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ABSTRACT

This study examined the relationship between developmentally appropriate and traditional teaching methods and the mathematics achievement of 15 average and 10 students with disabilities. Data were collected in four first grade classes, one second grade class, and one multi-age inclusion program. A descriptive research design was used with observations, interviews, and questionnaires. Principal component methods were used to generate continuous composite variables that described teacher presentation, materials, grouping, and curriculum. The outcome measure was a curriculum-based measure of mathematics achievement. Analysis found that variables characterizing the developmentally appropriate versus traditional continuum were not associated with mathematics achievement. For both general and special education students, achievement was associated with measures of student mathematical processing and strategy instruction. Use of abstract mathematics-only manipulative materials and math worksheets was negatively related to achievement. The findings suggest the debate about developmentally appropriate versus traditional practices is not fruitful. Nine tables of data are appended. (Contains 31 references). (Author/JLS)

Are Developmentally Appropriate or Traditional Teaching Practices Related to the Mathematics Achievement of General and Special Education Students?

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Abstract

Recently, developmentally appropriate practices have been distinguished from traditional practices and advocated as one way to reform primary general education classrooms. Relatively little research has examined the efficacy of developmentally appropriate versus traditional practices. In particular, concerns have been raised about the effectiveness of this approach for students with disabilities. This study examined the relationship between developmentally appropriate and traditional teaching methods and the mathematics achievement of general and special education students. Observations, interviews and questionnaires were used to assess the mathematics teaching practices used with general and special education students. Because developmentally appropriate and traditional teaching practices are often characterized as a continuum, principal components methods were used to generate continuous composite variables that described teacher presentation, materials, grouping, and curriculum. The outcome measure was a curriculum-based measure of mathematics achievement. Principal components analysis found that variables characterizing the developmentally appropriate v. traditional continuum were not associated with mathematics achievement. Instead, consistent with previous research, achievement was associated with measures of student mathematical processing and strategy instruction. Use of abstract, mathematics only materials (e.g., place value mats) and math worksheets was negatively related to achievement. Placement in general versus special education class was also associated with achievement. These findings suggest that the debate about developmentally appropriate versus traditional practices is not fruitful.

Are Developmentally Appropriate or Traditional Teaching Practices Related to the Mathematics Achievement of General and Special Education Students?

Recently, "developmentally appropriate practice" has been advocated as one way to reform primary general education classrooms. In 1987, responding to concern over the increased emphasis on formal academic instruction in early childhood programs, the National Association for the Education of Young Children (NAEYC) released a document outlining developmentally appropriate practices (Bredekamp, 1987). The document described teaching practices as existing on a continuum with one end being desired over the other, depending on the individual student and immediate context. Bredekamp described two philosophical dimensions for teachers to consider in planning: students' developmental level and individual student needs.

Some examples of teacher presentation practices considered to be developmentally appropriate (Bredekamp, 1987) are that teachers should: allow students to choose the activities in which they engage (i.e. self-initiated choice of stations); implement thematic units; integrate math with other subject areas; consider student interests; share classroom decision making with students; and act as facilitators of learning by asking questions, sharing ideas, and making suggestions. Grouping practices recommended for teachers are that they: facilitate individual and small group learning; be flexible in their grouping practices; and arrange heterogeneous ability groups. Teachers should also allow students the opportunity: to choose between working individually or in a group; to interact with adults and children while learning; and to learn in a multi-age setting. Developmentally appropriate practices also include the recommendation that students actively engage with a variety of materials (i.e. manipulatives).

As of 1993, 300,000 copies of the NAEYC document and several million brochures had been sold (Bredekamp, 1993). This popularity has spawned a number of other publications interpreting developmentally appropriate practices. Some materials espousing developmentally appropriate practices have described traditional teaching practices as undesirable (e. g. Gestwicki, 1995; Gronlund, 1995; Passidomo, 1994), and called for virtually exclusive use of "developmentally appropriate" techniques. Instead of a continuum of teaching practices where each end may be appropriate depending on context and individual needs of students, some authors have portrayed the developmentally appropriate/traditional continuum as having a "right" and a "wrong" end (Gestwicki, 1995; Gronlund, 1995). According to these authors, the continuum should serve as a guide for teachers who are committed to shifting away from traditional to developmentally appropriate teaching. That is, teachers should place themselves on the continuum and move from the "inappropriate"/traditional end toward the developmentally "appropriate" end. Presentation practices that these authors describe as being exemplified by the traditional end of the continuum include: lack of student choice; direct instruction in a single discipline; and teacher controlled curriculum and activity. Traditional grouping practices are described as: large group instruction; single age classrooms; and fixed, homogeneous group assignment. In regard to materials, math worksheets are considered to be traditional.

As illustrated by Bredekamp's bibliography, there is only a limited body of research that examines the effectiveness of practices on the developmental/traditional continuum. That is, little is known about how a teacher's use of practices on this continuum influences student achievement. Thus, the purpose of this investigation was to examine the relationship between implementation of practices on the developmental/traditional continuum and student achievement.

Early Childhood Special Education and Developmentally Appropriate Practices

Bredekamp's (1987) document has been criticized for including virtually no mention of students with disabilities (Mallory, 1992). Bredekamp (1993) stated that one of the principles underlying developmentally appropriate practice is that adaptations in learning environments and teaching practices "should be made for the wide range of differences between individual children" (p.261). Others have argued that even though Bredekamp (1993) recommends inclusion of special needs students in the general education classroom, the principle she outlined may not be sufficient for children with special needs (Atwater, Carta, Schwartz, & McConnell, 1994; Carta, 1995; Carta, Atwater, Schwartz, & McConnell, 1993; Carta, Schwartz, Atwater, & McConnell, 1993; Lubeck, 1994; Mallory, 1994). Atwater and colleagues (1994) expressed concern that developmentally appropriate practice has been misinterpreted as being the "best practice" and as equally beneficial for children with disabilities. While it is one measure of a quality program, Atwater and colleagues called for developmentally appropriate practice to be expanded in order to adequately accommodate children with diverse needs.

Others have gone further, and argued that there are fundamental philosophical differences between developmentally appropriate practice and effective early childhood special education (Carta, 1995; Carta, Schwartz, Atwater, & McConnell, 1991). According to these authors, early childhood special educators believe in providing interventions as early as possible for students with special needs. Advocates for developmentally appropriate practice do not emphasize accelerating development, arguing instead that children will develop on a natural course. Carta (1995) suggested that this philosophical dichotomy may have led to the concern among early childhood special educators that developmentally appropriate practice does not recognize the value of direct instruction and teacher-directed activities (Carta, Schwartz, Atwater, & McConell, 1991). Burton, Higgins Hains, Hanline, McClean, and McCormick (1992) pointed out that developmentally appropriate practice is often characterized as a methodology that should never include direct instructional strategies which are clearly a part of early childhood special education. These (traditional) direct instruction practices include teacher modeling, frequent teacher-student interaction, specific feedback, and teacher monitoring of all pupils (Brophy & Good, 1986).

Given these debated philosophical differences, it is not surprising that Carta et al., (1991) called for more research to "demonstrate the effectiveness of this approach [developmentally appropriate practice] for all children with and without disabilities" (p.15). This call for research was echoed by Wolery, Strain, and Bailey (1992). The present study addressed that objective. This research examined the relationship between a teacher's location on the continuum of practices and their primary special and general education students' achievement.

Mathematics and Developmentally Appropriate Practices

A review of recent publications by the NCTM confirms that there are many similarities between recent recommendations for mathematics instruction and developmentally appropriate practices. NCTM (1989;1991) called for actively involving children in learning and providing a wide variety of manipulatives. They recommended addressing problem solving, considering students' thought processes, modeling mathematical ideas, integrating math lessons with other subject areas, and understanding pupils' developmental levels. Consistent with the view that teaching practices exist on a continuum, NCTM called for flexibility in methodology and some use of more traditional approaches. For example, the standards have recommended a mix of individual, cooperative pairs, small group activities, and whole class direct instruction in the teaching of mathematics. Because of clear similarities between the NCTM recommendations and developmentally appropriate practices, this research focused on developmentally appropriate and traditional mathematics instruction and achievement.

The NCTM (1989; 1991) documents suggested that teachers of math need to study more than general teaching practices (such as developmentally appropriate practices), as one set of teaching practices does not necessarily facilitate learning in all disciplines. Instead, mathematics teaching must be informed by research on mathematics. Accordingly, in this study we measured certain practices specific to mathematics instruction.

Teaching Practices Specific to Math

In our analysis, we included the extent to which the teachers' curriculum followed NCTM recommendations to de-emphasize the operations of addition, subtraction, multiplication and division. We also chose to distinguish several categories of materials from our observations (see Table 3). This decision was informed by the NCTM recommendation that teachers should use a wide variety of manipulatives; it also reflected concern that research has not yet demonstrated conclusively exactly what kinds of manipulatives are crucial to learning mathematics (Clements & McMillen, 1996). Thornton and Wilson (1993) suggest that teachers engage students in presentations in front of the class, so we coded whenever this practice occurred in our observations.

We asked whether teachers included math vocabulary in their instruction because of Monroe and Punchyshyn's (1995) review demonstrating the importance of explicitly teaching vocabulary specific to math. They pointed out that a majority of the words found in elementary math books are not among those that children most frequently encounter in their reading materials.

Lastly, Peterson, Swing, Stark, and Wans (1984) found that the number of strategies students reported using as they worked on math was positively related to their achievement in mathematics. Consequently, we considered the types of strategies teachers either modeled or mentioned. Modeling of activities is deemed important in the process of preparing children to learn addition and subtraction and we noted in our observations whenever teachers modeled for students (NCTM, 1991; Davydov, 1982)

Summary of Research Question

This research examined the relationship between a continuum of developmentally appropriate and traditional practices and student achievement. Supported by the literature, we included students with and without disabilities as participants, and focused on mathematics instruction and achievement. This research asked "What is the relationship between teachers' location on a continuum of developmentally appropriate and traditional practices, and the achievement of special and general education students in mathematics?"

Method

Design

This research employed a descriptive design which was consistent with the conceptualization of developmentally appropriate practices as a continuum of practices. We measured (though observation, interviews, and questionnaires) the naturally occurring practices of teachers. These data were used to define a series of (continuous) variables that characterized a continuum of developmental to traditional approaches to presentation, grouping, materials, and curriculum. For each variable, each teacher was located on the continuum. This then allowed us to examine the association between location on the continuum and student achievement. We rejected a two group design as incompatible with the conceptualization of a continuum of practices.

Groundwork for the present research was established by previous involvement with the school. During the 1993-1994 school year, qualitative observations were made of four students for five days each, to gather baseline information about instructional practices in the school. During the 1994-1995 school year, qualitative observations were made of the multi-age, inter-disciplinary centers offered by two teams of teachers, to develop an understanding of how developmental appropriate practices were enacted by teachers in this setting. Interviews with teachers, instructional leaders, and the principal were conducted each year, to gather information about their concepts of developmentally appropriate and traditional practices.

Because the literature does not offer a universally understood definition of developmentally appropriate practices, the present study used a collaborative research model, wherein the participating teachers provided the definitions of the developmentally appropriate and traditional poles of the continuum of practices. According to these teachers, practices such as multi-age classes, stations/centers (stations: many locations with one math activity at each; centers: many math activities and resources at one location [Thornton, & Wilson, 1993]), cooperative learning, flexible grouping, individualized instruction, student choice, and themes or cross-disciplinary lessons represented the developmental end of the continuum. These teachers characterized teacher-led instruction, whole class grouping, structured individual seatwork, and frequent use of worksheets as representing the traditional end of the continuum.

Consistent with an action-research approach, in June and September 1995, the researchers met with the principal and participating teachers to design the research. Also included in this group was the Project Leader responsible for staff development in developmentally appropriate practices. These meetings confirmed, through teacher reports, that it would be difficult to categorize "developmental" or "traditional" groups of teachers. These teacher reports provided support for a descriptive design, which allowed teachers to implement their chosen methods, then relate these methods to student outcomes.

The Project Leader's view of developmentally appropriate practices was that they could meet the needs of all students, including students with disabilities, so the decision was made to sample both students with disabilities and "average" achieving students in general education settings. Certain of the collaborating teachers designed an inclusion program using developmentally appropriate practices. They believed that the emphasis on individualization made developmentally appropriate practices an appropriate methodology for all students, including students with disabilities. Other teachers included students with disabilities into more traditional general education settings.

We solicited teacher input regarding the academic discipline most amenable to developmentally appropriate practices. They unanimously reported that developmentally appropriate practices were most readily implemented in math class, so the decision was made to focus the research on mathematics instruction and achievement.

Context of the Research

This research was conducted in one primary (grades K-2) school, during the 1995-1996 school year. At the beginning of the 1993-1994 school year, the districts' two elementary schools were changed from a traditional K-5 structure to a primary (K-2) and intermediate (3-5) configuration. Consistent with this developmental structure, the primary building adopted a reform initiative focused on developmentally appropriate practices.

To reform teaching practices, staff development in developmentally appropriate practices was offered. The vehicle for staff development was a position called "Project Leader." The Project Leader was expected to become expert in developmentally appropriate practices, through readings, conferences, and visitations, and to share this expertise with fellow teachers. A first Project Leader served from 1993-1994, a second from 1994-1996.

The second Project Leader characterized the developmentally appropriate reform effort as a "school within a school." According to the Project Leader, teachers could choose to adopt a developmental philosophy and/or practices, or could choose to continue more traditional practices. At the same time, all teachers were aware of building and district administrators' support for developmentally appropriate practices.

Teachers could also learn about developmentally appropriate practices from the district's adopted math curriculum (Eicholz et al., 1995). The teachers' manual for this curriculum provided suggestions to teachers about developmentally appropriate strategies for math instruction. For example, the teachers' manual directed teachers to adjust their instruction for different learning styles and ability levels to meet the individual needs of students, and advocated use of "mathematically rich manipulative experiences" (p. iii). The teachers' manual also called for offering a wide variety of instructional activities that could be completed individually or in cooperation with other students. Finally, the manual provided suggestions on how to integrate math lessons with other subject areas.

Participants

Teacher Sample. Data were collected in four first grade classrooms, one second grade class, and in one multi-age inclusion program organized by one special education, one first grade, and one second grade teacher. Teachers ranged from 3 to 25 years of teaching experience, with 1 to 9 years at their present grade level.

Student Sample. We identified all students with disabilities in grades 1 and 2 who received math instruction in general education classrooms. Parent permission was solicited. Teachers of participating students were asked to nominate "average" students, and parental permission was sought. The resulting sample included ten special education (eight first and two second) and 15 average (ten first and five second) grade students. One of the special education students was multiply handicapped. Preliminary analysis revealed that this subject performed as an outlier on all achievement measures, so we chose not to include that student in the final analysis. That subject's teacher (and the teacher's general education students) was retained because the observed and reported practices were still taking place in an inclusion setting.

The remaining nine special education students were labeled speech impaired. Five of the subjects' placement was "related services and transition from special class," one received consultant services, one's placement was resource room, and two were placed in a special class. Student records included IQ scores for seven of the special education subjects. The average IQ of that group was 82 with a standard deviation of 10.

Given the centrality of language to learning at the primary age, we administered two language measures as a basis for description of the special and general education groups (see Table 1). Standard scores derived from the Peabody Picture Vocabulary Test-Revised (Form L) provided a measure of the students' receptive vocabulary and standard scores earned on the Expressive One-Word Picture Vocabulary Test-Revised supplied a measure of the students' expressive vocabulary. Data in Table 1 documented that the "average group" had average language skills, and the two groups differed in language ability.

Measures

We designed two procedures in which teachers could report about their *curriculum, grouping, materials* and *presentation* in mathematics class: a teacher questionnaire and a semi-structured teacher interview. We also conducted lesson observations of teachers' *curriculum, materials, grouping* and *presentation* during math lessons. A student curriculum-based mathematics assessment served as the study's outcome measure.

Teacher Questionnaires. A questionnaire was designed to solicit teachers' *grouping, presentation* and *curriculum* in mathematics. Teachers were asked to select a typical week from the previous month, and to base their responses on that week. Teachers were asked how frequently (never, once, two to three times, more than three times) they had used these approaches to *grouping:* multi-age grouping; whole class instruction; individual structured assignments; centers; cooperative groups; and individual direct instruction. Teachers further indicated how often in their *presentation*: students worked at problem solving strategies; spent time on math vocabulary; explained their thought process; did oral presentations; engaged in thematically-based activities; spent time on a project of their own choosing; were given a choice of activities. They also reported the frequency with which they altered a lesson for student interest. With regard to *materials*, teachers reported the frequency with which they used manipulatives and worksheets. We ultimately eliminated the questionnaire data regarding manipulatives from our analysis because they did not constitute a variable; all teachers reported using them with the same frequency of 3 or more times a week.

The questionnaires also assessed *curriculum*. Teachers identified the mathematical topic(s) they concentrated on that week.

Teacher Interviews. An initial interview was designed to solicit the teachers' description and interpretation of their *grouping* and *presentation* in mathematics. We asked each teacher to list and describe the practices he or she used, and to characterize the practice as developmentally appropriate or traditional. Teachers were also asked to identify practices that were particularly appropriate for special education students.

The initial interview also solicited information about the teachers' *curriculum*. Teachers were given a grid with the curriculum domains (counting and number concepts; addition; subtraction; money; time; graphing and geometry; measurement and fractions; and multiplication and division) listed down the side, and the first and second half of the year listed across the top. Teachers were asked to specify the percentage of time that would be allocated to each domain of the curriculum during each half of the year.

In the final interview we shared with teachers how they had reported their *grouping* and *presentation* on the initial interview, and asked if they had additions or changes. Teachers were asked about their practices and effectiveness with special education students. We shared a preliminary coding of their observed grouping, materials, and presentation; teachers' comments were then used to refine the coding system. Teachers' reviewed and corrected the *curriculum* allocation chart they had constructed during the initial interview.

Lesson Narrative. A narrative record was made of all classroom events during lesson observations. In the lesson narrative, the observer recorded verbatim all classroom events and dialogue. These field notes recorded the teachers' presentation of the lesson, transcribed classroom dialogue, described or collected materials used, described student groupings, and noted instances when the target student was treated differently from others in the class. Particular attention was given to examples of traditional or developmentally appropriate practices. Lines of the narrative were numbered.

Following the observation, the observer briefly summarized the content and activities of the lesson. The observer reviewed the lesson narrative, to insure that all domains had been described.

To insure the trustworthiness of the lesson narratives, paired observations were conducted, prior to data collection for this study. In first and second grade classes in a school not involved in this research, the observer and the first author observed the same math lesson and recorded narratives. They then met to compare these, identify key differences and plan how the narratives could be made comprehensive. This process was repeated until line by line comparison of narratives indicated that the narratives were comprehensive in the way they reported lesson presentation, materials, grouping, curriculum content, student activity, and dialogue.

Student Curriculum-Based Math Assessment. A curriculum-based math test was created by the researchers to assess the relationship of developmentally appropriate or traditional mathematics instruction to mathematics achievement. The teachers' manuals for the district's first and second grade mathematics curriculum (Eicholz et al., 1995) were each analyzed to determine the proportion of time devoted to specific math topics: counting and number concepts; addition; subtraction; money, time; graphing and geometry; measurement and fractions; and multiplication and division. Based on the recommended proportion of teaching time, 65 representative items were selected from chapter tests. Use of items drawn from the curriculum provided evidence of content validity and ensured that the test format was familiar to pupils.

The first grade sub-test consisted of 31 items, representing all domains except multiplication and division. Coefficient alpha reliability was .90. The second grade sub-tests consisted of 34 items, and represented all domains. Coefficient alpha reliability was .92.

Each of the 65 items was scored as correct or incorrect. Preliminary analysis of the data revealed that often, students performed differently on first and second grade items. Thus, it was decided to report first and second grade sub test scores. In order to make the scores of first and second grade students comparable, standard scores by grade were developed for the first and second grade subtests.

Procedures

Teacher Questionnaires. Each teacher completed the questionnaire five times, once a month from December to April. Substitute coverage was provided for questionnaire completion. Teachers mailed the questionnaires to the researchers.

Teacher Interviews. All of the teacher interviews were conducted individually by the first author. Detailed notes were taken during the interview, and interviews were tape recorded. The initial interview took place in the fall, prior to any observations. The final interview occurred in the spring, after observations were completed. All interviews occurred during the school day, and substitute coverage was provided.

Lesson Observations. Each teacher was observed teaching five math lessons. Teachers were observed approximately once a month from December to April. The first author conducted all the observations.

Student Testing. Three student measures (two language and one math) were given in the fall, prior to classroom observations. Measures were administered in a single, individual session lasting approximately one half hour for first graders and 45 minutes for second graders. Each student was given a choice as to the order in which he or she preferred to complete the tests. All testing was done by the first author, after practice sessions conducted with first and second grade students in another school.

Both language measures were administered as directed in their manuals. All students were given both the first and second grade sub-tests of the math measure. Because many students would not be familiar with all of the content at pretest, students were encouraged to try their best on items with which they were unfamiliar, and told that some of the items were drawn from higher level texts. During testing, if a numeral was formed incorrectly or was illegible, the student was asked what answer he or she had just written. If the verbal response was correct, the item was scored as correct.

After classroom observations were completed in the spring, post testing was conducted. The math assessment was re-administered as described above.

Data Reduction and Coding

A large number of variables were derived from the interview, questionnaire, and lesson narrative data sources. Variables were defined within the domains of *grouping, materials, presentation* and *curriculum*. Data from the open-ended interviews and observations were coded, using a method of constant comparison (Glaser, 1978).

Questionnaire data. Teachers specified the frequency with which they used *presentation* practices on five independent questionnaires. Their responses were averaged across the five questionnaires.

Teachers' descriptions of the time during the sampled week allocated to different topics in the *curriculum* were summarized by comparing their allocation to that recommended in the teachers' manual. We summed the time the teacher reported allocating to the operations (counting and number concepts, addition, subtraction, multiplication and division), and subtracted from this sum the 70% time that the text allocated to the operations. This score indicated the extent to which the teacher emphasized operations, using the text as a standard. The teaching of "counting and number concepts" was always in the context of addition and subtraction, so we also included that topic in the category of operations. Teachers with positive scores taught operations more frequently than recommended by the text. Teachers with negative scores taught operations less frequently than recommended by the text.

Interview data. Teachers' responses were coded, using categories derived from their responses. Within the prespecified domains of *grouping* and *presentation*, the method of constant comparison (Glaser, 1978) was used to identify variables and levels.

Initial interview responses were read to develop a preliminary set of variables. Data pertinent to one variable was compiled on a separate sheet of paper, so that patterns could be observed and coded accordingly. One variable was coded at a time, and variable definitions were revised as needed during the coding process. Revision took two forms: variable definitions were made more specific, to increase the reliability of coding; and variable definitions were revised to become more focused on the distinctive features of the teachers' practices, to increase the validity of the coding system.

Member checking was used to insure trustworthiness of interview data. Coded data from the first interview were shared with teachers at the second interview. Teachers confirmed or disconfirmed the accuracy of these data, and added additional responses as needed. *Grouping*, *presentation,* and *materials* variables from the interviews are defined in Table 2.

Teachers' descriptions of the time allocated to different topics in the *curriculum* were summarized in the same fashion described for the questionnaire data. These scores indicated the extent to which the teachers reported that they emphasized operations, using the text as a standard.

Lesson Observation Data. Four categories of variables were derived from the observations/lesson narratives: *grouping, materials, presentation*, and *curriculum.* Lesson narratives were coded using constant comparison, as described for the interviews. The result of this process was four *grouping* variables, six variables related to *materials*, 15 *presentation* variables, and one *curriculum* variable.

Table 3 summarizes the individual variables derived from the lesson observations. The reader will note that some variables were coded in levels (with developmentally appropriate approaches given the highest value, and traditional the lowest). In other cases, once a variable was defined, we simply tallied the number of instances that variable was observed. For each variable, a teachers' scores were then averaged across the five observations.

Trustworthiness of coded observation data was ensured in two ways. Preliminary coded data were shared with teachers at the final interview. This member check was used to refine categories. Inter-rater agreement was then used to establish coding reliability. The first author coded all lesson narratives and the second author coded a sample of 40% of the lesson narratives. Inter-rater agreement in coding individual variables ranged from 81 to 100%, with an average reliability of 94%.

Teachers' observed *curriculum* emphasis across the five observations was coded and converted to a percentage, e.g., if two out of the five lessons observed covered addition, this was considered to be 40% emphasis on addition. As with the questionnaire and interview data, we compared the percentage of time the teacher was observed to teach operations to the standard of 70% set by the textbook.

Formation of Composite Variables

Given the large number of individual variables, a strategy was needed to aggregate data for ease of interpretation. We formed logical groups of variables (observed and reported grouping; observed and reported materials; observed presentation; reported presentation; and curriculum), and subjected these groupings to principal components analysis with varimax rotation. Because of the small number of teachers, the relatively high cut-off of .50 was set to conservatively establish whether a variable loaded on a component.

Each component identified by PCA was then inspected for interpretability as a composite variable. All components were found to be readily interpretable. Accordingly, factor scores from these analyses were then simplified (reduced to seven intervals). These simplified factor scores served as the composite variables which would be used to analyze the relationship between instructional practices and student achievement.

This strategy was selected for several reasons. We felt that using both logical and statistical groupings of variables was a better strategy than relying on only one approach.

Principal components methods were viewed as appropriate because they are exploratory, and derive relationships from the data. Using factor scores from the PCA allowed us to captured both the direction and extent of an individual variables' contribution to the composite variable. Further, recent research has documented the adequacy of principal components methods for small samples under appropriate conditions (see discussion in results section).

Observed and Reported Grouping. To analyze the fourteen variables related to *grouping*, principal components analysis with varimax rotation was conducted. Inspection of scree plots and eigenvalues revealed a single component, which accounted for 54% of the variance in the data. Item loadings are reported in Table 4. Simplified factor scores defined a composite variable.

The single component related to grouping was named *Observed and Reported Developmentally Appropriate v. Traditional Grouping.* Teachers with high scores on this component reported and/or were observed to use developmentally appropriate practices such as multi-age grouping, centers and/or stations, flexible grouping, and heterogeneous ability grouping. These teachers seldom reported or were seen to use the traditional practices of whole class instruction/seatwork and individual structured assignments. Teachers with low scores on this component demonstrated the opposite pattern of grouping in their classrooms. Three variables, frequency of using centers, cooperative groups, and individual direct instruction, had very low loadings and communalities. We chose to retain them in the analysis because when the data was run without those variables, the factor scores (within the seven intervals) remained the same.

Observed and Reported Materials. Seven variables related to the *materials* that a teacher used were analyzed using a principal components analysis with varimax rotation. Inspection of eigenvalues and scree plots revealed two components, accounting for 73% of the variance. Item loadings are reported in Table 5. Simplified factor scores were used to form two composite variables.

A first component was named *Observed Developmentally Appropriate v. Traditional Materials.* Teachers with high scores on this component were frequently observed to use developmentally appropriate materials such as real-world math materials (e.g., clocks), math games, and general materials from the real world (dice, doughnuts). Student written materials were used frequently, while teacher written materials were used infrequently. Teachers with low scores on this component exhibited the opposite profile of materials usage in their classroom, eschewing real world materials and emphasizing teacher written materials.

A second component was comprised of a single variable, *Observed and Reported Math Only Materials.* Teachers with high scores on this variable/component were frequently observed to use materials one would only expect to see in a math classroom, such as unifix cubes or place value mats. They also used math worksheets to introduce, review, and supplement their math lessons. Teachers with low scores on this component used fewer abstract math manipulatives and used worksheets only to review and/or supplement.

<u>Reported Presentation</u>. This process was again repeated with the 12 individual variables related to teachers' reported *presentation.* After a principal components analysis with varimax rotation, inspection of eigenvalues and scree plots revealed two components, which accounted for 76% of the variance in the data. Item loadings are reported in Table 6. For each component, simplified factor scores were used to form a composite variable.

A first component was identified as *Reported Process-Oriented Presentation.* Teachers with high scores on this component reported numerous strategies for meeting individual pupil needs, and numerous strategies for special education students; however, they also reported that they relied on external assistance for students with disabilities (special education efficacy). These teachers reported that their students frequently engaged in process-oriented activities such as problem solving, math vocabulary, explaining their thought processes, and oral presentations. These teachers also integrated math with other subject areas. Low scoring teachers for this component reported the opposite profile of presentation strategies.

A second reported presentation component was named *Reported Developmentally Appropriate v. Traditional Presentation.* Teachers with high scores on this component also integrated math with other subject areas. They reported frequent use of developmentally appropriate practices such as thematic units, giving students choice regarding projects and activities, and altering lessons based on student interests. They reported that they enjoyed teaching math. Teachers with low scores on this component reported more traditional approaches to presentation. For example, they infrequently reported use of thematic units, student choice, and reported they did not alter lessons based on student interests.

Observed Presentation. Variables related to teachers' observed *presentation* practices were analyzed using a principal components analysis. Inspection of eigenvalues and scree plots revealed two components, which accounted for 62% of the variance. Item loadings are reported in Table 7. For each component, simplified factor scores were used to form a composite variable.

A first component was called *Observed Active Teacher Presentation*. Teachers who scored high on this component were observed to use practices often cited in the effective teaching literature (Hunter, 1994): they planned relevant lessons by relating math to subject areas/life/world, modeled the activity prior to student work, model or mentioned general strategies, had a high degree of class involvement, and provided feedback about math as well as general feedback. These teachers tended to monitor all students simultaneously and solicited student point of view and explanatory answers. Low scoring teachers used these presentation practices less frequently.

The second component we termed *Observed Teacher Control.* Teachers with high scores on this component exhibited control of classroom processes. They solicited short, correct answers and seldom solicited explanatory responses. They modeled math strategies, and used students to assist the teacher presentation. These teachers frequently used verbal interventions to correct their students' behavior, did not use praise, and seldom provided students with choices about work. Teachers with low scores exhibited the opposite profile of behaviors.

Curriculum Data. We derived variables describing the emphasis of the mathematics curriculum from three sources: observations of five daily lessons, questionnaire reports characterizing five weeks of instruction, and interview responses that provided a year's overview. Since the source that was most objective (observations) was the least comprehensive, while the most comprehensive data derived from teacher-report, we elected to combine these three variables. The three curriculum variables were subjected to principal components analysis with varimax rotation. Inspection of eigenvalues and scree plots indicated one component in the data, which accounted for 64% of the variance. Item loadings are reported in Table 8. Simplified factor scores were used to form a composite variable.

This component was called *Observed & Reported Emphasis on Operations*. Teachers with high scores on this component reported and were observed to devote more time to operations than was specified in their teachers manual. These teachers were considered to be traditional. Teachers with low scores were viewed as more developmentally appropriate, as they devoted less than expected time to operations.

Results

Approach to Data Analysis and Rationale

This research sought to establish the nature of relationships among teachers' reported and observed developmentally appropriate and traditional practices (i.e., curriculum, materials, grouping, and presentation) and students' achievement in mathematics and language. Principal components analysis with varimax rotation was used to specify the relationships among these variables.

We used principal components analysis to answer the research question in the following manner. Each student's row of data included their posttest standard scores on the first and second grade sub-tests of the mathematics outcome measure. Each student was also assigned his or her teachers' composite variable scores for curriculum, materials, grouping, and presentation. These scores were then subjected to a principal components analysis. If variables that represented the developmentally appropriate/traditional continuum were associated with student achievement, then these would form a single component. If developmentally appropriate or traditional teaching practices were not associated with mathematics achievement, then the teaching practices would form a component that was distinct form the component where student achievement loaded.

Principal components analysis was selected for several reasons. First, principal components analysis was consistent with the design, which characterized teaching practices as continuous variables, with developmentally appropriate practices at one end of the continuum, and traditional practices at the other. Principal components methods allowed us to examine the direction and extent of relationship among continuous variables.

Second, principal components analysis was selected because it is exploratory. It extracts from the data the relationships among the variables. Since this research was not designed using pre-specified hypotheses about the relationship between developmentally appropriate practices and achievement, an exploratory method was appropriate.

Parsimony was a third reason for choosing principal components analysis. A single analysis allowed us to examine many teaching practices simultaneously, and to ascertain the relationship among these practices and student achievement.

Most importantly, principal components methods have recently been shown to be appropriate for studies like this one, where the number of subjects was small, relative to the number of variables. Specifically, recent work has identified novel strategies for modifying common factor methods for small samples (Pruzek & Lepak, 1992). Principal components analysis has been found to approximate well these idealized common factor methods for small samples, particularly when the number of variables exceeds 15-20. When the population structures are relatively clear, then small sample principal components analysis (with samples of 50 or under) can routinely recover these structures (Pruzek, 1988). Further strengthening our confidence in this method, Guadagnoli, & Velicer (1988) report that components with four or more loadings above .60, or three or more above .80, can be considered to be reliable regardless of sample size. Review of tables 4 through 9 will show that we consistently obtained high loadings.

The following data were entered into the principal components analysis: students' posttest first and second grade math sub-test achievement scores; and students' educational placement (special class, resource, consultant, transition, or general education only). The instruction that each student received was entered, using their teacher's score on these composite variables: *Observed Developmentally Appropriate v. Traditional Materials, Observed and Reported Developmentally Appropriate v. Traditional Grouping, Reported Developmentally Appropriate v. Traditional Presentation, Observed & Reported Emphasis on Operations, Observed Active Teacher Presentation, Observed Teacher Control, Observed and Reported Math Only Materials, and Reported Process-Oriented Presentation.*

Inspection of a scree plot and eigenvalues revealed two rotated components, accounting for 70% of the variance in the data. Table 9 summarizes the factor loadings for each variable. Variables that loaded above a criterion of .50 were considered to be associated with a component. The reader will note that the component structure is quite clear, with many high loadings and only one cross loading.

Each component is described below. The implications of the component structure for the research question are discussed.

Traditional v. Developmentally Appropriate Practices (Component One)

A first component was named Traditional v. Developmentally Appropriate Practices. Loading here were all of the variables that most clearly characterized a continuum of developmentally appropriate versus traditional teaching practices. Loading in a negative direction were: *Observed Developmentally Appropriate v. Traditional Materials, Observed and Reported Developmentally Appropriate v. Traditional Grouping,* and *Reported Developmentally Appropriate v. Traditional Presentation.* Also loading, but in a positive direction, were *Observed & Reported Emphasis on Operations*, *Observed Active Teacher Presentation, Observed Teacher Control,* and *Observed and Reported Math Only Materials.*

These variables are often associated with a direct instruction approach, and were thus associated with the traditional end of the developmentally appropriate/traditional continuum.

None of the student achievement variables loaded on this component. This indicated that for our data set there was no relationship between student achievement and use of developmentally appropriate or traditional teaching practices.

Student Achievement (Component Two)

Student achievement on the first and second grade mathematics subtests loaded on the second component. Also loading here was the variable that summarized special education placement, indicating that special education students in more restrictive placements earned lower achievement scores, while general education students earned the highest achievement scores.

Two teaching variables were associated with student achievement: *Observed and Reported Math Only Materials*, and *Reported Process-Oriented Presentation*. A teacher's reported emphasis on student processing and/or strategies was associated with student achievement. This finding is consistent with previous research documenting the efficacy of instruction focused on student processing and/or strategy use.

Interestingly, use of abstract, math-only manipulatives (e.g., place value mats) and worksheets during all phases of learning was negatively related to achievement. Students had lower achievement if their teachers spent more time using these materials.

Conclusions

The recommendation that teachers use developmentally appropriate practices is based primarily in theory. Little empirical support for use of these practices is provided in previous publications. This study was conducted as one step examining empirical support for the theoretically based recommendations made by advocates of developmentally appropriate practices.

In our analysis we uncovered a clear "developmentally appropriate practices versus traditional" component. The categories of composite variables defining this component--developmentally appropriate practices versus traditional teacher presentation, grouping, and use of materials--were not related to math achievement. One conclusion that may be tentatively drawn from this finding is that primary teachers may choose to organize their classrooms along developmental or traditional lines, and not affect their students' achievement in math.

Bredekamp's (1987, 1993) documents may not be sufficient as a guide for teachers responsible for math instruction, and debating developmentally appropriate practices and traditional teaching may distract attention from instructional variables more closely associated with student achievement. While we cannot conclude from our research that practices central to developmentally appropriate practices have a negative impact on math achievement, neither can we support the call for a move away from the traditional end of the developmentally appropriate practices/traditional continuum of teaching practices (Gestwicki, 1995; Gronlund, 1995; Passidomo, 1994). Also, focus on the criticism that developmentally appropriate practices do not adequately address the needs of special education students (Atwater, Carta, Schwartz, & McConnell, 1994; Carta, 1995; Carta, Atwater, Schwartz, & McConnell, 1993; Carta, Schwartz, Atwater, & McConnell, 1993; Lubeck, 1994; Mallory, 1994) may be unwarranted in light of the fact that developmentally appropriate practices were not associated with achievement for special education or general education students in our sample.

Our finding that the composite variable including abstract math manipulatives was negatively associated with achievement leads to further questions. Clements and McMillen (1996) mention that research has yet to demonstrate conclusively what types of manipulatives are crucial to mathematics learning, while Thompson (1994) articulates the concern that manipulatives must be accompanied by conceptually oriented instruction to be meaningful for students engaged in the process of learning math. Future research exploring in more detail the type of instruction accompanying the use of abstract math manipulatives could shed light on situations in which they may be of value.

The composite variable *Reported Process Oriented Instruction* was positively associated with achievement. This finding supports the call for increased emphasis on problem solving strategies and allowing students the opportunity to explain their thought processes in math classrooms (Fuson, 1992; Dougherty, & Scott, 1993; Peterson, 1988; Thornton, & Wilson, 1993). That this composite correlated with achievement is also consistent with Monroe and Punchyshyn's (1995) contention that the teaching of general math vocabulary may facilitate students' achievement in math, as well as Thornton and Wilson's (1993) call for teachers to engage students in presentations in front of the class during math instruction.

It is our hope that further research will be conducted exploring the relationship between the developmentally appropriate practices/traditional continuum of teaching practices and achievement. The present research offers an innovative methodology within which developmentally appropriate practices and traditional teaching practices can be conceptualized as continuous variables. These continuous variables serve as valid representations of the continuum of teaching practices described in the literature (e. g. Bredekamp, 1993, 1987; Gestwicki, 1995; Gronlund, 1995; Passidomo, 1994), as well as by the teachers in our study. The principal components analysis employed to uncover relationships among the teaching practices, and between the practices and achievement offers a reliable method of exploration.

Table 1

Achievement of Students with Disabilities and General Education Students

Variable	Students With Disabilities		General Education	
	Pre	Post	Pre	Post
One Word Expressive	101 (14)		108 (12)	
PPVT-R Receptive	87 (9)		106 (9)	
First Grade Math	17 (5)	23 (4)	21 (6)	26 (3)
Second Grade Math	03 (2)	09 (4)	07 (6)	17 (9)

IQ and Vocabulary scores are standard scores. Math scores are raw scores.

Standard deviations are in parentheses.

N = 24 (Students with Disabilities = 9; General Education Students = 15)

Table 2

Interview Variables and Scoring Methods

Variable	Scoring
Grouping	
Use of Multiage	math class and center time center time only never
Use of centers and stations	centers and stations stations only centers only none
Flexible grouping	flexible no flexibility
Ability grouping	heterogeneous homogeneous
Presentation	
Special education efficacy	comfortable meeting special ed needs rely on external support
Strategies for meeting individual needs	articulated 7-10 articulated 4-6 articulated 1-3
Special education strategies	list specific strategies strategies depend on need same as regular ed
Subject area integration	integrate in math class integrate-but not in math
Materials	
Purpose of worksheets	to review and supplement to introduce, review, and supplement

Table 3

Observed Variables and Scoring Methods

Variable	Scoring
Grouping	
Multiage math class	yes or no
Small group work assigned	assigned stations assigned partner/ group work no small group work
Flexible execution of small group work	mixed group and individual all grouped no grouping
Execution of whole class seatwork	mixed independent and teacher led all independent all teacher led no whole class seatwork
Materials (all materials were tallied and averaged)	
Real world math	e. g. clock, money
Math games	e. g. bingo, computer
Real world materials	e. g. donuts, dice, TV Guide
Student written	e. g. worksheets, slates
Teacher written	e. g. blackboard, chart
Abstract/math only manipulatives	e. g. unifix cubes, work mat
Presentation	
Math related to subject area/life/world	planned as part of lesson incidental references (3-5) incidental references (1-2) no external references
Activity modeled prior to student work	with class participation without class participation no need/pretest no model
Class Involvement	lots of back and forth some back and forth little back and forth
Monitors whole class work	all pupils simultaneously most pupils some pupils doesn't monitor

Table 3 continued

Observed Variables and Scoring Methods

Variable	Scoring
Teacher Presentation continued	
Choice related to classwork	where to work/which stations own pace material/assignment no choice
(all of the following were tallied and averaged)	
General strategies modeled/mentioned	e. g. Check all answers; take your time
Solicits student prediction/point of view	e. g. What do you think will happen?
Math feedback	e. g. Very good, two went away.
General feedback	e. g. Good, Excellent, Nice job
Solicits explanatory answer	e. g. How did we get that answer?
Solicits short correct answer	e. g. What's the sum? How many?
Math strategies modeled	e. g. Demonstrates use of number line
Students aid in presentation	e. g. 1 or 2 students at a time to the front
Praise/reward behavior	e. g. Good teamwork; Great listening!
Direct intervention to correct behavior	e. g. Sit properly; Stop humming!

Table 4

Rotated Factor Loadings for Observed and Reported Grouping Variables

Variables	Developmental vs. Traditional
Multi-age math class (O)	.94
Use of multi-age (I)	.85
Frequency of multi-age grouping (Q)	.82
Small group work assigned (O)	.88
Flexible execution of small group work (O)	.67
Use of centers and stations (I)	.92
Flexible grouping (I)	.80
Ability grouping (I)	.64
Execution of whole class seatwork (O)	-.83
Whole class instruction (Q)	-.80
Individual structured assignments (Q)	-.76
Frequency of centers (Q)	.37
Cooperative groups (Q)	.08
Individual direct instruction (Q)	-.01

note: variables from the questionnaire are indicated by Q; those drawn from the interview are indicated by I; those drawn from the observations are indicated by O

Table 5

Rotated Factor Loadings for Observed and Reported Materials Variables

Variables	Developmental vs. Traditional	Math Only Materials
Real world math (e. g. clock, money)	.96	-.11
Math games (e. g. bingo, computer)	.94	.20
Real world materials (e. g. dice, dominos)	.61	.08
Student written (e. g. slates, worksheets)	.63	.41
Teacher written (e. g. chalkboard, chart paper)	-.76	.29
Abstract math/only manipulatives (e. g. unifix cubes)	.12	.88
Reported purpose of worksheets	.11	-.94

Table 6

Rotated Factor Loadings for Reported Presentation Variables

Variables	Process	Developmental vs. Traditional
Special education efficacy (I)	-.68	.08
Strategies for meeting individual needs (I)	.80	-.14
Special education strategies (I)	.97	.10
Problem solving strategies (Q)	.97	.12
Students spent time on math vocabulary (Q)	.90	-.10
Students explained their thought process (Q)	.81	.18
Subject area integration (I)	.67	-.36
Students did oral presentation (Q)	.60	.60
Students engaged in thematic units (Q)	.29	.90
Students spent time on project of own choosing (Q)	-.26	.81
Students were given choice of activity (Q)	-.19	.91
Math lesson altered for student interest (Q)	.27	.81

note: variables from the questionnaire are indicated by Q; those drawn from the interview are indicated by I

Table 7

Rotated Factor Loadings for Observed Presentation Variables

Variables	Active Teacher	Teacher Control
Math related to subject area/life/world	.63	-.39
Activity modeled prior to student work	.85	-.09
General strategies modeled/mentioned	.62	.05
Class involvement	.72	.32
Math feedback	.83	-.04
General feedback	.74	.12
Monitors whole class work	.52	-.14
Solicits student prediction/point of view	.77	.05
Solicits explanatory answer	.56	-.64
Solicits short correct answer	.08	.90
Math strategies modeled	.31	.81
Students aid in presentation	.07	.80
Direct intervention to correct behavior	-.29	.64
Praise/reward behavior	.31	-.76
Choice related to class work	-.45	-.69

Table 8

Rotated Factor Loadings for Observed and Reported Computation Variables

Variables	Traditional vs. Developmental
Percentage of time allocated to operations (Observation)	.92
Percentage of time allocated to operations (Interview)	.76
Percentage of time allocated to operations (Questionnaire)	.72

Table 9

Rotated Factor Loadings for Composite and Achievement Variables

Variables	Traditional vs. Developmental	Student Achievement
Observed Developmental vs. Traditional Materials	-.94	-.17
Observed/Reported Developmental vs. Traditional Grouping	-.89	-.26
Reported Developmental vs. Traditional Presentation	-.71	.39
Observed/Reported Emphasis on Operations	.95	.00
Observed Active Teacher Presentation	.64	.33
Observed Teacher Control	.62	-.33
Observed/Reported Math Only Materials	.58	-.64
Reported Process Oriented Presentation	-.11	.64
First grade math post test	-.19	.84
Second grade math post test	-.05	.80
Level of special ed placement	.35	.78

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