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AUTHOR	Jarvis, Carolyn H.; Blank, Barbara Busse
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ABSTRACT

The Great Starts Mathematics Approach, the early childhood component of the Staff Development Program in Mathematics, Science, and Computer Science, is a collaborative 3-year staff development project. The project's goal is to develop a model for improving mathematics instruction in kindergarten through second grade. This is the evaluation report of the implementation of the program during the project's second year. School principals, teachers, and paraprofessionals from two schools attended monthly mathematics workshops held after school. Training activities focused on teaching mathematical relationships and concepts through directed play and exploration with concrete materials. Although student achievement as measured by the scores on the second-grade mathematics test did not show improvement, correlational analyses indicate some relationship between teaching techniques as observed in the classrooms and test scores. Children whose teachers used more product-oriented teaching techniques tended to have lower scores on the mathematics test than children whose teachers used process-oriented techniques. Chapters included are: (1) "Introduction"; (2) "In-Service Professional Development and Staffing"; (3) "Classroom Implementation"; (4) "Student Achievement"; and (5) "Conclusions and Recommendations." Descriptions of classroom activities and teaching techniques used by field staff in the classroom are appended. Twelve references are listed. (YP)

OREA Report

GREAT STARTS MATHEMATICS APPROACH
1987-88

Office of Research, Evaluation, and Assessment
New York City Board of Education
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John Schoener, Administrator
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GREAT STARTS MATHEMATICS APPROACH
1987-88

Prepared by
Early Childhood Evaluation Unit
Carolyn H. Jarvis, Evaluation Manager
Barbara Busse Blank, Evaluation Associate

New York City Public Schools
Office of Research, Evaluation, and Assessment
Robert Tobias, Director

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SUMMARY

The Great Starts Mathematics Approach, the early childhood component of the Staff Development Program in Mathematics, Science, and Computer Science, is a collaborative three-year staff development project of the Board of Education's Early Childhood Education Unit and Community School District 3. The project's goal is to develop a model for improving mathematics instruction in kindergarten through second grade. OREA evaluated program implementation during the project's second year.

School principals, teachers, and paraprofessionals from two schools attended monthly mathematics workshops held after school. A district staff developer spent approximately two days every week in each school, where she visited classrooms and met with classroom staff. Training activities focused on teaching mathematical relationships and concepts through directed play and exploration with concrete materials.

The two project schools were very different before the start of the program. Teachers and administrators began the training with different levels of understanding and experience. As a result, the program was better implemented in one project school than in the other. Teachers in the second school need additional, individualized staff development and more time in order to better implement project ideas and activities.

Although student achievement as measured by the scores on the second-grade mathematics test did not show improvement, correlational analyses indicate some relationship between teaching techniques as observed in the classrooms and test scores. Children whose teachers used more product-oriented teaching techniques i.e., posed questions or problems for which only one correct answer or one possible solution was accepted, tended to have lower scores on the mathematics test than children whose teachers used process-oriented techniques, i.e., asked children for estimations, explanations, and alternative solutions as recommended by the project.

TABLE OF CONTENTS

		PAGE
I.	INTRODUCTION	1
	Philosophical Background	1
	Program Background	2
	The Evaluation Study	4
	The Evaluation Report	6
II.	IN-SERVICE PROFESSIONAL DEVELOPMENT AND STAFFING	7
	In-Service Training Activities	7
	The Program Philosophy	7
	The Program Schools	9
	Teacher and Paraprofessional Assessments of Program In-Service Training	10
	Principals' Perceptions of the Program	14
III.	CLASSROOM IMPLEMENTATION	15
	Classroom Observation Instruments	16
	Classroom Environment	17
	Classroom Activities	21
IV.	STUDENT ACHIEVEMENT	33
	Student Characteristics	33
	Student Achievement	35
V.	CONCLUSIONS AND RECOMMENDATIONS	42
	APPENDIX	45
	Appendix A	46
	REFERENCES	50

LIST OF TABLES

		PAGE
TABLE 1:	Percentage of Staff Indicating that the Overall Professional Development Had a Major Impact on Implementation of Great Starts Program Goals, June 1988	11
TABLE 2:	Percentage of Staff Indicating an Interest in Possible Future Professional Development Activities, June 1988	13
TABLE 3:	Percentage of Classrooms with Observed Mathematics Materials, by School, June 1988	18
TABLE 4:	Percentage of Classrooms with Interest Areas, by School, June 1988	20
TABLE 5:	Percentage of Classroom Activities, by School, June 1988	[illegible]
TABLE 6:	Percentage of Instances of Mathematics Activities, by Classroom Groups and School, June 1988	25
TABLE 7:	Percentage of Instances of Non-Mathematics Instructional Activities, by Classroom Groups and School, June 1988	25
TABLE 8:	Percentage of Instances of Non-Mathematics Experiential Activities, by Classroom Groups and School, June 1988	26
TABLE 9:	Percentage of Non-Learning Activities, by Classroom Groups and School, June 1988	26
TABLE 10:	Percentage of Instances of Teacher-Child Interactions, by Types of Activity, June 1988	28
TABLE 11:	Percentage of Instances of Various Mathematics Activities, by School, June 1988	29

		PAGE
TABLE 12:	Teachers' Ratings of Teaching Techniques As Important and Often Used in Their Classrooms, by School, June 1988	31
TABLE 13:	Percentage of Observed Instances of Process- and Product-Oriented Teaching Techniques by School, June 1988	32
TABLE 14:	Percentage of Second Grade Students with Prekindergarten and Kindergarten Experience, by School, June 1988	34
TABLE 15:	Distribution of 1987 and 1988 City-Wide Second Grade Mathematics Test Scores, by School	36
TABLE 16:	Mean Second Grade NCE Scores on the April 1988 Citywide Mathematics Test, by Subtest and School	37
TABLE 17:	Mean NCEs on April 1988 Citywide Mathematics Test and Types of Teaching Techniques, by School for Second Grade Classrooms in the Observation Sample	38
TABLE 18:	Correlational Statistics for the MAT-6, New York City Edition, Mathematics Subtest, and Total Test Scale Scores, by Teaching Technique	40

I. INTRODUCTION

PHILOSOPHICAL BACKGROUND

There is growing concern about the teaching and learning of mathematics in schools across the United States. "As early as the end of first grade, students in three countries--Taiwan, China, and Japan--test higher than American students in most subjects, but particularly in math skills and problem-solving" (Gordon, 1987, p.4). Minority students do even less well than the general population, often falling behind in mathematical skills as early as the third grade. In New York City, educators and economists are concerned that many public school students are so lacking in mathematics skills that they will be unable to find work, since most of the city's jobs now require some math proficiency. According to Samuel Ehrenhalt, Regional Commissioner of Labor Statistics, "Students' lack of mathematics skills will affect the city's future economic growth" (Lewis, 1989).

The blame for the crisis in mathematics education ranges from criticism of the fragmented presentation of mathematical ideas in textbooks, to teachers' discomfort with the subject area (National Council of Teachers of Mathematics, 1989). According to New York City educators, as reported in a July 1988 New York Times article on minority pupils and math, teachers often spend more attention and time on reading instruction in the early grades than they do on mathematics. Additionally, the teachers themselves are often not knowledgeable or enthusiastic about mathematics, and lack training and supervision in its teaching.

In many classrooms and at all grade levels, rituals of drill and practice which encourage rote memorization of algorithms, are established. As a result, students have difficulty transferring mathematics skills they have learned in one context to related operations (Vobejda, 1987).

In the February 1988 edition of Arithmetic Teacher, Wolfinger points out that early childhood teachers too often emphasize arithmetic to the exclusion of mathematics. Arithmetic, which focuses on computation, is oriented toward skill development and includes such topics as symbol recognition, sums and differences, place value, and regrouping. Said Wolfinger, "The outcome of arithmetic, whether taught through the manipulation of materials or through memorization, is the same: a particular answer to a particular problem using a structured approach." In contrast, mathematics, which includes exploration of materials, patterning, comparing, graphing, sorting, and classifying, is concerned with the development of concepts. Wolfinger argues that a sound program for young children "should emphasize mathematics rather than arithmetic, should develop understanding rather than answers, and should generate concepts rather than folders of completed worksheets" (p.4).

PROGRAM BACKGROUND

The Great Starts Mathematics Approach is the early childhood component of the Staff Development Program in Mathematics, Science, and Computer Science initiated in the summer of 1982 by the New York City Board of Education, Division of Curriculum and

Instruction, with funds provided by the New York City Council. Its overall goal is to improve the quality of mathematics, science, and computer science instruction in New York City's public schools.*

Great Starts was initiated during the winter of 1986-87 by the Board of Education's Early Childhood Education Unit in collaboration with Community School District 3. The program was implemented in two of the District's schools. The goal was to develop a model for changing the way mathematics is taught in kindergarten through second grade so as to encourage children to think mathematically. Specific program objectives were to:

- develop a classroom climate that encourages children to learn from each other; talk about, create and solve mathematical problems; and rely on personal judgments of correctness;
- assist teachers to use manipulatives as tools which enable children to develop mathematical ideas, fostering gradual transitions to more abstract formats;
- develop teaching strategies that heighten mathematical processing and logical reasoning in students;
- create teacher-peer support networks for the development of the classroom mathematics program;
- develop techniques for ongoing assessment of children's mathematical learning;
- improve children's performance in mathematics, including improvement on the standardized citywide mathematics test;

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*See Staff Development Program in Mathematics, Science, and Computer Science Report, 1986-87: End of Year Report, OREA Instructional Support Evaluation Unit for a description of other components of the program.

- improve children's attitudes toward mathematics; and
- improve teachers' attitudes and confidence about teaching mathematics.

The Great Starts Mathematics Approach is a staff development program designed to assist teachers and paraprofessionals working as a team to implement a process-oriented approach for mathematics instruction in their classrooms. The program was funded at $10,000 per year for three years. Funds were used for staff development activities and for the purchase of mathematics materials for the classrooms.

THE EVALUATION STUDY

The Office of Research, Evaluation, and Assessment (OREA) assessed program implementation at the end of the program's second year. The evaluation, which was planned and carried out in collaboration with Community School District 3 staff, focused on program implementation, and addressed the following questions:

- What in-service training was provided to teachers and paraprofessionals? How did staff assess the training? What impact did the training have upon classroom practices?
- What special equipment, materials, and classroom activities were provided to children as a result of the program? What instructional grouping patterns (i.e., small group, total group) were evident in the classrooms? What teaching techniques were used during instructional activities?
- Did children's second grade test scores in mathematics improve as a result of their participation in the program?

Classroom Implementation

To assess classroom implementation, OREA field staff observed ten classes in the two Great Starts schools (hereafter referred to as School A and School B). The ten Great Starts classrooms were selected for evaluation by the district staff because they best represented program implementation in the particular schools.

A modified version of a standard observation system* was used by OREA field consultants to observe classrooms. Consultants collected information about materials present in the classroom, classroom activities, grouping for instruction, patterns of interaction between children and adults, and teaching techniques. In addition to the classroom observations, OREA staff interviewed school principals, and all Great Starts teachers and paraprofessionals completed questionnaires.

Student Growth

District staff collected demographic and attendance data for all second grade students in the two Great Starts schools. In addition, students' scores on the Grade Two Metropolitan Achievement Test, Edition 6, Mathematics, New York City Edition, were obtained from centrally-based Board of Education test files and compared to second grade scores for the previous year.

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*OREA modified, with permission, a classroom observation system developed by Jane Stallings and other staff at the Stanford Research Institute.

THE EVALUATION REPORT

The report which follows presents findings related to the implementation of the Great Starts program at the end of the program's second year. Chapter II describes the program, the project schools, the educational philosophy underlying the in-service professional development activities, and the program participants' assessments of those activities. Classroom implementation is described in Chapter III. Chapter IV discusses second grade student achievement, and the relationships between teaching techniques and achievement. Conclusions and recommendations are presented in Chapter V.

II. IN-SERVICE PROFESSIONAL DEVELOPMENT AND STAFFING

IN-SERVICE TRAINING ACTIVITIES

The district early childhood liaison and the district staff developer, assisted by three mathematics consultants from local universities, planned and conducted monthly staff development meetings attended by school principals, teachers, and classroom paraprofessionals. The monthly meetings, held after school, included workshops on mathematics curriculum, classroom management, the making and use of various kinds of mathematics manipulatives, and the integration of mathematical reasoning (such as the recognition of patterns) into other areas of the curriculum. The district staff developer spent approximately two days each week in each of the two schools. While in the schools, she held lunch-hour meetings with the teachers and paraprofessionals, and visited classrooms to provide hands-on assistance. Occasionally, the three mathematics consultants also visited classrooms to help teachers with curriculum activities.

THE PROGRAM PHILOSOPHY

More traditional methods for teaching mathematics often start at the pictorial level, usually introducing computational concepts via pictures on worksheets. Children are encouraged to memorize arithmetic facts. In this approach, learning depends on the passive absorption of information by the child.

The Great Starts Mathematics Approach follows a process-oriented theory of learning which views children as active participants in their own learning. In Great Starts, the curriculum is focused on conceptual development. Mathematics is viewed as a way of looking at and communicating and thinking about the properties of phenomena in the world, not simply as a skill with number facts and arithmetic operations. According to the recent National Council of Teachers of Mathematics standards (1989), "A conceptual approach enables children to acquire clear and stable concepts by constructing meanings in the context of physical situations, and allows mathematical abstractions to emerge from empirical experience" (p.17).

Educational research has shown that children develop an understanding of mathematical relations, concepts, and ideas through directed play and exploration with manipulatives, i.e., concrete materials. Children learn and remember mathematical ideas best when instruction progresses from the concrete to the pictorial to the abstract. For example, children at the initial, concrete level of addition begin by combining sets of real objects such as blocks, washers, or bottlecaps, and by observing the outcomes--that is, a set of two blocks combined with four blocks makes a set of six blocks. Children can then learn to record their observations symbolically, and to later work with exercises which use pictures of objects to combine sets. Finally, the children develop an understanding of abstract mathematical sentences such as: $2 + 4 = 6$.

THE PROGRAM SCHOOLS

The district selected two schools to participate in the program. The two schools began at two very different points. The first one, School A, had been an open classroom school for almost twenty years. Teachers used a child-centered approach, and were familiar with teaching individual and small groups of children. The school advocated process-oriented learning approaches. The school's curriculum, however, emphasized the development of oral language, reading, and writing skills. Many teachers had continued to teach mathematics in traditional ways, and still required students to memorize arithmetic facts and complete pages of arithmetic worksheets. The school was invited to participate in the program because the faculty had already decided that they wanted to improve their mathematics instruction. Great Starts was compatible with the school's overall philosophy about teaching and learning.

The second one, School B, was a more traditional school. Children sat at desks arranged in rows, and were generally taught as a whole class. The school had a long record of low-achievement test scores in both reading and mathematics, and had been designated as one of the 16 elementary schools (out of 631 elementary schools in the city) under review by the Chancellor. The district staff selected School B for participation in the program because they hoped it would help strengthen the school's academic program. In both schools, the principals and all kindergarten, first, and second grade teachers and paraprofessionals participated in the staff development sessions.

TEACHER AND PARAPROFESSIONAL ASSESSMENTS OF PROGRAM IN-SERVICE TRAINING

Teacher and Paraprofessional Background

Twenty Great Starts teachers completed a questionnaire which asked for information about their professional background and their experience in the Great Starts program. Most of the teachers in both schools were very experienced. None were first year teachers, although several were teaching in an early childhood classroom for the first time. All but four teachers had an early childhood and/or common branches teaching license. One had a common branches bilingual license. Three Great Starts teachers held temporary per diem licenses and one had only a bilingual license. At the time of the evaluation, 12 of the 20 teachers had been involved in the Great Starts Approach for over a year.

The majority of the Great Starts educational assistants were also very experienced. All of the paraprofessionals reported having had more than ten years of work or volunteer experience in the educational area. Six of the ten had worked in the Great Starts program from its beginning.

Staff Assessment of Professional Development Training

As shown in Table 1, almost all teachers and paraprofessionals agreed that the professional development activities had a major impact on their understanding of how to teach mathematics, and provided useful curriculum to guide planning throughout the year.

TABLE 1

Percentage of Staff Indicating that the Overall Professional Development Effort Had a Major Impact on Implementation of Great Starts Program Goals, June 1988

Program Goals	Teachers (N=20)	Paraprofessionals (N=10)
Understanding ways to teach mathematics	90%	90%
Providing mathematics curriculum to guide planning throughout the year	75	70
Organizing and managing the classroom to emphasize mathematical ideas	45	80

- Almost all teachers and paraprofessionals agreed that the professional development activities had a major impact on their understanding of how to teach mathematics, and provided useful curriculum to guide planning.

Specific activities they found useful were the workshops on mathematics, visits by the staff developer, workshops on manipulatives, and the handouts distributed at each workshop. Many teachers commented favorably on the films which demonstrated how to work with manipulatives in the context of specific topic areas. However, many teachers also suggested that the workshops involving manipulatives, games, or activities could be made more useful if they addressed just one topic and its specifically related skills.

A majority of the teachers and a few paraprofessionals stated they did not find the workshops in classroom management of mathematics activities particularly useful. According to one teacher, "I didn't like the workshop in which a lot was spoken about management [because while] the ideas were all right ... [they] were not operationally realistic."

Because of payment and scheduling problems, the consultants were not able to visit the classrooms to assist the teachers and paraprofessionals as frequently as they would have liked. As a result most teachers did not find the contribution of the mathematics consultants very useful. When there was contact between the consultants and individual members of the staff, consultants were viewed favorably. The district staff developer, on the other hand, was in the schools weekly, and was able to visit the classrooms more regularly. Seventy-five percent of the teachers and 90 percent of the paraprofessionals thought the staff developer's assistance was useful.

The single comment most often made about the Great Starts professional development activities by teachers and paraprofessionals concerned the personal and professional benefits obtained from exchanging and sharing ideas with one another. Principals also viewed these sharing opportunities as a positive part of the program.

Suggestions for Future Staff Development

As shown in Table 2, a majority of the staff indicated an interest in attending workshops in individualized math instruction, observation and assessment techniques, and developing and managing mathematics learning centers. Only half of the teachers, but 80 percent of the paraprofessionals, were interested in a workshop on making teacher-made materials.

TABLE 2

Percentage of Staff Indicating an Interest in Possible Future Professional Development Activities, June 1988

Future Activities	Teachers (N=20)	Paraprofessionals (N=10)
Individualizing math instruction	80%	90%
Observing and assessing children's progress in mathematics	80	100
Development and management of math learning centers	90	90
Making teacher-made math materials	50	80

- A majority of teachers were interested in attending workshops on individualizing math instruction, observation and assessment techniques, and developing and managing learning centers. Eighty percent or more of the paraprofessionals were interested in all four types of activities.

PRINCIPALS' PERCEPTIONS OF THE PROGRAM

During the site visits, OREA staff interviewed the two school principals. Both principals felt that their respective schools had profited from the program. They agreed that teachers and paraprofessionals had gained a deeper appreciation of the teaching and learning of mathematics.

The principal of School A felt the staff development activities were informative, and had helped him gain new insights and techniques for developing a mathematical program in his school. He thought the program met the school's needs, but that the curriculum did not always match the citywide mathematics program. He stated that one of the problems in implementing the Great Starts program was that teachers felt they needed to make constant accommodations in order to prepare the children for the citywide achievement tests. He recommended that the standardized mathematics tests be used as a diagnostic device rather than as an assessment of achievement. This principal also suggested that program designers pay more attention to the needs of the paraprofessionals, arrange more visitations between Schools A and B for teachers and paraprofessionals, hold workshops in teachers' classrooms, and provide for more classroom visits by the consultants.

The principal of School B believed that the staff development activities had been very informative for the teachers, but had not been helpful to him as an administrator. The principal considered Great Starts to be a pilot program, and therefore believed it was too early to make any substantive comments about the approach.

III. CLASSROOM IMPLEMENTATION

In this section, information is presented about the ways in which the classroom environment emphasized mathematical ideas, how children were grouped for mathematics instruction, and the teaching strategies used in the classroom.

CLASSROOM OBSERVATION INSTRUMENTS

The classroom observation instrument had two sections. The classroom environment section of the form was used to record information about the physical environment, including the organization of space and the presence and use of mathematics supplies and equipment. The classroom observation section of the form was used to record classroom activities, teaching techniques, math materials, and grouping patterns.* The observation form was completed once every ten minutes over a period of four hours, yielding 16 observations per classroom and a total of 240 completed forms for the 15 classrooms.** To fill in an observation form, the observer scanned the room clockwise and recorded what each person in the room was doing. When the observer saw the teacher, the exact words the teacher was saying and the context in which they were said were recorded. Teaching techniques were coded only when the teacher was interacting with

*Coding categories and descriptions are contained in Appendix A.

**Classroom observations were also made in two non-Great Starts schools.

a student or group of students involved in educational activities. Only the teacher's words were recorded.

CLASSROOM ENVIRONMENT

Mathematics Equipment and Supplies

OREA field consultants documented the kinds of mathematics materials and equipment available for use by children in the classrooms. Materials and equipment that were stored in closets were not recorded, since they were not readily available to the children. As indicated in Table 3, classrooms in both schools had a variety of manipulatives with which children could explore mathematical ideas. Mathematics textbooks were not seen in any kindergarten classrooms, and worksheets were seen in only half of the first and second grade classrooms in the Great Starts schools. No calculators* were observed in any of the classrooms.

Teacher/child-made materials were present in all of School A's classrooms, and realia (such as milk containers, pasta, beans, rocks, pinecones, etc.) were observed in all but one of School A's classrooms. Similar materials were observed in half the classrooms in School B. These types of materials, which cost little or nothing and which can help to diversify the materials

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*NCTM (1989) has recommended that calculators be made available to all children to assist with cumbersome computations. Many mathematics educators view computation as consuming undue amounts of instructional time which, in turn, deprives students from learning important mathematical concepts they will need in the future.

TABLE 3

Percentage of Classrooms with Observed Mathematics Materials, by School, June 1988

Mathematics Materials	School A (N=6)	School B (N=4)
Unit blocks	100%	100%
Structured math materials	100	100
Non-structured math materials	100	75
Measuring equipment	100	75
Geometric shapes	100	75
Math games/puzzles (teacher/child-made)	100	50
Task cards	83	75
Math games/puzzles (commercial)	83	50
Realia	83	50
Math worksheets	67	50
Math textbooks	50	0
Calculators	0	0

- A variety of materials were available to both schools. School A classrooms had more materials than classrooms in School B.

available to children, were emphasized during staff development sessions.

Half of the teachers rated the workshops on teacher-made materials and activities as one of the best aspects of the professional development program. The remainder objected to teacher-made materials, complaining that teacher-made materials take hours of teachers' time to make, are usually made of non-durable material, and often have small pieces that are easily lost. They also reported that sometimes they were not sure how to use the materials they had learned to make in the workshops. On the other hand, almost all of the teachers had positive comments about commercially available math manipulatives, and many teachers requested workshops on teaching with cuisinaire rods and unifix cubes.

Interest Areas

Interest areas are areas of the classroom set aside for specific learning activities designed to help facilitate individual and small group exploratory activities. They contain a variety of instructional materials which children can use independently of adult supervision. As shown in Table 4, a variety of these areas were observed. In general, housekeeping areas were seen only in kindergarten classrooms. Surprisingly, two classrooms in School B had no mathematics areas.

TABLE 4

Percentage of Classrooms with Interest Areas, by School, June 1988

Interest Areas	School A (N=6)	School B (N=4)
Mathematics	100%	50%
Manipulatives	83	75
Blocks	83	100
Science	83	75
Listening/Music	83	0
Art	83	50
Housekeeping	33	25
Other[a]	67	0

[a]The other category includes one or more of the following interest areas: sand/water table, library/language arts, or writing.

- A variety of interest areas were observed in both schools. Only half of the observed classrooms in School B contained mathematics centers.

CLASSROOM ACTIVITIES

Observation and Coding Techniques Used by Evaluators

Observers recorded the various kinds of mathematics activities that occurred in the classroom, particularly those involving mathematical thinking. The observation form was modified to include eight categories of mathematics activities: seven mirrored grade-appropriate strands or topics; the eighth was used for unanticipated mathematical areas. All non-mathematics activities were coded in other categories. Field staff were instructed to fill in only one category per observed activity.

For the purpose of the observations and subsequent analyses, the mathematics strands were partitioned into mutually exclusive groups. In cases where field staff were unsure of which strand to choose to code the activity, they were instructed to try to determine the goal of the activity and then choose the category most closely related to that goal. For example, children were observed linking cuisinaire rods together. The children may have been using the rods to measure, to create a pattern, or to solve a number sentence. If the children followed a written pattern on a worksheet (i.e., Red Red Blue Red Red), the activity was coded under Category 1 - Patterns, Relations, and Functions. If they connected the rods to measure an object, the activity was coded under Category 5 - Measurement. If they used the rods to solve a number sentence, or word problem, the activity was coded under Category 3 - Mathematical Rules.

If an activity was not related to any form of mathematical or logical reasoning, it was coded in the other categories. Non-math instructional activities included such activities as reading and writing. If, however, a teacher was reading a story about a child going to the store, and the story required students to add items or money, the activity was coded under Category 3 - Mathematical Rules. Non-math experiential activities included activities such as singing and dramatic play. Again, if a song was accompanied by rhythmic hand clapping, the activity was coded in Category 1 - Patterns, Relations and Functions.* For an overall general description of the data, the individual mathematics activities were collapsed into one category. In addition, several non-academic activities were collapsed into a broad category labeled "Non-Learning." Observing and Classroom Management were collapsed into a category called "Other." (See Table 5.)

Observation Findings Regarding Classroom Activities

As shown in Table 5, on the day of observation, over half of the activities in the classrooms in School A were coded as mathematics activities. This finding could be interpreted in several ways. One possibility is that teachers were aware that OREA field consultants were in their classrooms to observe their mathematics program, and therefore may have arranged for more

*For further information on this exercise, see Appendix A.

TABLE 5

Percentage of Classroom Activities, by School
June 1988

School	N[a]	Math Activities	Non-Math Instructional	Non-Math Experiential	Non-Learning[b]	Other[c]
A	6	54%	24%	9%	8%	5%
B	4	42	35	7	14	2

[a]Number of classrooms observed.

[b]Includes discipline, off-task child, negative interactions, inappropriate social interactions, and transitional activities.

[c]Includes observing and classroom management.

- On the day of observation, most of the activities coded in both schools were Math activities.
- More non-math instructional and non-learning activities were observed in School B than in School A.

mathematics activities than usual. An alternative interpretation is that teachers in School A were successful in integrating mathematical ideas with other areas of the curriculum. The latter interpretation was supported by the notes written by field consultants on the observation forms.

For a closer look at what was going on within each broad category of activities, each category was subdivided into four different group configurations--one child, small group, large group, and total group. According to the National Association for the Education of Young Children (1987), developmentally-appropriate learning settings provide numerous opportunities for children to work individually and in small groups. In child-centered classrooms, teachers act as guides, structuring children's activities in accordance with their abilities and interests. In traditional classrooms, work is done in large groups in which teachers "cover the curriculum" and teaching is directed toward the child of "average" ability.

In School A, the majority of activities involved either one child engaged in an activity on his/her own, or several children involved in small groups. This was true with mathematics activities, non-mathematics instructional activities, non-mathematics experiential activities, and even with non-learning activities (See Tables 6, 7, 8, and 9). A very different pattern was observed in School B. Although a majority of individual children or small groups were observed during mathematics activities, the percentage of instances of large and total group configurations increased for both non-mathematics instructional and non-learning activities. This suggests that in School B, during mathematics and non-mathematics experiential activities, teachers grouped students appropriately. This was not, however, the case for other types of activities.

TABLE 6

Percentage of Instances of Mathematics Activities, by Classroom Groups and School, June 1988

		Grouping Patterns			
School	Classrooms	One Child	Small Group	Large Group	Total Group
A	6	24%	72%	0%	4%
B	4	33	51	0	16

- In both schools most mathematics activities involved individual children or small groups.

TABLE 7

Percentage of Instances of Non-Mathematics Instructional Activities, by Classroom Groups and School, June 1988

		Classroom Groups			
School	Classrooms	One Child	Small Group	Large Group	Total Group
A	6	35%	48%	9%	8%
B	4	23	13	25	39

- In School A most non-mathematics instructional activities involved individual children or small groups. The opposite was observed in School B.

TABLE 8

Percentage of Instances of Non-Mathematics Experiential Activities, by Classroom Groups and School, June 1988

		Classroom Groups			
School	Classrooms	One Child	Small Group	Large Group	Total Group
A	6	15%	63%	0%	22%
B	4	0	92	0	8

- In both schools most non-mathematics experiential activities involved small groups.

TABLE 9

Percentage of Non-Learning Activities, by Classroom Groups and School, June 1988

		Grouping Patterns			
School	Classrooms	One Child	Small Group	Large Group	Total Group
A	6	69%	26%	0%	5%
B	4	48	20	12	20

- More non-learning activities involved either a large or total group in School B than in School A.

In order to find out how teachers involved themselves in the classroom, the categories were reanalyzed to include only those activities in which the teacher was present.

Table 10 shows that School B teachers interacted with the children most often in non-math instructional activities. Furthermore, when School B teachers involved themselves in mathematics activities, they worked with the total group. Teachers in School A tended to work with individual or small groups of children during all types of activities.

Another way in which School A differed from School B was in the number of instances of non-learning activities. There were more non-learning activities in School B; there were more instances of total group involvement in non-learning activities; and teachers spent more of their time involved in non-learning activities than teachers in School A.

TABLE 10

Percentage of Instances of Teacher-Child Interactions by Type of Activity, June 1988

Sch	Class-Rooms	Activity Type: Math Activities	Non-Math Instructional	Non-Math Experiential	Non-Learning[a]	Adult Non-Interaction	Other[b]
A	6	43%	36%	11%	2%	2%	6%
B	4	30	48	2	11	3	6

[a]Includes discipline, off-task child, negative interactions, inappropriate social interactions, transitional activities.

[b]Includes observing and classroom management.

- School B teachers interacted with the children most often in non-math instructional activities.
- Teachers were involved in more non-learning activities in School B than in School A.

When the individual types of mathematics activities* were examined, differences between School A and School B were noted. As shown in Table 11, for example, one-third of the mathematics activities observed in School B were in the category of Space and Geometry, while only seven percent of the activities in School A fell into this category.

TABLE 11

Percentage of Instances Of Various Mathematics Activities by School, June 1988

Mathematics Activities	School A (N=6)	School B (N=4)
Patterns, Relations, Functions	23%	19%
Number	17	27
Mathematical Rules	37	14
Fractions	14	0
Measurement	1	7
Space and Geometry	7	33
Statistics	1	0

*See Appendix A.

Further analysis of the individual observation forms revealed that the specific activity coded most often in the category of Space and Geometry involved an individual child constructing something out of LEGO blocks. While this is a useful discovery activity, it appears to have been overused on the day of observation. In contrast, far fewer instances (seven percent) of such activities were observed in School A classrooms. The majority of activities in School A classrooms were either Mathematics Rules or Patterns, Relations, and Functions.

Product-Oriented vs. Process-Oriented Teaching Techniques

Briefly, product-oriented teaching techniques are defined as instances where teachers give step-by-step instructions, and ask students questions that have only a single correct answer. In contrast, process-oriented techniques are defined as instances where teachers ask children for their own estimations, explanations, alternative solutions, or model strategies for solving problems. There was no formal workshop that addressed process-oriented versus product-oriented teaching techniques in mathematics at the pilot schools during the school year. Instead, teachers shared teaching techniques informally, and when they saw a need, the staff developer and consultants reviewed appropriate techniques with teachers.

As part of one in-service activity, the Great Starts teachers were asked to rate various techniques in terms of their importance and how often they used them in their classrooms. Table 12 shows the answers received. Half of the teachers in chool B, but only one teacher in School A, rated "giving rules," a product-oriented technique, as very important and one they often used. The majority of teachers in school A rated process techniques as very important and the ones they most often used.

TABLE 12

Teachers' Ratings of Teaching Techniques as Important and Often Used in Their Classrooms by School, June 1988

Teaching Technique	Percentage of Teachers	
	School A (N=12)	School B (N=8)
Product Techniques		
Giving rules	7%	50%
Explaining skills	45	13
Asking for correct answers	17	38
Process Techniques		
Asking for estimates	50	38
Asking for alternatives	67	38
Asking for justification	17	13

- More of the teachers in School A rated process-oriented teaching techniques as very important and ones they used often in their classrooms than did teachers in School B.
- Proportionately more teachers in School B rated product-oriented teaching techniques as very important and ones they used often in their classrooms than did teachers in School A.

The observed use of either process-oriented o1 product-oriented techniques in the classrooms was consistent with the teachers' ratings of their importance and use. It seems that teachers were clearly aware of the techniques they used in their classrooms. As shown in Table 13, 71 percent of the instances of observed teaching techniques for School A were process-oriented, while in School B, nearly the same percentage (72 percent) of the observed instances were product-oriented teaching techniques.

TABLE 13

Percentage of Observed Instances of Process- and Product-Oriented Teaching Techniques by School, June 1988

		Teaching Technique			
School	Classrooms	Process-Oriented	(N[a])	Product-Oriented	(N[a])
A	6	71%	(50)	29%	(20)
B	4	28	(12)	72	(32)

[a]Number of observed instances.

- Process-oriented teaching techniques were observed more in School A classrooms while product-oriented teaching techniques were observed more in School B classrooms.

IV. STUDENT ACHIEVEMENT

STUDENT CHARACTERISTICS

Background demographic and school information for all second grade students in the two schools was collected by district staff developers.

Demographic Information

The mean age of the second graders at the time of citywide testing in April was 7 years and 10 months. A slight majority (56 percent) of the second grade students was female. Almost all (92 percent) of the students spoke English in their homes. Spanish was the primary language for seven percent of the students. At the end of the 1987-88 school year, only three children were still considered Limited English Proficient.

Prior Educational Experience

Information about students' prior educational experience was obtained from cumulative records kept in the schools. The majority of second grade students in both School A and School B had attended kindergarten. As shown in Table 14, however, a larger percentage of children in School B were known not to have attended prekindergarten.

Approximately half (55 percent of School A and 50 percent of School B) of the Great Starts second graders had attended their respective schools for their entire first and second grade years. Because of high pupil mobility, the other half (50 percent of

School B and 42 percent of School A) of the second grade students had been in the program only during their second grade year.

TABLE 14

Percentage of Second Grade Students with Prekindergarten and Kindergarten Experience, by School, June 1988

Prior School Experience	School A (N=86)	School B (N=40)
Attended Prekindergarten		
Yes	37%	15%
No	27	40
Unknown	36	45
Attended Kindergarten		
Yes	79	85
No	4	8
Unknown	17	7

- A larger percentage of children in School B had not attended prekindergarten.

Attendance and Retention Performance

Student attendance was similar for the two schools. The average attendance rate was 89 percent, with a range from 87 to 92 percent.

Two children had been retained for another year in second grade.

Tests Used

Mathematics achievement was measured by the Metropolitan Achievement Test (MAT), Edition 6 in 1987, and by the New York City Edition of the MAT-6 (a customized version of the 1987 test) in 1988. The MAT-6, New York City Edition consisted of three subtests: Concepts, Problem Solving, and Computation. The Concepts subtest measured skill in numeration, geometry, and measurement. Specifically, number concepts to one thousand, fractions, shapes, figures, money, time, and customary and metric measurement were assessed. The Problem Solving subtest consisted of graphs, tables, and teacher-dictated word problems. The Computation subtest measured skill in applying the four basic operations: addition, subtraction, multiplication, and division with whole numbers.

Achievement Outcomes

In both schools, as shown in Table 15, a smaller percentage of students scored in the top quartile in 1988 than in 1987. For School A, however, the decrease in students in the fourth quartile was counterbalanced by an increase in students who scored in the third quartile. As a result, in School A, the percentage of students who scored at or above grade level increased slightly from 1987 (50.7 percent) to 1988 (53.5 percent). The reverse was found in School B, where the percentage of students scoring at or above grade level decreased between 1987 (26.5 percent) and 1988 (17.5 percent).

TABLE 15

Distribution of Citywide Second Grade 1987 and 1988
Mathematics Test Scores, by School

School	Year Tested	Students Tested	Distribution of National Percentile Scores: Below Grade Level: Quartile 1 (1 - 25) N	%	Quartile 2 (26 - 49) N	%	Above Grade Level: Quartile 3 (50 - 75) N	%	Quartile 4 (76 - 99) N	%
A	1987	65	21	32.3%	11	16.9%	6	9.2%	27	41.5%
	1988	86	25	29.1	15	17.4	16	18.6	30	34.9
B	1987	56	34	60.7	7	12.5	8	14.3	7	12.5
	1988	40	26	65.0	7	17.5	6	15.0	1	2.5

- In both schools, a smaller percentage of children scored in the top quartile in 1988 than in 1987.
- In School A, the percentage of students who scored at or above grade level increased slightly from 1987 to 1988.

Table 16 shows the mean normal curve equivalent (N.C.E.)* scores for three subtests and the total test. Students in both School A and School B performed slightly better on the Concepts and Problem Solving subtests than on the Computation section of the test.

TABLE 16

Mean Second Grade NCE Scores on the April 1988 Citywide Mathematics Test by Subtest and School

		Subtest							
		Concepts		Problem Solving		Computation		Total Test	
School	N[a] Tested	Mean NCE	SD[b]	Mean NCE	SD[b]	Mean NCE	SD[b]	Mean NCE	SD[b]
School A	86	55.2	24.8	53.0	23.7	48.0	26.3	51.5	26.9
School B	40	34.5	18.2	31.5	16.8	30.8	21.3	29.4	19.8

[a] Number of students.

[b] Standard deviation.

- Second-grade students in School A scored at grade level on the citywide mathematics test.

Relationship Between Teaching Techniques and Student Achievement

As described earlier in this report, OREA field staff collected data on the teaching techniques used during the classroom observations. Observation data were available for four

*Normal curve equivalent scores are derived from percentile ranks, but unlike percentile ranks, are based on an equal-interval scale which ranges from one to 99 with a mean score of 50 and a standard deviation of approximately 21. Because N.C.E. scores are equally spaced apart, statistical calculations such as averages are meaningful. A N.C.E. score of 50 is at grade level.

first/second grade bridge classes in School A and one second grade classroom in School B. The same types of observation data were collected by the same field consultants in one second grade classroom in each of two non-Great Starts classrooms (Schools C and D) in the same school district. Table 17 shows the mean NCE scores for the observed classrooms in each of the four schools and the mean number of product-oriented and process-oriented teaching techniques observed in those classrooms.

TABLE 17

Mean NCE Scores on April 1988 Citywide Mathematics Test and Types of Teaching Techniques by School for Second Grade Classrooms in the Observation Sample

School	Number of Classes	Students Tested	Mean Total NCE Score	Mean Process-Oriented Techniques	Mean Product-Oriented Techniques
A	4	47	53.6	11	2
B	1	26	[illegible]	5	6
C	1	21	42.6	1	5
D	1	24	30.1	4	8

As described earlier, process-oriented techniques were defined as instances where teachers asked children for estimations, explanations, alternative solutions, or modeled strategies for solving problems. Instances in which teachers gave step-by-step instructions, provided "cookbook" answers, or asked children questions which had only one correct answer were coded as product-oriented techniques. Teachers in School A used more process-oriented teaching techniques than teachers in the other three schools. Students in School A also had higher scores on the citywide mathematics test, as noted earlier.

Correlational analyses were conducted to examine the relationship between process and non-process teaching techniques and mathematics test scores. Correlation coefficients were calculated for total test and subtest scale scores with instances of process-oriented and product-oriented teaching techniques. As shown in Table 18, instances of product-oriented teaching techniques were found to be significantly negatively correlated with achievement as measured by total test scale scores ($r = -.42$). That is, students whose teachers were observed to use <u>more</u> <u>product-oriented</u> techniques tended to have <u>lower</u> scores on the mathematics test. On the other hand, instances of process-oriented teaching techniques were significantly positively correlated with achievement ($r = .32$). The same pattern occurred with each of the six correlations calculated for the subtests. Process-oriented teaching techniques correlated best with scores on the Concepts subtest. A possible explanation for this is that the correct answers could be estimated more easily on the Concepts subtest than on the other two subtests;

TABLE 18

Correlational Statistics for the MAT-6, New York City Edition, Mathematics Subtest and Total Test Scale Scores by Teaching Technique

Teaching Techniques	Correlational Statistics							
	Concepts		Problem-Solving		Computation		Total-Test	
	r	p	r	p	r	p	r	p
Process-Oriented	.36	.000	.24	.008	.28	.002	.32	.000
Product-Oriented	-.43	.000	-.35	.000	-.41	.002	-.42	.000

r = Pearson product moment coefficient of correlation between test scores and teaching techniques.

p = Level of significance.

- Students whose teachers were observed to use more product-oriented techniques tended to have lower scores on the mathematics test, while instances of process-oriented teaching techniques were significantly positively correlated with achievements.

also students who felt more comfortable and had more practice estimating answers did better.

The negative correlations between product-oriented techniques and the test scores were stronger than the positive relationships found between process-oriented techniques and achievement scores. It appears, therefore, that contrary to popular beliefs, product-oriented teaching techniques may be detrimental to students' success in mathematics--at least as measured by the MAT-6. Drill and practice, asking for single correct answers, or giving students step by step procedures may not ensure even rote memorization of arithmetic facts. Challenging children to make an informed guess, to provide alternative answers, or to pose new and interesting problems stimulates their interest and may result in a more meaningful understanding of mathematics.

V. CONCLUSIONS AND RECOMMENDATIONS

In order to function in today's technological society children can no longer be taught only to memorize arithmetic facts; they must develop a mathematical orientation toward understanding, analyzing, and solving problems. The Great Starts Mathematics Approach is an attempt to provide children with this orientation by training teachers to teach mathematical relationships, concepts, and ideas through directed play and exploration with concrete materials. During the first two years of implementation, the three-year Great Starts Mathematics Approach program developed an early childhood mathematics curriculum and a design for training teachers to use the new curriculum in their classrooms.

As described in this report, the two project schools were very different before the start of the program. Teachers and administrators in one school were familiar with an educational philosophy and teaching strategies compatible with the philosophy underlying Great Starts. Teachers in this school were searching for ways to improve their mathematics instruction and asked to participate in the program. The second school had previously been identified as one of the "worst" in the city and was selected by district supervisors to be part of the program. Even though the program was imposed upon them, the teaching staff in the second school agreed to participate in the training sessions held after school. The staff development activities for all staff were essentially the same. It is not surprising, therefore, that teachers in the first school, whose educational philosophy and practices were already compatible with the program, were able to implement the activities and ideas more easily. Teachers in the second school will need additional training and experience before they reach the same levels of competency.

According to Ball and Wilcox (1989), "Focusing on techniques of teaching without, for instance, engaging teachers in considering their assumptions about learning, may prove a futile intervention" (p.34). If the Great Starts Mathematics Approach is to be used by different teachers with different backgrounds and experiences in different schools, then staff development will have to be more individualized. As part of their professional development, less experienced teachers will need to become actively engaged in trying the newly-introduced techniques through modeling, coaching, and observations in classrooms of their more skilled peers.

Although student achievement--as measured by second grade standardized test scores--did not improve, correlational analyses showed a relationship between teaching techniques observed in the classrooms and the standardized test scores. Children whose teachers used product-oriented techniques (i.e., posed questions or problems for which there was one correct answer or solution) tended to have <u>lower</u> scores on the mathematics test than children whose teachers used the process-oriented techniques (i.e., asked children for estimations, explanations, and alternative solutions) recommended by the Great Starts Mathematics Approach. There is some preliminary evidence, therefore, that better implementation of the Great Starts Mathematics Approach may result in higher student achievement in mathematics. It's possible, however, that the benefits of a conceptual approach to mathematics learning may not become truly manifest until students become involved with higher order mathematics, such as formal algebra and deductive geometry.

According to the National Council of Teachers of Mathematics (1989), standardized norm-referenced tests are too limited in scope to be used as the sole indicator of student knowledge and skills and, therefore, may be inappropriate for use in evaluating the outcomes of conceptually-based mathematics programs. N.C.T.M recommends assessing students' mathematical knowledge through a variety of methods "such as observations of students doing mathematics, performance and oral tasks, and written tests" (pp.238-239).

Great Starts has the potential for becoming a model for improving mathematics education in the early grades. The project simply needs more time for this potential to be transformed into reality. OREA makes the following recommendations for program improvement:

- Project staff should continue professional development activities for school principals, teachers, and paraprofessionals. In addition to providing teachers with curriculum materials and activities, staff development should be planned to help teaching staff grapple with the philosophical assumptions that underpin process-oriented teaching.

- Project staff should identify a variety of methods for assessing student knowledge and skills in mathematics, and incorporate these methods into the program design.

APPENDIX

APPENDIX A

DESCRIPTIONS OF CLASSROOM ACTIVITIES AND TEACHING TECHNIQUES USED BY FIELD STAFF IN THE CLASSROOM

Mathematics Activities.

1. Patterns, relations and functions. This category focuses on the foundation of algebraic thinking. Activities in this category include simple or complex sorting and classifying; ordering sets by quantity (more than, less than); exploring functional relationships, for example, counting two by two--as each child stands up, the number of eyes are counted; focusing on patterns (numerical, shape, colors, auditory, e.g., handclapping) through activities which may include music or art. Activities involving the observation of regularities in the world which can then be described with numbers best characterize the types of activities to include in this category.

2. Number. Activities included in this category involve the development and use of whole number concepts. Particular activities included in this category are one-to-one correspondence activities; activities involving cardinal and ordinal numbers; rote counting, counting songs, and rote recall of number facts; sequencing whole numbers; and rudimentary place value concepts.

3. Mathematical rules (algebra). This category focuses on the development and use of rules for performing mathematical operations. Activities included in this category are working with number sentences; performing addition and subtraction problems; applying exchange; and place value operations. Games such as "guess my rule" should be included in this category.

4. Fractions. This category involves all activities that focus on the division of wholes into parts. These activities could include discussion of halves, three-fourths, etc.

5. Measurement. This category includes any activity involving standard (unit) or nonstandard measuring. Activities could include using string to compare lengths; using pencils, sticks, clips, cuisinaire rods, unifix cubes, etc., to measure; liquid measure (cooking); and volume measure (sandbox activities using containers).

6. Geometry and space. These activities involve the discussion or exploration of geometrical properties of objects (sides, angles, circumference, shape) or the discussion or exploration of spatial relationships (above, below, between, inside, outside, etc.). Activities could include using attribute blocks; using geoboards; folding to discuss symmetry; using tangram puzzles; using parquetry blocks to sort and identify shapes; building objects with LEGOs; mapping (e.g., using blocks or paper and pencil to recreate a neighborhood--if mapping involves measuring, code in category 5).

7. Statistics and probability. The activities in this category focus on the use of data to describe real world events and on the development of estimation strategies. Activities include collecting data, for example, noting the number of sunny days on the classroom calendar, and creating a graph by month; doing a classroom survey; and guessing and estimating answers.

8. Other math subject areas. This category covers any other math activity that cannot be coded in any of the above categories. Note the kind of activity and the materials used in the space provided on the back of Form B.

Other Classroom Activities

9. Non-Math instructional activities. These activities do not directly or indirectly relate to mathematical thinking. Activities could include reading, social studies, writing.

10. Non-Math experiential activities. These activities do not directly or indirectly relate to mathematical thinking. Activities could include singing, dramatic play, free play with blocks. (If block play is focused on a mathematical activity, such as examination of shapes or mapping, include in appropriate categories).

11. Non-learning activities. These activities are not directly or indirectly related to the classroom curriculum. Activities within this category are off-task children, negative interactions, inappropriate social interactions, transitional activities.

12. Refocusing off-task children. These actions are non-punitive disciplinary actions. For example, an adult breaks up a negative interaction between children by refocusing their attention to some other activity.

13. Discipline/punitive control. This category is coded when punitive action is taken, e.g., punishing a child by making the child stand alone in a corner.

14. Adult non-interaction. The adult is not involved with the students. The teacher (paraprofessional or other adult) is engaged in social interaction or transitional activities. The appropriate side-note circles are coded.

15. Observing. This category is to be used for persons who are watching other people or activities: a teacher who is overseeing children in an activity; a child watching another group playing, and so on. If the adult is not interacting with children during observation, the appropriate side-note circles are marked.

16. Classroom management. Activities in this category are daily classroom activities or events--distributing materials, setting up equipment and furniture, taking attendance, checking materials in a cupboard, gathering up materials and equipment, and cleaning up. If the adult is not interacting with children while engaging in classroom management, the appropriate side-note circles are marked.

TEACHING TECHNIQUES

(Code only for teachers engaged in activities in Categories 1-10)

Product-Oriented Techniques

a. Telling. Teaching by telling involves giving step-by-step instructions to children--providing cookbook solutions for children to follow.

b. Asking NP (Not Process). Asking NP is a teaching technique in which the teacher asks children questions that only have a single answer. For example, How much is 30 + 40?; Q: Where did Johnny go in the story? A: The store.

Process-Oriented Techniques

c. Asking Est. (Estimation). This teaching technique asks children to estimate their answers or to guess. For example: How many small blocks do you think you need to balance the large blocks?

d. Asking Exp. (Explanation). This technique asks the children to explain or justify their answers. For example: Can you tell (show) me how you worked out balancing the scale?

e. Asking Alt. (Alternative)--This teaching technique asks the children for alternative options. For example, Can you do that another way?; Did you all do it the same way? Is there a different size block you could use to balance the scale?

f. Modeling--This technique has the teacher actively showing, with manipulatives or dramatization, strategies for solving problems.

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