THE TALENT DEVELOPMENT MIDDLE SCHOOL
An Elective Replacement Approach to Providing Extra Help in Math — The CATAMA Program (Computer- and Team-Assisted Mathematics Acceleration)

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The Center

Every child has the capacity to succeed in school and in life. Yet far too many children, especially those from poor and minority families, are placed at risk by school practices that are based on a sorting paradigm in which some students receive high-expectations instruction while the rest are relegated to lower quality education and lower quality futures. The sorting perspective must be replaced by a "talent development" model that asserts that all children are capable of succeeding in a rich and demanding curriculum with appropriate assistance and support.

The mission of the Center for Research on the Education of Students Placed At Risk (CRESPAR) is to conduct the research, development, evaluation, and dissemination needed to transform schooling for students placed at risk. The work of the Center is guided by three central themes — ensuring the success of all students at key development points, building on students' personal and cultural assets, and scaling up effective programs — and conducted through seven research and development programs and a program of institutional activities.

CRESPAR is organized as a partnership of Johns Hopkins University and Howard University, in collaboration with researchers at the University of California at Santa Barbara, University of California at Los Angeles, University of Chicago, Manpower Demonstration Research Corporation, University of Memphis, Haskell Indian Nations University, and University of Houston-Clear Lake.

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Abstract

In Talent Development Middle Schools, students needing extra help in mathematics participate in the Computer- and Team-Assisted Mathematics Acceleration (CATAMA) course. CATAMA is an innovative combination of computer-assisted instruction and structured cooperative learning that students receive *in addition* to their regular math course for about ten weeks of the school year. This report presents two studies of CATAMA. The first compares growth in math achievement for 96 seventh graders, 48 of whom participated in CATAMA for ten weeks and 48 of whom were students of similar prior achievement who attended a comparison school where CATAMA is not offered. The second study reports data from interviews with CATAMA participants and observations of the program in action. Growth in mathematics procedures achievement was about one-half a standard deviation higher for CATAMA participants than for students in the comparison sample. High levels of student engagement and cooperation were observed among participants. Students liked being in CATAMA and working with a partner and a computer to strengthen their procedural knowledge and skills. The discussion suggests that CATAMA has many advantages — compared to other approaches to providing extra help in math — on several dimensions, including cost, capacity, and flexibility.

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Introduction

The Talent Development Middle School is a whole-school reform model developed by researchers, educators, and experienced curriculum writers at Johns Hopkins University and Howard University in collaboration with middle school practitioners. The Talent Development Model aims to develop the talent of all students by helping middle schools with high concentrations of poverty establish standards-driven curriculum and instruction in all major subject areas for all students, intensive extra-help opportunities for students in mathematics and reading, innovative approaches to school organization and staffing, and focused and sustained professional development opportunities for teachers (Mac Iver, Balfanz, Plank, & Ruby, 1998; Plank & Mac Iver, 1998; Mac Iver, & Plank, 1997, Mac Iver, Plank, & Balfanz, 1997; Madhere & Mac Iver, 1996; Useem, 1998). Talent Development Middle School staff from Johns Hopkins assist schools in phasing in these reforms over a three to four year period. This report describes how the Talent Development approach to providing extra help in mathematics has been applied in the nation's first Talent Development Middle School in Philadelphia, and describes our ongoing efforts to evaluate and refine this approach.

Extra Help: Who Needs It?

Middle schools which seek to offer all students a standards-driven mathematics curriculum that prepares them for college and features "teaching for meaning" (Knapp, 1995) need effective extra-help programs to provide additional support for students whose procedural knowledge and skills are weak compared to local or national norms. Although almost all public schools offer some type of extra-help program in mathematics, remarkably little data exists concerning the effects of different extra-help opportunities on students' outcomes. Evidence suggests that provision of trained adult tutors who work one-to-one or one-to-two with students is effective, especially if these tutors adapt the content and pace of instruction to the needs of individual students and if tutoring is provided in addition to regular classroom instruction and therefore adds to instructional time (Cooledge & Wurster, 1985; Devin-Sheehan, Feldman, & Allen, 1976; Mac Iver, 1991; Wasik & Slavin, 1990; Wilks & Clarke, 1988). However, most schools cannot afford to hire adult tutors to serve students who need extra help, especially if they have many such students. In fact, schools in which extra-help opportunities are needed most (e.g., in middle schools in which the average achievement of students upon entry to the school is considerably below national norms) are the very schools that are least likely to offer one-to-one tutoring.

Mac Iver (1991) used data from NELS:88 to investigate the effects of different types of extra-help programs in the middle grades on students' standardized test scores in both reading and math. He found that these correlational data suggested that approaches in which struggling students receive a substantial extra dose of instruction (e.g., an elective replacement class, a Saturday class, or summer classes) were much more effective than less intensive approaches (small group pull-out programs and before- or after-school coaching classes). Mac Iver (1991) urged researchers to test the replicability of these findings with intervention studies that first implement and then evaluate intensive approaches. This report presents the results of two such studies.

In middle schools that have very high proportions of students from low-income families, almost all students in the school need extra help in mathematics. This extra help is especially important in schools that are beginning implementation of the Talent Development blueprint for middle school reform. First, many students are significantly behind local and national achievement norms in mathematics and need an opportunity to catch up quickly so that they will not be overwhelmed by the challenging learning tasks that they will face once a standards-driven curriculum pervades the school. Second, some students need extra help because they currently receive their regular mathematics course from a teacher who is not yet offering excellent curriculum and instruction in mathematics (e.g., teachers or long-term substitutes whose knowledge of math content, pedagogy, or classroom management is weak and teachers who have low expectations for their students who maintain a slow pace and offer mostly dumbed-down content or review content rather than new content). Third, many of the stronger students in the school also need extra help in mathematics in order to increase their chances of competing successfully in the broader educational marketplace (e.g., gaining admission to the best available high school programs so that they can enter an educational trajectory that is likely to lead to high SAT scores and admission to an excellent college or university).

What Kind of Extra Help is Provided?

In Talent Development Middle Schools, students needing extra help in mathematics participate in the Computer- and Team-Assisted Mathematics Acceleration (CATAMA) course. CATAMA is an accelerated learning course that students receive *in addition* to their regular math course. CATAMA replaces an elective course for about ten weeks of the school year to provide a substantial "extra dose" of intensive instruction.

As its name implies, the CATAMA course involves an innovative combination of computer-assisted instruction and structured cooperative learning. Different software is used for students from different grade levels. Seventh graders, for example, are assigned an individualized sequence of lessons from the SkillsBank 3 computer program, which contains 100 lessons covering a broad spectrum of proficiencies in math computation, math concepts, word problems, geometry, algebra, and thinking skills. They are first given a placement test to identify which lessons each student needs and to create partnerships between students who need the same sequence of lessons. There are 20 students in each section of CATAMA and 10 computers in the CATAMA lab. Partners share a computer each day and take turns reading aloud the on-screen examples, hints, and explanations and solving the 8 to 10 problems that accompany each lesson. When a partnership completes a subsection of lessons, each student takes an individual quiz to assess individual learning of the concepts and skills covered in that subsection. Similarly, when a partnership completes all the lessons in a section, each student takes an individual exam to assess his or her mastery.

Each partnership is paired with another partnership to form a four-person cooperative learning team. If one partnership in a team gets stuck, it is the other partnership's job to help them get unstuck. Teammates encourage each other and help each other learn. (For example, when a student's computer is unavailable to him because his or her partner is taking an individual quiz or exam on the computer, the student may work with the other two members of his team.) Teams that are successful in helping every team member learn receive certificates or other modest rewards to recognize the team's success.

Although students spend a majority of their time working with their partner on the computer, the teacher frequently offers whole-class or small group lessons on specific concepts or skills to supplement or reinforce the computer-based instruction.

This report presents two studies of CATAMA. The first study compares the growth in math achievement for 96 seventh graders, 48 of whom participated in the CATAMA course for ten weeks during the 1996-1997 school year and 48 of whom were students of similar prior achievement who attended the Talent Development Middle School's comparison school where CATAMA is not offered. The second study is a qualitative study of the CATAMA program in the 1997-1998 school year and involves interviews with CATAMA participants and observations of the program in action.

These studies are followed by a general discussion of the CATAMA program which compares the "elective replacement" approach to providing extra help with other approaches along dimensions such as cost-effectiveness and capacity.

Study 1
Growth in Math Achievement by Seventh Graders Participating or Not Participating in the CATAMA Program

Participants

Sixty-five seventh graders participated in the CATAMA program at Central East Middle School in Philadelphia during the 1996-1997 school year. Prior mathematics achievement data from Spring 1996 on the abbreviated battery of the Stanford 9 achievement test were available for 58 of these 65 CATAMA participants. To obtain an estimate of the effect of CATAMA on students' mathematics achievement, we drew a comparison sample of seventh graders — with matching prior total mathematics scale scores from Spring 1996 — from Central East Middle School's demographically matched comparison school.[1]

We selected our comparison sample by printing out a list of prior achievement data for all seventh graders from the comparison school who had completed the mathematics battery of the abbreviated version of the Stanford 9 Achievement Test in Spring 1996. Students were sorted according to their total mathematics score on this test. For each CATAMA participant, we then chose a comparison student whose total mathematics score was equal to that of the participant (Main Criterion). If there was more than one student in the comparison school whose total mathematics score from Spring 1996 equaled that of the CATAMA participant, then we used the following additional criteria in selecting a comparison student (in order of priority):

Additional Criterion 1: Choose a student who matches the CATAMA participant exactly on the two subscales (problem-solving and procedures) of the total mathematics battery.

Additional Criterion 2: Choose a student who matches the CATAMA participant's gender.

If more than one student met the Main Criterion and both of the two Additional Criteria, we used a random number table to select among these students. If there were no students who met the main criterion — no student whose total mathematics score was an exact match to that of the participant — we selected the closest available match as long as there was a student within at least 6 points of the participant on the total mathematics scale. Once a comparison site student was assigned as a match, he or she was removed from the available pool. Matches were found for 48 of the 58 CATAMA participants who had prior achievement data. Thus, the main analyses reported here focus on 48 CATAMA participants and a matched sample of 48 nonparticipants from the comparison school.

Our procedure resulted in the selection of a comparison sample whose prior achievement was highly similar to that of CATAMA participants (Mean Math Total Scale Scores from Spring 1996: $\underline{M}_{(\text{comparison sample})} = 652$ and $\underline{M}_{(\text{CATAMA participants})} = 653$, $\underline{t} = .204$, $\underline{p} = .84$)

End-of-Year Mathematics Procedures Scale Scores

We hoped that analyses of students' mathematics procedures scale scores from Spring 1997 would indicate that holding prior achievement constant, CATAMA participants demonstrate greater mastery of mathematics procedures than students in the comparison sample. In addition, we thought that the effect of CATAMA participation on mathematics procedures achievement might be stronger for students with relatively higher levels of prior achievement (the students for whom achieving a substantial boost in mathematics proficiency might have a very tangible and salient payoff — allowing them to qualify for a selective admission high school program.).

Table 1. Multiple Regression Model to Predict Seventh Graders' End-of-Year Mathematics Procedures Scale Scores on the Stanford 9 Achievement Test (N=96 students)

Predictor	B	Se	p-value	Standardized Coefficients
Intercept	674.57	3.27	.00	
PRIOR_MATH_ACH	.62	.14	.00	β = .47
CATAMA_PARTICIPATION	12.16	4.62	.01	δ = .49
PRIOR X CATAMA	.40	.20	.05	

Note. PRIOR_MATH_ACH is grand-mean-centered. $R^2 = .46$.

Table 1 summarizes the results from a multiple regression model in which students' end-of-year mathematics procedures scale scores (MATH_PROCEDURES) are predicted based on 3 variables: students' prior mathematics total scale scores from the end of the previous school year (PRIOR_MATH_ACH), students' participation in CATAMA

(CATAMA_PARTICIPATION, coded 0 for non-participants, and 1 for participants), and a product term representing the interaction of these two variables (PRIOR X CATAMA).

As expected, student's prior math achievement is a significant predictor of their end-of-year mathematics procedures scale scores (b = .62). As the β coefficient associated with this effect indicates, a one standard deviation increase in students' prior math achievement is associated with an increase of .47 standard deviations in their mathematics procedures scale scores.

The coefficient for CATAMA PARTICIPATION (12.16) indicates that mathematics procedures achievement scale scores were much higher for typical CATAMA participants than for students in the comparison sample. This effect of CATAMA PARTICIPATION is expressed in standard deviation units in the final column where the effect size coefficient (δ) indicates that math procedures achievement scale scores were about one-half of a standard deviation higher for the average CATAMA participant than for the average student in the matched comparison sample. This effect of CATAMA participation on mathematics procedures scale scores translates into an 11-point advantage in students' end-of-year national percentile ranks — the typical CATAMA participant was boosted to the 54th national percentile in math procedures achievement, while the typical student from the matched comparison sample reached only the 43rd national percentile.

Finally, there is also a significant interaction between prior math achievement and CATAMA participation (b = .40). To explore the nature of this interaction, we examined growth in students' math procedures scale scores for participants and nonparticipants across the entire prior achievement spectrum. This inspection revealed that CATAMA participants outgained nonparticipants across the entire prior achievement spectrum, except for the four participants and four nonparticipants with the lowest starting points (those whose total math scale scores from the previous spring were between 585 and 624).[2] Table 2 summarizes the mean growth in math procedures scale scores obtained by participants and nonparticipants for these 8 cases (with prior total math scale scores below 625) and for the other 88 cases (with scores above 625). For the 88 cases with starting points on the math total scale over 625, CATAMA participants grew by 28.6 points on average (outgaining nonparticipants by almost 18 points). The four CATAMA participants with starting points on the math total scale that were below 625 also showed dramatic growth (growing 37.3 points on average). However, these four CATAMA participants were outgained by their four matches from the comparison sample by about 24 points. It may be that the four seventh graders from the comparison school with the lowest starting points received one-to-one tutoring or some other similarly intense form of help.

Table 2. Growth in Math Procedures Scale Scores (between Spring 96 and Spring 97) for CATAMA Participants and Nonparticipants Whose Prior Total Math Achievement Scale Scores Were Greater than 625 or Less than 625

Group	n	Mean Growth	SD
Prior Total Math Achievement Greater than 625			
CATAMA Participants	44	**28.6**	28.7
Nonparticipants	44	**10.9**	23.0
Prior Total Math Achievement Less than 625			
CATAMA Participants	4	**37.3**	11.6
Nonparticipants	4	**61.5**	8.2

In summary, the results indicate that CATAMA participants from across the entire prior achievement spectrum showed dramatic growth in their understanding and application of math procedures. Also, for the vast majority of CATAMA participants, this dramatic growth was much larger than the growth observed in similar students from the comparison sample.

Number of Seventh Graders Meeting Minimum Criterion on Mathematics Procedures Test for Admission into Special Admission High School Programs

One concrete goal of the CATAMA program is to help greater numbers of seventh graders to boost their end-of-year mathematics procedures test scores in mathematics on the Stanford 9 to at least the 85th local percentile. Many of the special admission high schools in Philadelphia — such as George Washington Carver High School of Engineering and Science, Central High School, or Philadelphia High School for Girls — require a student to score at this percentile or above at the end of the seventh-grade year in order to be considered for admission as a ninth grader. Eighteen of 48 CATAMA participants reached the 85th citywide percentile on their mathematics procedures test as opposed to only 7 of the 48 matched students from the comparison sample (χ^2 (1) = 6.54, $\underline{p}$ =.01).

End-of-Year Mathematics Problem-Solving Scale Scores

Despite the strong positive impact of CATAMA participation on students' procedural knowledge and skills in mathematics, we anticipated no impact of CATAMA on students' performance on the problem-solving subtest of the Stanford 9 because this test emphasizes nontraditional competencies such as reasoning in spatial contexts, reasoning with proportions, reasoning from graphs, identifying and using patterns and functional relationships, understanding variables, expressions, equations, and probability, understanding geometric objects and relationships and using geometry in solving problems. These competencies figure prominently in the NCTM standards as important proficiencies that have not received much attention in traditional curriculum and instruction nor in traditional software packages such as Skillsbank 3. These competencies all receive a great deal of attention in the standards-driven curriculum that Central East Middle School began implementing this school year, the year *after* Study 1 was conducted. One reason for the CATAMA program is to reassure teachers that they can begin focusing more on these important new proficiencies in the regular classroom, because students who need extra work on their procedural knowledge and skills participate in CATAMA in addition to attending a regular math class.

As expected, multiple regression analyses which control for students' prior total mathematics achievement scale scores indicate that CATAMA participants scored no better and no worse than nonparticipants on the problem-solving subtest ($b = .17$, $p = .97$). A follow-up analysis indicated that this finding of "no benefit of CATAMA" on the problem-solving subtest was true across the entire achievement spectrum. That is, there was no PRIOR ACHIEVEMENT x CATAMA PARTICIPATION interaction ($b = -.03$, $p = .84$).

For the typical student served, the CATAMA program was an effective "booster shot" that assisted students in achieving a dramatic gain of about one-half of a standard deviation more than comparison students in their knowledge of mathematical procedures. Nevertheless, there are many remaining questions concerning what the CATAMA program looks like in actual practice, students' perceptions of CATAMA, and the cost effectiveness of CATAMA relative to alternative approaches. Study 2 (conducted during Winter 1998) and the general discussion that follows it address many of these questions.

Study 2
Qualitative Study of CATAMA in Practice

Observations and interviews were used to examine the CATAMA program and explore three critical relationships, those between student and teacher, student and student, and student and computer. During the 1997-1998 school year the CATAMA program was observed on six occasions by the second author of this report. Each observation consisted of viewing the operation of the program during multiple sections in a school day. Each section served students in different grade levels (fifth, sixth, and seventh grade). These observations were followed by structured interviews with fifth and seventh grade students participating in the CATAMA program during the winter term of 1998.

Observing CATAMA

Repeated observations of the CATAMA program revealed several consistent features: a relaxed but purposeful atmosphere, a strong bond between the students and teacher, and high levels of student engagement and cooperation.

Student-teacher interactions. The CATAMA lab is housed in what was once a storage room in the factory that was subsequently converted into Central East Middle School. It is a long and narrow space without windows and has a recalcitrant heating system. Despite these architectural shortcomings, the CATAMA teacher has made it a cheery place decorated with instructional posters conveying information on problem-solving strategies, cooperative behavior, and mathematical procedures. Each of the long walls of the room is lined with five computers, each with two chairs. At the front of the room are the teacher's desk, an overhead projector, and a blackboard.

During the observed sessions, the students seemed accustomed to the routine and productive climate established by the teacher. Typically they entered quickly, selected a white board slate (which is used for scratch work and whole class exercises) from a common bin, sat down at their computers, entered their password, and got to work. Once all the students were settled at their computers, the teacher frequently used an overhead projector to pose a warm-up problem that was linked to the lessons the students were currently studying in their math class. With the fifth grade students, this warm-up was followed on several occasions by a period of whole class direct instruction. The teacher reports that she added this innovation to her routine this year in response to the school's implementation of a more challenging standards-based curriculum. This instruction is often used to preview material that will be covered in upcoming lessons in the students' math class. The teacher reports that one benefit of this preview strategy is that students who have been identified by their math teacher as low ability students often become the class experts in new procedures (because they have already learned how to do them in CATAMA class). This in turn alters students' and teachers' perceptions of the students' mathematical abilities.

After these opening activities, each student works on the computer software program (Cornerstone Math in fifth and sixth grade and Skillsbank 3 in seventh grade) with his or her partner for about 30 to 40 minutes per period. Since the partners are paired according to their results on a pretest and the software enables students to repeat sections until they are satisfied with their progress and have passed a quiz, each partnership in the class is often working on different topics and problems. While the students do this, the teacher performs a variety of instructive and supportive roles. During the six observations, these included working with small groups of students at the blackboard, testing individual fifth graders on their multiplication facts, helping students at their computers (this ranged from helping to interpret the computer program to modeling alternative solution strategies), monitoring student progress, and troubleshooting software and computer glitches. At the end of the period, students who did not have sufficient time to begin the next section or complete a quiz or test were allowed to play computer math games or non-computer-based math games such as "24." These non-computer games were also used when computer or software failures limited the number of computers available.

Two positive types of student-teacher interactions were repeatedly and consistently observed. First, although there were periods of conversation among partners and other students that were not related to mathematics and occasional behavioral outbursts that would force the teacher to call the class to order, there was a very high level of time on task across all the students. This high level appears to be the result of at least three factors: (a) a positive reward structure established by the teacher in the classroom using a variety of point systems to identify and reward partnerships and teams that worked diligently, engaged in productive behavior, and helped each other; (b) the teacher's firm but obviously caring personality; and (c) the engaging nature of the work performed in the classroom.

A second positive feature of student-teacher interaction repeatedly observed was the flexible use of resources. The teacher, especially with the fifth graders who had been identified as in need of extra help, used a variety of methods and materials to fill in the basic mathematical knowledge the students needed and to get them used to the procedures and expectations of the new standards-based curriculum that was being implemented. Although partnership work using math-focused software still formed the core of CATAMA, it was enriched with whole class instruction, small group instruction, fact contests, and mathematical games. These tools were used in a semi-structured way that let students, to some extent, move between them as needed. This proved particularly effective with the fifth graders, many of whom appeared to have high energy levels and trouble attending to a single task for more than ten minutes. By providing them with a variety of tasks and learning situations, an environment was created which accommodated their restless energy but kept them focused on mathematical learning.

Student-student and student-computer interactions. The dominant form of student-student interaction witnessed in the six observations was between partners. Most of this conversation was centered on mathematics and appeared to be productive in nature. Partners were observed actively helping each other and demonstrating mathematical procedures. They were also observed sharing what might be called unconventional problem-solving strategies. These were typically strategies for deducing the correct multiple choice answer without fully completing the mathematical procedures called for. Relatively few occasions of one student dominating the interactions were observed. This may in part be a result of pairing students who have similar pretest scores, and in part a result of the individual accountability features built into the program. Even though the students work through the lessons as a two-person partnership, they take quizzes and tests individually. Thus the incentive for the partnership is not simply to complete the lessons as quickly and accurately as possible but for both students to pass their individual quizzes and tests.

The design of CATAMA calls for students to work first in partnerships and then in teams of four (i.e., if two partners cannot understand something, they are supposed to ask the two other members of their team before the teacher). However, relatively little work in teams of four was observed. Students at times worked in groups greater than two but these often seemed to be based more on friendships than assigned teams. Students working alone (due to the absence of a partner) were observed as frequently, if not more, than students working in teams of four.

Student Interviews

During the winter term of 1998, CATAMA served three populations. Two sections of fifth graders identified by teachers as the students in their class most in need of extra help were taught, along with one section of sixth grade students similarly selected by one teacher from her two sections. CATAMA also served two sections of seventh graders whose sixth grade standardized test scores (abbreviated version of the Stanford 9) placed them between the 50th and 84th percentile locally. These students were selected in an attempt to boost them above the 85th local percentile because scoring above the 85th percentile on the Stanford 9 administered in April of seventh grade is one of the requirements for admission to selective citywide high schools. It was believed — and supported by evidence obtained in Study 1 — that giving these students a double-dose of targeted math instruction prior to the test would increase the number of students scoring above the 85th percentile.

Interviews were conducted with 30 fifth graders and 15 seventh graders who attended CATAMA on one of two days during the third and fourth weeks of the winter term of 1998. The interviews were held in the back of the CATAMA classroom while the class was in session. The interviews were conducted by a research assistant using a protocol based on observations during the fall and winter and discussions with the CATAMA teacher. The interview protocol was designed to query students in four areas: (a) their views on participating in CATAMA, (b) their relations with their partners, (c) their views on CATAMA instructional approaches, and (d) the impact of CATAMA on their mathematical performance and confidence. It consisted of nineteen items which were answered on a Likert scale of "not at all or no," "a little," and "a lot or yes" and three open-ended items.

Table 3. Student Views on Participating in CATAMA

Question	Grade	No/Not at All	A Little	Yes/A Lot
Did you want to come to the lab?	5th (n = 30)	13%	10%	77%
	7th (n = 15)	0%	7%	93%
Do you like the lab?	5th	0%	7%	93%
	7th	0%	0%	100%
Do you like working with the computer?	5th	3%	0%	97%
	7th	0%	7%	93%
Do you like working with a partner?	5th	3%	7%	87%
	7th	0%	20%	80%
Do you like working in a team of 4?	5th	50%	7%	3%*
	7th	47%	27%	27%
Would you rather work on the computer by yourself?	5th	83%	0%	13%
	7th	47%	20%	27%

* Forty percent of the fifth graders said they could not answer the question.

Student Views on Participating in CATAMA (Table 3). The interview results indicate that almost all students liked participating in CATAMA. This is significant because participation in CATAMA is not voluntary on the part of students and replaces an elective class. Students were selected based on varying criteria and a letter was sent home asking parents for permission to provide CATAMA to the student in lieu of an elective (art, music, gym, family life, etc.) for ten weeks. (The parents of a small number of students, about 2%, did not consent to their children's participation in CATAMA.)

A higher percentage of seventh graders than fifth graders stated that they wanted to attend (93% versus 77%), which is not surprising because their participation may have a real and immediate consequence (admission to a better high school). Still, three-fourths of the fifth graders — students who were identified by their teachers as being those "most in need of extra help" — reported that they wanted to come to CATAMA. This indicates that one of the goals of the program, designing extra help so that it does not stigmatize students, has been achieved.

The interview results also show that almost all the students liked working with computers and that large majorities (80%) liked working with a partner. About half the students, however, did not like working in four person teams and between 13% and 27% of the students said they would prefer to work by themselves.

Partner Relations (Table 4). The interview results indicate that students worked well together in their partnerships. These results also are consistent with the repeated observational findings that students discussed mathematics with each other and helped each other. Almost all of the students reported giving help to and receiving help from their partners. Although 47% of seventh graders stated that on occasion they let their partners provide an answer without explanation, only 13% reported this happening a lot. Fifth graders appear not to have understood this question. Eighty-three percent of them gave no answer.

Instructional Methods (Table 5). The interviews support a number of hypotheses on why students liked the CATAMA lab and why high levels of engagement were observed. Eighty percent or more of the students interviewed agreed that they liked the lab because you can redo sections to get higher scores, get your answer checked right away, and get help when you need it. The only area of disagreement between the fifth and seventh graders regarded pace. Ninety-three percent of the seventh graders reported that one of the things they liked about CATAMA was that you could set your own pace. This view was shared by only 57% of the fifth graders.

Table 4. Partner Relations

Question	Grade	No/Not at All	A Little	Yes/A Lot
Does your partner help you with things you don't understand?	5th (n = 30) 7th (n = 15)	7% 7%	0% 7%	90% 87%
Do you help explain problems to your partner if he/she does not understand?	5th 7th	0% 7%	0% 13%	97% 80%
Do you let your partner give the right answer even if you don't understand?	5th 7th	7% 40%	0% 47%	10%* 13%

* Eighty-three percent of the fifth graders did not answer (i.e., replied "don't know" or "don't understand").

Table 5. Views on CATAMA Instructional Methods

Question	Grade	No/Not at All	A Little	Yes/A Lot
What do you like about the lab?				
Can redo the section to get a higher score	5th (n = 30) 7th (n = 15)	3% 0%	3% 7%	93% 93%
Get the answer checked right away	5th 7th	10% 0%	3% 27%	87% 79%
Can set your own pace	5th 7th	33% 7%	10% 0%	57% 93%
Can get help when you need it	5th 7th	0% 7%	7% 7%	93% 87%

Table 6. Effect of CATAMA on Self-Perception of Mathematical Skill and Confidence

Question	Grade	No/Not at All	A Little	Yes/A Lot
Is the lab work what you are learning in your math class?	5th	42%	20%	37%
	7th	27%	33%	40%
Compared to before do you understand math better?	5th	13%	7%	80%
	7th	13%	7%	80%
Do you think it's because of the lab?	5th	13%	17%	70%
	7th	0%	40%	53%
Compared to before do you feel more confident?	5th	0%	13%	87%
	7th	7%	13%	80%

Self-Perception of Mathematical Skill and Confidence (Table 6). The students disagreed on whether or not their work in CATAMA was related to what they were learning in their regular math class. About equal numbers said it was and was not. Actually, parts of CATAMA are often directly linked to the material currently being covered in the students' math class (the warm-up activities) and other parts are designed to improve students' knowledge of basic facts and mathematical procedures (the computer-assisted instruction).

Eighty percent of the students felt that they currently understood math better than before and 80 to 90 percent of these students believed that CATAMA had played some role in improving their understanding. Fifth graders more than seventh graders (70% versus 53%) said that CATAMA had played a large role in their increased understanding. Almost all fifth and seventh graders participating in CATAMA (87% and 80%) also reported that they are feeling more confident in their mathematical abilities

Summary. Both the observational study and student interviews indicate that CATAMA was a productive and beneficial experience for students. High levels of student engagement and cooperation were observed and reported by students. Students liked being in CATAMA, working with a partner, and using computers. They appreciated the semi-structured but focused environment that has been created by the CATAMA teacher, as well as the ability to get immediate and constructive feedback from both her and the computer software. Students also believed and liked that CATAMA improved their math skills and attitudes. In short, the observations and interviews supported the notion that CATAMA is an effective means of providing extra help.

Discussion

Study 1's results from the 1996-1997 school year confirm that the Talent Development Middle School's elective replacement class in mathematics helped many seventh graders achieve dramatic gains in their procedural knowledge and skills. The typical CATAMA participant outperformed students from the comparison sample by almost half a standard deviation on the mathematics procedures subtest of the Stanford 9. Further analyses revealed that the CATAMA program also helped greater numbers of seventh graders boost their end-of-year mathematics procedures test scores on the Stanford 9 to at least the 85th local percentile, helping them meet one of the standards for admission at most of Philadelphia's selective admission high school programs.

Study 2's results from Winter 1998 suggest that the CATAMA program was characterized by productive, on-task student-teacher interactions, student-student interactions, and student-computer interactions. In addition, students liked being in CATAMA and viewed it as a helpful booster shot rather than an unwelcome overdose of mathematics. They appreciated the flexible, task-focused learning environment of CATAMA that was tailored to their partnership's learning needs and pace of mastery.

The elective replacement approach to providing extra help, although found in only 17% of the nation's middle schools, has many advantages compared to more common extra-help programs (Mac Iver, 1991). Large numbers of students can be served each year. Attendance is high because the elective period of academic instruction is part of the regular school day. It is not a pullout program, so students do not miss regular academic instruction. Also, CATAMA does not stigmatize students as some remedial programs do, but rather is viewed as a "plum elective." Finally, CATAMA is proving to be academically effective, while little evidence exists for the effectiveness of other programs, such as extended school day or contractual for-profit tutoring.

An elective replacement approach to extra help is also cost effective. The major expenses in creating a CATAMA lab are the cost of a teacher, the computers, and the software. In many cases, CATAMA labs can be staffed by reassigning existing staff. Because many low-performing schools are also Title I schools, the CATAMA position can often be staffed by Title I resource teachers. When staff cannot be reassigned, the cost for a teacher ranges from approximately 45 to 65 thousand dollars. Sufficient computers also often exist within the building; when they do not, ten computers — adequate for the lab — can be bought for ten thousand dollars. The necessary software can be purchased for less than five thousand dollars. At the maximum, this means that a CATAMA lab can be operated for 65 thousand dollars a year with one-time start-up costs of 15 thousand dollars. Since a single lab can serve three hundred students per year, the per student cost of providing ten weeks of extra help is 267 dollars per student in the start-up year and 216 dollars in each following year for up to 50 hours of extra help.

This is a favorable cost compared to two increasingly common alternatives for providing extra-help: (a) extended school day or extended school year programs and (b) contracting out to for-profit tutoring businesses. Unlike many extended day or after-school approaches and also unlike many extended-year or summer school approaches, the elective replacement approach does not require schools to keep their building open longer or pay their teachers for additional hours. (Of course, many extended-day and extended-year programs may not be comparable to CATAMA because they cover many subjects and have many purposes beyond improving students' proficiency in mathematics.) Compared to for-profit tutoring approaches, CATAMA classes provide similar services (but with a higher student-teacher ratio) at about one-third of the cost.[3]

The relatively low cost of the CATAMA lab and the elective replacement approach to extra help in general enables the provision of extra help to a wider range of students within a school. Virtually all students in low-performing middle schools need extra help in mathematics. For example, in this study, we discussed two overlapping populations of students: (1) students from various grade levels in the middle school who had been identified either by their teachers or standardized test scores as needing extra help in order to succeed at the challenging learning tasks contained in a standards-based mathematics curriculum, and (2) a subset of the seventh graders served by CATAMA who had scored between the 50th and 84th citywide percentile on standardized tests at the end of sixth grade. These seventh graders are in need of extra help on two levels. First, if they can improve their test scores and place in the 85th percentile locally, they will meet one of the requirements for admission to the city's best high schools. Second, although these students fall between the 50th and 84th percentile locally, many are still performing below national grade level norms.

A CATAMA lab can serve 300 students per year. This means that in a 5-8 middle school of 1,000 students, all of the students can be provided at least 10 weeks of additional math instruction during their middle school career and 200 of the students can be served twice. CATAMA allows help to be offered to all those who need it, not just to the school's lowest performers. More expensive forms of extra help, like contracting out to outside vendors or providing one-to-one tutoring, could be reserved for the lowest-performing students (such as the four very low-performing students from the comparison school who demonstrated remarkable gains).

A final feature of the CATAMA program is its flexibility. It can be used to provide both remediation and enrichment. For different groups of students, different mixes of computer-based, small group, and whole class instruction can be provided. The software and instruction can be tailored to support specific mathematics curriculums and/or to prepare students for different types of assessment. The observational and interview data indicate that much of the power of the program may be in its mix. The CATAMA lab combines a skilled and effective teacher who can provide a wide range of help to diverse students with the use of computers and peer collaboration which enable students to work at their own level, exercise some control over their learning, receive immediate feedback, and engage in mathematical discussions. It is this potent combination that is at the heart of CATAMA's success.

Endnotes

[1] After Central East had agreed to become the nation's first Talent Development Middle School, the research office of the School District of Philadelphia identified the other school as an appropriate comparison site, because it was very similar to Central East in terms of student population and characteristics of the teaching staff. Neither school is a magnet school. Each school serves fifth, sixth, seventh, and eighth grades. Each enrolls approximately 1,000 students. Over 85 percent of the students from each school come from low income families. Also, many of the students have learned English as their second language. At Central East, 53 percent of the students spoke a language other than English before they started going to school. At the control school, the comparable number is 48 percent.

Central East's student body is about 45 percent Hispanic, with most of these students being of Puerto Rican descent. Another 24 percent of the students are African-American. About 13 percent of the students are of Asian descent, primarily Cambodian and Vietnamese. Another 8 percent are white. The remaining 10 percent identify themselves as belonging to other racial or ethnic groups. These other groups include Arab-Americans and biracial students. The control school's student body is similarly diverse although, in comparison with Central East, it has a higher proportion of Hispanic and white students, a somewhat lower proportion of African-American students, and few Asian-American students. Specifically, 57 percent of the students are Hispanic; 16 percent are African-American; 15 percent are white; fewer than 1 percent are Asian-American; and the remainder describe themselves as biracial or other.

[2] If the regression model in Table 1 is re-estimated after eliminating these 8 cases with the lowest prior achievement, the PRIOR MATH X CATAMA interaction disappears ($b = .14$, $p = .61$). After this nonsignificant interaction term is removed from the model, the estimated effect size (δ) associated with CATAMA participation is .60 for these 88 cases.

[3] The CATAMA approach is considerably less expensive than contracting out for tutoring services. Sylvan Learning Systems is one of the largest outside providers of extra help in public schools. Information provided in a recent news release (Sylvan Learning Systems, Inc., 1998) of a contract it has been awarded by the Compton Unified School District in Los Angeles County enables a rough comparison between Sylvan's services and costs and those of CATAMA. The press release states "Sylvan transforms classrooms designated for the program by the school system into Sylvan Learning Centers, similar to suburban retail locations, by equipping them with carpeting, furniture, instructional materials, and computers. Also, Sylvan conducts a series of assessment tests to gauge each student's academic strengths and weaknesses, and tailors individual education plans to each student's needs. Sylvan Learning Centers are staffed to

provide for small student/teacher ratios (typically 3 students per instructor), ensuring direct personalized instruction for every student." With the exception of the carpeting and the one-to-three staffing level, all of these services are provided by CATAMA.

According to the published report, the contract with Compton Unified School District has a total potential value of 5.4 million dollars over three years. During this time Sylvan will provide extra-help in the form of two one-hour sessions per week during and after regular school hours throughout the school year and during the summer to 1,200 students in seven elementary schools and one middle school. This translates into a per student cost of $1,500 for up to 96 hours of extra help (assuming a 48-week year). This indicates that for equivalent hours of extra-help, CATAMA costs about one-third as much as hiring Sylvan. It is possible that outside vendors such as Sylvan may be more effective than CATAMA or that a few students may need more intensive forms of tutoring. However, given both the high costs of outside tutoring vendors compared to CATAMA and CATAMA's greater capacity, schools and districts should seek out hard data on program effectiveness and compare the costs and benefits of an elective replacement approach to those of an tutoring vendor before signing a contract with such a vendor.

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