Threats to Validity

There were several constraints placed upon this evaluation which created threats to the internal validity of inferences about the effects of the project. In addition, because this evaluation was formative and included such a small sample, there are many limitations to which these results can be generalized. These threats and limitations and their implications will be discussed in the following list.

1. Pretest instruments were administered after the project was in progress. The Math Anxiety Scale, Attitude about School Scale, and the Student Questionnaire were administered about two weeks after the project began. Even though we requested the students to fill out the questionnaires as if we had given the instruments to the students on the first day of school (for the second semester), some students may have been confused and not understood this request. We should also recognize that it would have been impossible for the students to complete the questionnaires without any biases from the previous few weeks that the intervention had been in operation. In addition, the Metra achievement tests were administered by the volunteers while the project was in operation. A few pretests were administered as late as the beginning of March, about two months into the project.
2. There were inconsistencies in how the Metra pretests and posttests were administered. The volunteers administered the pretests over a two month period of time; however, the posttest were administered in one day. The volunteers only administered one pretest at a time, but the all four posttests were administered to students in one setting. The volunteers were not as rigorous in administering the pretests as the evaluators were in the posttests. For example, some of the volunteers cued or prompted the students in solving some of the test items. Some volunteers lost track of time in timed items and allowed the students to continue over the maximum time of a minute.
3. There was not a direct match between the instructional objectives of the class (scope and sequence), the criterion-referenced tests and the software in the computer lab. It is unfair to judge a student's performance on the achievement tests if the tests did not measure what the teacher was teaching. For example, if a student scored 50 percent correct of the items on the Fractions test, we might be inclined to conclude that the project didn't do any good. However, if the teacher only taught 50 percent of the items on the test to the students, then we might say the student did very well on the test. The tests were designed to measure basic math computational skills. We do not know to what degree the teacher taught the same basic math computation skills that were assessed in the Metra tests.

4. The lack of representativeness of the students in this class posed a threat to the external validity of the evaluation data. The students were not randomly selected to participate, and this group may be very different than students in other classes. Since this group was so small, it is unlikely that this group is typical or representative of the students who will participate in this project in the future. The degree to which generalizations are made from the results of this study should be severely limited. Since this was a formative evaluation, it was more important to identify the effects of the project on the students than it was to be able to generalize the results to some larger sample.
5. The responses for student no. 9 were not used in the data analysis of the affective data. Inspection of the instruments he completed showed that he responded to every item the same, regardless of whether it was a positive or negative Likert item. As we administered the questionnaires, we remembered this student completing each of the scales within a matter of minutes, finishing at least 10 minutes before any other student.
6. The results from Volunteer Tutor Activity Sheets does not represent the activities of all the volunteers because only a few of the volunteers filled them out as they were asked. We asked one volunteer why she wasn't filling out the sheet and she said that she didn't want to be bothered with paper work. Two other volunteers indicated that they were not aware that they were suppose to be filling out the sheets everyday. Very little data from these sheets were used in the data analysis because they did not represent all the volunteers typical activities.
7. The R.A.T. pretest was given in September, 1986, however, the project did not begin until January, 1987. It is possible that much of the student learning which resulted in a significant difference between the pretest and posttest results could have occurred previous to the implementation of the project. Also, we cannot provide information about how these tests were administered, and what controls were taken to ensure validity and reliability of the results.
8. At times it seemed as though student motivation to do their best on the tests were at a minimum, especially when conducting the Metra posttests. Some of the evaluators commented that it seemed some of the students deliberately said they could not do a certain unit of the test (even though they probably could have if they had tried) so they could finish the test early and leave. Other students may not have taken the time to truthfully report how they felt about math when we conducted the affective postmeasures.
9. The positive reinforcement question on the Student Questionnaire may have reported incomplete data (question no. 4). The question asked students to limit their response to the previous week. A time frame within the last week was given because we felt students may not be able to remember incidences longer than that time period. Some problems with this is that the students may have had a bad week when we came or a week was too short period of time to limit their response.
10. The trustworthiness of qualitative data (such as the data collected in interviews and field notes) was not established through triangulation and member checking through multiple sources as described by Guba and Lincoln (1981). In addition, the observations should have been conducted much more frequently and for longer durations. These procedures were not conducted because of budget and time constraints.
11. The data analysis of the Syracuse Math Anxiety Scale results showed that some of the items might have had too high of a readability level. Items which scored very well in previous results administered by Dr. Richard Sudweeks to upper high school students did not prove to be good items in these results. For example, the first item reads, "I'm allergic to math courses." This item scored very high using results from high school students; however, it did not score very well using the results from this study. Possibly the students could not decode the word allergic. Also, some of the items contained double negatives, which might have confused some of the students.

12. Some of the students' responses to the study habits questions (questions 1 through 3) on the Student Questionnaire conflicted. For example, a student might have responded that he studies math 2-3 times a week in the first question; however, then responded to the second question that he doesn't spend anytime studying during the week. Students may have misunderstood the questions or not have read carefully enough as they were filling completing the questionnaire.

After reviewing these threats to validity, you may ask, "Why do the evaluation?" Popham has said, "the practical constraints of many educational settings prevent us from designing evaluation studies as tidily as we might in a laboratory (1975, p. 200)." Compromises become necessary as we work with situations which involve human subjects and other practical considerations (Applegate, 1985). It is worth repeating here that the function of this evaluation was formative, to provide information about how this project can be improved. While it is true that generalizability from the results of this study are limited due to the threats of validity identified, these results provide stakeholders with the project improvement data expected from a formative evaluation.

Implementation of the Project

The project was not fully implemented as it should have been according to the original design. In fact, most of the components of the original design were not implemented. The project's main objective to maximize the use of computers by having students execute specific programs commensurate with their instructional needs was not realized. Even though the teacher attempted to have students run specific programs for their particular instructional needs, what actually happened in the computer lab did not match what should have happened according to the original design.

Because there is so much variance between the original project design and what actually happened in the implementation of the project, making inferences about the original project is not appropriate. We must stress the point that the inferences and conclusions made in this study must be limited to the project as it was implemented and not as it was designed.

Several reasons were stated earlier in this report explaining why the project was not implemented as it was designed. The following primary problems or issues affecting proper implementation are summarized. First, assignments and expectations were not clear. Educators were confused concerning how the project should have been implemented and according to what criteria. There seemed to be a lack of communication among those participating at the site as well as a lack of communication between those at the site and the district level. Related to this issue, people were not accountable for their specific responsibilities. No formal reporting system was established. Many of the problems which occurred might have been identified much earlier and overcome had such a system been in operation. Second, school administrators did not have the necessary time to attend to the project and the complete some their responsibilities. They did not realize the necessary time commitment this project required to successfully implement. Because other tasks emerged which took priority over this project, many of the tasks were uncompleted.

Impact on Students

What affect did the project have on student achievement? This question is very difficult to answer because there were so many threats to validity. What this means is that we need to be very cautious about any conclusions and inferences made concerning this project. Had data been collected with fewer threats to validity, the results of the study might have showed something different. But it is important to remember that the function of this study was formative, not summative. The quantitative data were collected and statistical data analysis procedures conducted to help us understand what impact the project had on students and how it could be improved.

The only criterion-referenced test which showed a statistical significance between pretest and posttest were the results on the Fractions Test. The R.A.T. showed a significant difference between pretest and posttest administered at the beginning and again at the end of the year. There are several reasons which could explain why only the Fractions test was significant. For example, the teacher may have covered fractions in some detail in direct class instruction during most of the duration of the project. Perhaps students practiced fractions more frequently than other math skills because the best computer games dealt with fractions. Even though the R.A.T. scores showed a significant difference, we need to remember that the pretest were administered in September 1986, four months before the intervention was started. We cannot conclude from these results that the significance between the pretest and posttests results were caused by the intervention.

The findings showed that the students seem to have a good understanding of the concepts and the necessary math skills for the criteria in the Math 1 test. However, their scores were not very high for the other three tests. The average scores for percent correct on the Math 2, Fractions and Decimals posttests were, respectively, 72, 57, and 56 percent. At the conclusion of the project, most students could not perform many of the math computational skills required in the tests. Again, we should reiterate that the criterion-referenced tests did not directly match the instructional objectives of the class.

The qualitative data showed that most people thought the students learned more about math as a result of this project than the traditional approach the students had the previous semester. The teacher felt that the students in her pilot study class did better than her students in a similar basic math class primarily because of the project.

How did the project influence student attitudes? The quantitative results showed that the project didn't influence the students either positively or negatively. Before and after the project, students seemed to have a rather neutral attitude (leaning more on the positive side than the negative) about math.

The qualitative results suggested that almost all the participants felt that the students attitudes about math became more positive as a result of the project. No one mentioned that the project had a negative affect on students' attitudes about math.

How did the project influence students' anxiety towards math? As with the previous measure, the quantitative results revealed that the project did not influence the students either positively or negatively. Preproject and postproject, students reported a neutral (leaning more on the low anxiety side than the high anxiety side) anxiety level about math.

The volunteers and school personnel were unsure about what affect the project had on student's anxiety level. Most people indicated that they couldn't make a judgment. Some people said the project decreased some of the students' anxiety level, and a few said there was no change. No one indicated that the project increased student anxiety towards math.

How did the project affect the homework study habits of the students? The quantitative data (obtained through self-report) suggested that the project didn't influence students' study habits. The interview data showed that most of the students said their study habits improved as a result of the project. The teacher also felt the students' study habits improved because of the project.

To what extent did the students receive positive reinforcement? Results from the Student Questionnaire suggested positive reinforcement from an adult did not change much from preproject to postproject. Most students reported that they never received positive reinforcement from an adult. These results seem to conflict with the quantitative results. All of the volunteers said they freely gave positive reinforcement to the students when they tutored them. One possible reason for this discrepancy is that many of the students were not tutored and did not receive praise from the volunteers.

To what extent did the students receive individual attention? The students reported that they never or only sometimes received individual help. These reports seem to agree with the data collected from volunteer interviews. Most of the volunteers said they rarely tutored students.

Strengths, Weaknesses and Suggestions Identified by Project Participants

Despite the major weaknesses of this project, it appears that most people were generally pleased with it, even though it wasn't really the same project that was suppose to be implemented. Most people would like to see the project implemented again, but more in accordance to original design and using the recommendations of this study. Participants suggestions along with those of the evaluators have been summarized and are listed in the next section of this report (RECOMMENDATIONS).

RECOMMENDATIONS

Mostly all the participants judged this project to have a high degree of merit and worth. They would like to see the project continue, but with more control so it is implemented as it was designed. The following section lists the primary recommendations on how the project can be improved when it is implemented in the future.

1. In discussion and consultation with the participants of the project, develop a design document which gives a detailed description of the purpose of the project, how it is to function, how it is to be implemented, etc. This document should also list specific responsibilities and timelines when individuals should give an accounting on the status of their responsibilities. Someone should be responsible for tracking the implementation of the project to ensure that all the specific tasks are completed.
2. Hire a computer lab supervisor. This person should take the bulk of the responsibility to make sure that all of the components of the project are implemented and function properly. He or she at a minimum should be responsible for the following responsibilities: (a) in consultation with teachers and other necessary people, ensure that the instructional objectives for the classes match the achievement tests and the software, (b) organize and maintain the management system, (c) supervise the activities of the volunteers in the lab and train them, (d) ensure that appropriate and effective software is purchased for the lab, (e) organize and maintain the record keeping system in the computer lab, and (f) work closely with the volunteer coordinator to ensure consistent and regular scheduling of volunteers.
3. Train volunteers. They should not only be trained on how to effectively use the computers, but also how to effectively tutor students. Volunteers should be given sufficient orientation so they understand the whole picture of what the project is trying to accomplish and how they fit into that plan. Give the volunteers copies of the student and teacher materials so they can be prepared on the math skills students are learning. Teach volunteers the scope and sequence of the class they will be assisting. Give the volunteers more responsibility in the teaching and evaluating students progress. Volunteers do not enjoy just supervising the computer lab. They feel a great sense of reward and contribution by assisting students one-on-one in tutoring situations.
4. Computer Lab. Have students work individually on the computers instead of in pairs. This may require reducing the time each student sits at a computer, but even this reduced time will be more effective than working with a partner. Furnish the computer lab with the necessary materials or furnishings to assist instruction. For example, purchase drapes to reduce the glare on the screen and prevent the sun from melting the disks left out. Higher chairs would help in keyboarding tasks. Keep detailed records of what programs students have executed and their success. This will prevent students from only executing games the entire hour and encourage them to continually progress to more difficult problems. Purchase record keeping programs for the Apple IIe

systems in the lab to manage these records. Set up a regular schedule so that volunteers will at the same time everyday and not have to rotate on the school's schedule.

5. Eighth hour. Allow students to voluntarily come during the eighth hour to make up work, run favorite math games, receive individual tutor from a volunteer, etc. Most of the fun computer games which do not have much instructional worth or merit could be made available for students to run during this time.

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