The Effects of Grouping Practices and Curricular Adjustments on Achievement

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*The purpose of this study was to examine the effects of curricular (textbook, revised, and differentiated) and grouping (whole, between, and within-class) practices on intermediate students' achievement in mathematics. A pretest-posttest, quasi-experimental design using a stratified random sample of 31 teachers and their students (*N *= 645) was used in this study. Achievement data were collected using a curriculum-based assessment. Repeated measures analysis of variance was employed to investigate the effects of grouping arrangements and curricular design on the treatment and comparison group posttest scores. Results indicated significant differences, F (5, 246) = 22.618, p <. 001, between comparison and revision treatment groups on the posttest after adjusting for grade level (4 or 5). Further results indicated significant differences, F (11, 673) = 41.548, p <. 001, among all treatment groups after adjusting for grade level.*

Introduction

> The problem of curriculum is to economize scarce learning potential by making the most judicious and appropriate selection of study content. Human intelligence is too rare and precious a thing to squander on a haphazard program of instruction. (Phenix, 1958, p. 59)

Researchers in the field of gifted education have long advocated for enhanced and differentiated curriculum for high-ability students (Kaplan, 1986; Passow, 1962; Renzulli, 1994; Rogers, 1993; Tomlinson, 1999; VanTassel-Baska, 1986; Ward, 1980). Among their recommendations, they propose the frequent and appropriate use of flexible within- and between-class groupings. The purpose of this study was to examine the effects of ability grouping (whole, between, and within-class) and curricular practices (textbook, revised, and differentiated) on intermediate students' achievement in mathematics.

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Researchers suggest that moderate gains occur in students' academic achievement when educators adopt practices used in gifted education such as ability grouping (Kulik & Kulik, 1990; Slavin, 1987); curriculum revision (Wiggins & McTighe, 1998); strategies to enhance higher level thinking skills, concept-based instruction, and problem-based learning (Delisle, 1997); and constructivist pedagogy (Bechtol & Sorenson, 1993; Brooks & Brooks, 1995; Bloom, 1976; Feldhusen, 1989; VanTassel-Baska, 1986; Walberg, 1985). Previous research on practices that enhance student achievement suggest that practices such as between-class grouping (Kulik & Kulik, 1982; Rogers, 1991) and flexible, within-class grouping (Slavin, 1988) can create substantial achievement gains for able learners and nontrivial gains for average and struggling learners when instruction is tailored to students' readiness levels. Other research (Archambault et al., 1993; Dettmer & Landrum, 1998; Renzulli, 1994; Tomlinson et al., 1995) suggests that revised and differentiated curricula may enhance the academic achievement of students. Little research within the field, however, has compared the effects of curriculum revision, or differentiation practices, combined with various grouping arrangements on student achievement. Because it is unlikely that one strategy (i.e., ability grouping practices), operating in isolation, is as effective as multiple interventions (i.e., ability grouping combined with appropriate curriculum), this study investigated the combined effects of grouping practices and curricular adjustments on elementary students' mathematics achievement.

Background of the Study

Related literature provides background information that focuses on three grouping practices (whole-class, between-class, and within-class flexible groups) and two curricular adjustments (revision and differentiation) that have demonstrated moderate to impressive achievement gains for diverse learners.

Common Grouping Practices

Ability grouping has been defined as a practice that places students into classrooms or small groups based on an initial assessment of their levels of readiness or ability (Kulik, 1992). Kulik found that grouping practices have different effects on student achievement based on the type of grouping practice and the subsequent curriculum developed for those groups. He suggested that there are three different kinds of grouping practices: programs in which all groups follow the same curriculum (whole-class instruction), programs in which each group follows curriculum based on its specific needs (between-class), and programs that make curricular adjustments for groups of students within their regular classroom (within-class, flexible).

Whole-class instruction is characterized by the utilization of a traditional, textbook-dominated curriculum (Bagley, 1931; Goodlad, 1984; Reis et. al., 1993), movement through the curriculum at the same pace using the same methods and materials (Cuban, 1984; Goodlad), and instruction for the entire class at the same time (Good & Brophy, 1994).

The most popular between-class grouping plan is the Joplin Plan (Floyd, 1954). The earliest version of this plan included the cross-grade grouping of elementary students in reading. During the time reserved for reading, students in grades 4, 5, and 6 would proceed to different classrooms to receive instruction and use materials geared to their readiness levels. Today, between-class grouping is used most often to address content differentiation or acceleration for high-ability students in reading and mathematics.

Another important type of grouping arrangement is within-class or flexible grouping (Benbow, 1998; Davis & Rimm, 1994; Feldhusen & Moon, 1992; Kulik, 1992; Kulik & Kulik, 1990; Renzulli, 1994; Slavin, 1987; Tomlinson, 1995, 1999; Westberg, Archambault, Dobyns, & Salvin, 1993). This practice groups students within the same class into smaller groups for specific activities and purposes (Kulik & Kulik, 1992). Typically, the teacher presents a lesson to the whole class and then places students into small groups based on demonstrated performance, interests, levels of prior knowledge, etc. (Renzulli).

Research on Grouping Practices

In an early summary of ability grouping practices, Passow (1962) suggested that the results of numerous studies on ability grouping depended less on the "fact of grouping itself than upon the philosophy behind the grouping, the accuracy with which grouping is made for the purposes intended, the differentiations in content, method, and speed, and the technique of the teacher" (p. 284).

Later meta-analytic studies suggest that average effect sizes for student achievement in classes that utilize between-class grouping with curricular adjustment is .33, a small but nontrivial effect size (Kulik & Kulik, 1982). Kulik and Kulik investigated 16 controlled studies of between-class grouping in one or two subjects. Twelve of those studies found higher achievement levels in the between-class versus whole-class grouping arrangements. In these studies, effect sizes for different ability levels were reported separately. A median effect size of .12 was reported for the high-achieving group, -.01 for the middle group, and .29 for the low- achieving group (Kulik & Kulik). Slavin (1987) found a median effect size of .45 for between-class grouping, while Rogers (1991) noted average effect sizes of .34. Additionally, Mills, Ablard, and Gustin (1994) found large effect sizes (*ES* = 2.4 *SD*) for fifth graders enrolled in a between-class, flexibly-paced mathematics course with appropriate curricular adjustment.

Finally, Slavin (1988) found significant, moderate effect sizes (*ES* = .41) and Kulik (1992) small average effect sizes (*ES* = .25) for within-class (flexible) grouping. Nine of Kulik's 11 studies reported higher overall achievement levels with flexible grouping arrangements (average *ES* = .25) over whole-class instruction. Lou et al. (1996) found average effect sizes of +.17 in a meta-analysis of within-class grouping versus no grouping. In comparisons of heterogeneous versus homogeneous within-class grouping, they found average effect sizes of +.12 for homogeneous grouping. Slavin (1987) argued that research on within-class grouping in mathematics "consistently supports this practice in upper elementary grades" (p. 320). He also contends that "there is no evidence to suggest that achievement gains due to within-class ability grouping in mathematics are achieved at the expense of low achievers" (p. 320). Results from meta-analytic studies of ability grouping are summarized in Table 1. The subject matter for which the grouping was used did not appear to impact the resulting effect sizes.

Table 1
Effect Sizes for Various Grouping Arrangements

Type of grouping	Curricular adjustment	Subject(s)	Effect size	Author	Citation
Ability	No	Math	.14	Kulik	1992
Ability	No	Not specified	.12	Lou et al.	1996
FSG*	No	Math	.41	Slavin	1987
FSG	No	Not specified	.25	Kulik	1992
FSG	No	Not specified	.17	Lou et al.	1996
Joplin	Yes	Math & reading	.33	Kulik & Kulik	1982
Joplin	Yes	Not specified	.45	Slavin	1987
Joplin	Yes	Not specified	.34	Rogers	1993
Joplin	Yes	Math	2.4	Mills et al.	1994

*FSG represents flexible small groups.

Grouping practices alone will have only small to moderate effects on achievement if they are not complemented with appropriately revised and differentiated curricula (Kulik & Kulik, 1992; Rogers, 1993; Slavin, 1987).

Curriculum Revision and Differentiation

Current research suggests that textbook-based curriculum units, even those specifically targeting gifted students, suffer from a lack of variety and in-depth presentation of the major principles and concepts within a discipline (Erickson, 1998; Flanders, 1987; Renzulli, 1994). Curriculum revision involves the critical analysis and remodeling of existing curriculum in order to improve the quality or the rigor of the content, the assessment, the teaching and learning activities, the resources, the assignments, or the overall alignment among these components (Cuoco, Goldenberg, & Mark, 1995; Maker, 1982; Paul, Binker, Jensen, & Kreklau, 1990; Renzulli). Curriculum differentiation involves the assessment of students' prior knowledge and the subsequent use of tiered instruction or alternative curriculum and instruction based on the prior knowledge, interests, and learning styles of the varied students in a classroom (Renzulli; Tomlinson, 1995, 1999).

Mathematics and the Future

Mathematics instruction was the focus of this study due to two factors: national concerns over student achievement in mathematics and technology, and the existence of an identified, national set of standards for mathematics instruction. The Trends in International Mathematics and Science Study (TIMSS) report (National Center for Education Statistics, 1997) warned that the top 1% of mathematics students in the United States are not achieving at the same levels as students in Europe and Asia. Further, the National Council of Teachers of Mathematics (NCTM; 2000) has proposed standards that reflect the needs of a technologically advanced society. Grouws and Cebulla (1999) proposed specific keys to increased achievement in mathematics: Instruction should focus on a meaningful development of important mathematical ideas, students should learn new concepts and skills in the process of solving real world problems, students should have the opportunity to discover and invent new knowledge and practice what they have learned, teachers should have an openness to student solution methods and student interaction, and finally, there should be a focus on small group learning as the predominant grouping arrangement within the classroom.

The Present Study

These challenges make it imperative that researchers investigate the effectiveness of innovative practices (i.e., grouping and curricular) that may succeed in increasing the depth and breadth of student learning to enhance and further their levels of achievement. Previous research on practices that enhance student achievement suggest that adapting pedagogy from gifted education, such as between-class (Kulik & Kulik, 1982; Rogers, 1991) and flexible, within-class grouping (Slavin, 1988), may create substantial achievement gains for able learners and nontrivial gains for average and struggling learners when instruction is tailored to students' readiness levels. Several research studies (Cawelti, 1999; Kulik & Kulik, 1984, 1990; Slavin, 1988; Walberg, 1985) have described curricular practices that also have significant effects on student learning and achievement. Little research, however, has compared the effects of the various grouping practices with curriculum revision and differentiation practices on student achievement. The purpose of this study was to investigate the effects of different grouping practices (whole class, within-class, and between-class) and curricular adjustments (revised or differentiated, combined with flexible grouping) on intermediate students' mathematics achievement. The results of this study may be critically important to researchers and educators in gifted education as the current emphasis on preparing students for standardized testing, the conventional wisdom that ability grouping is harmful, and the No Child Left Behind legislation (U.S. Department of Education, n.d.) negatively impact the educational lives of gifted and talented students.

The literature reviewed in this study led to two testable hypotheses about the relationship between curricular type and grouping arrangement: (1) students in classrooms where curriculum is revised will demonstrate positive and significant gains in mathematics achievement over comparable students in classrooms using their regular textbook curriculum with whole-class instruction; and (2) students in classrooms where curriculum is differentiated and ability grouping is employed will demonstrate positive and significant gains in mathematics achievement over comparable students in classrooms using their regular textbook curriculum with whole-class instruction.

Method

Participants

The participants consisted of 31 grade 4 or 5 teachers and their students from four New England school districts who had sought professional development assistance from researchers at the National Research Center on the Gifted and Talented at the University of Connecticut. Parental permission was sought for student participation in the research study.

Instrumentation

Because a norm-referenced assessment was inappropriate for a short, focused curriculum unit, a curriculum-based assessment (i.e., an assessment based on local standards and adopted textbooks and curriculum materials) was developed immediately prior to initiating the study to assess students' mathematics achievement. Item stems were created based on objectives of the NCTM (2000) and the textbooks used in grades 3–8 by the participating schools. Readability of item stems and responses and appropriateness of grade-level objectives for the assessment were verified by a random sample of mathematics teachers from grades 4 and 5. Content validity was assessed through a panel of content experts made up of gifted education and mathematics specialists, representative classroom teachers, and a random sample of grade 4 and 5 students. Construct validity was established through an exploratory factor analysis that produced six meaningful factors: reading data from graphs and charts, analyzing data from graphs and charts, calculating descriptive statistics, interpreting probability statements, problem solving using graphs and charts, and problem solving using statistics and probability. Alpha reliability was assessed by administering the original 30-item instrument to a pilot sample of 240 students in grades 4 and 5 in two New England schools (Gable & Wolf, 1993). An alpha reliability estimate of .67 was calculated for the total instrument. Based on individual item difficulties and corrected item-total correlation values, 8 items were deleted and 13 new items added for a total of 35 items. Results from a second pilot study estimated the alpha reliability of the revised instrument to be .78.

Treatment Conditions

Hypotheses were investigated using multivariate methods. Student was the unit of analysis in this study as different students within intact classrooms were exposed to different instruction and grouping arrangements (Burstein, 1980). Teachers and their students were randomly assigned to the comparison or 1 of 4 treatment groups (further subdivided into low, middle, and high subgroups of prior knowledge levels). Students were administered identical pre- and posttest forms of the curriculum-based assessment in mathematics created for the treatment unit on data representation and analysis. The posttest was administered approximately 8–12 weeks after the pretest. Students scoring in the top 33% on the pretest were assigned to the "high" treatment subgroup (based on levels of prior knowledge); those students scoring in the middle 34% were assigned to the "middle" treatment subgroup, and those students scoring in the lowest 33% were assigned to the "low" treatment subgroup. Table 2 summarizes the different treatment groups, their abbreviations, and the number of students assigned to each. Students in the revised and differentiated subgroups were all exposed to the treatment unit, however, only those in the within and between-class groups had curriculum adjusted for their levels of prior knowledge.

After administration of the preassessment, teachers in the treatment groups were provided with a unit binder created by the researcher that contained the eight lessons scripted out to ensure standardization of instruction and treatment fidelity. Teachers in the study completed the equivalent of eight lessons pertaining to data representation and analysis for a total of 3 weeks and a total contact time of 16 hours.

Further, each lesson contained a synopsis of the major principles, concepts, and objectives for the lesson along with definitions of key terms, (e.g., mean, median, mode, standard deviation), and illustrations of statistical and graphical calculations within the lesson. Additionally, teachers in the within-class grouping treatments received a color-coded set of all three lesson plans used by the between-class grouping treatments (i.e., three sets of differentiated lesson plans, scripted and color coded for students with low, middle, and high levels of prior knowledge; see Appendix).

Comparison Group. Comparison teachers were instructed to teach the equivalent of eight lessons (16 hours of contact time) from their regular textbook on data representation and analysis. They were also instructed not to supplement their regular textbook with any additional materials or resources or discuss instructional units with other teachers in their buildings.

Revision Group. The researcher developed all lessons for the revised unit that derived from principles of curriculum remodeling: to analyze and remove unchallenging and repetitive content; to enhance existing curricular units through the use of advance organizers, higher level abstract questioning strategies, and critical thinking skills (Burns & Reis, 1991; Halpern, 1996; Paul et al., 1990); to con-

Table 2
Treatment Groups: Grouping and Curricula

Treatment	Grouping	Curriculum	Levels of prior knowledge	Abbreviation	Group number
Comparison	Whole	Regular textbook	Low	Comp-low	1
Comparison	Whole	Regular textbook	Middle	Comp-mid	2
Comparison	Whole	Regular textbook	High	Comp-high	3
Revised	Whole	Treatment unit	Low	Rev-low	4
Revised	Whole	Treatment unit	Middle	Rev-mid	5
Revised	Whole	Treatment unit	High	Rev-high	6
FSG*	Within	Treatment unit**	Low	FSG-low	7
FSG	Within	Treatment unit**	Middle	FSG-mid	8
FSG	Within	Treatment unit**	High	FSG-high	9
Joplin	Between	Treatment unit**	Low	Joplin-low	10
Joplin	Between	Treatment unit**	Middle	Joplin-mid	11
Joplin	Between	Treatment unit**	High	Joplin-high	12

* FSG represents flexible small groups.
**Differentiated for prior knowledge.

nect the unit of study to the disciplines (Bruner, 1975; Gardner, 1999; Phenix, 1964; Renzulli, 1988); and to design units of study based on interdisciplinary concepts (Erickson, 1998; Jacobs, 1989; Kaplan, 1986).

Differentiation Group. The lessons created for the differentiation unit derived from principles of curriculum differentiation: to use preassessment in determining students' strengths and interests, to use flexible grouping practices based on those preassessed areas, and to increase the breadth (interest, choices, and learning style variation) and depth (lessons for different ability levels) of the curriculum for diverse learners.

Within the body of the scripted unit, teachers were provided with additional strategies for teaching students with different levels of prior knowledge. Teachers in the within-class and between-class-low groups were provided strategies for teaching struggling learners. These included: fewer problems or assignments, more manipulative materials, or different approaches to teaching the material (e.g., more visual or tactile demonstrations, larger print, or different learning environments). The researcher reminded teachers that students with low levels of prior knowledge needed more scaffolding of instructions and tasks.

The within- and between-class-high teachers were reminded and provided with strategies for teaching students with high levels of prior knowledge who needed to be challenged with enriched or accelerated learning activities. Within- and between-class-high teachers were further notified that lessons in the mathematics unit were appropriate for middle school students, so an assumption was made that they would provide more challenging and complex instruction for their students.

Finally, teachers in the ability grouping treatments were provided strategies for managing different grouping arrangements within and between classrooms and supplementary materials that could be used in an interest or learning center. These strategies included the use of "anchor activities," activities students could engage in independently while the teacher was working with other students; learning centers, for which materials and additional resources were provided; and management strategies and suggested classroom rules for students working in small groups and moving between classrooms for instruction.

Lessons. The content for the eight treatment lessons included the location and definition of the field of statistics within the structure of the disciplines, the interpretation and analysis of different types of graphs, stem-and-leaf plots, measures of central tendency (i.e., mean, median, mode, and range), sampling techniques, probability, and a culminating project. For the first lesson, Introduction to the Fields of Statistics and Probability, revised and remodeled for all students in the revision groups and students in the within- and between-class-middle groups; teachers were asked to display a picture and article that had appeared in the local newspaper regarding a "juiced baseball." In the article, the author displayed a chart that demonstrated that more home runs were hit in the last 10 years than at any time during the 20th century. Students would be shown pictures of the inside of a baseball and probed for their hypotheses regarding this phenomenon. They would suggest that the baseball was lighter, the inner material was different, etc. Then students would be reintroduced to the article, which suggested that their original hypotheses were incorrect. The idea was to introduce students to the field of statistics and the controversial issues addressed by practicing professionals by suggesting that those who interpret statistics often do so with their own agenda (Renzulli, 1988; Tomlinson et al., 2002). The follow-up to this activity was the introduction of a Knowledge Tree that placed the fields of statistics and probability within the realm of mathematics and the sciences (Phenix, 1964; Renzulli, Leppien, & Hays, 2000). The introduction of the Knowledge Tree allowed students to visualize the relationships within and between the disciplines.

Objectives for a second lesson, differentiated for students in all within and between subgroups, asked students to debate a phenomenon, hypothesize the results, and collect data to confirm or deny their hypothesis. In Lesson 3: Analyzing Information From Graphs and Charts, as an introductory "hook," students were engaged in a discussion of the most popular Disney film of all time. Discussion questions were scripted and differentiated for students with different levels of prior knowledge. The teacher would introduce the unit by emphatically suggesting that her favorite Disney film was the best of all time. She would then lead them in a spirited debate and provide scaffolding that would allow them to discuss possible methods of data collection. Prior to collecting the data, students would be asked to write a journal entry to predict what film would be most popular and why. Students would then use the data they collected to graph and display their results. Types of data collected, graphs, and discussion of results were differentiated. Finally, students were asked to respond to a differentiated journal prompt that would explain any discrepancy between their hypothesis and results.

The final project reflected students' creation of an original survey research instrument, differentiated for different levels of prior knowledge, that would be shared with an authentic audience (Renzulli, 1977). The culminating project samples were based on techniques of research-based instruction (Schack & Starko, 1998) and problem-based learning (Delisle, 1997).

The lesson outline for the 3-week unit is summarized in Table 3.

Treatment Fidelity

To assess treatment fidelity, treatment teachers used a unit plan that was scripted to ensure standardization of treatment. Additionally, treatment teachers maintained a checklist of completed curriculum components and collected examples of student work. Data from teachers who did not complete a minimum of six lessons were not included in the analyses. Data related to the lesson component matrices were analyzed using analysis of variance (ANOVA) and multiple regression analyses to assess the effect of incomplete lesson components on students' posttest scores. There were no significant differences in students' posttest scores among teachers based on the number of treatment components they completed.

Data Analysis

Hypotheses were investigated using multivariate methods. Student was the unit of analysis in this study as different students within intact classrooms were exposed to different instruction and grouping arrangements (Burstein, 1980).

Initial Differences Among Groups. The researcher conducted an initial assessment of treatment group equivalence using the preassessment scores. Analysis of variance (ANOVA) with post hoc Scheffé comparisons was conducted. The omnibus test found significant preassessment score differences among students assigned to the low, middle, and high prior-knowledge groups, however, these differences

Table 3
Modified/Differentiated Mathematics Unit Outline

Week One	Introduction to the field of statistics	Interpreting, estimating, and predicting with graphs	Interpreting, estimating, and predicting with graphs	Analyzing information from graphs and charts	Analyzing information from graphs and charts
Week Two	Stem-and-leaf plots	Stem-and-leaf plots	Mean, median, and mode	Mean, median, and mode	Mean, median, and mode
Week Three	Sampling procedures	Probability	Probability	Probability	Final project due

were an assumed part of the study. The Scheffé post hoc permitted separate analyses across treatment groups that were formed on the basis of prior knowledge and suggested there were no significant differences among students in comparable treatment groups (e.g., comparison-high vs. between-class-high) on the pretest. Therefore, a decision was made to use repeated measures analysis of variance rather than analysis of covariance to analyze the data.

Repeated measures analysis of variance (ANOVA) was used to analyze pre- and posttest data from the curriculum-based assessment (Tabachnick & Fidell, 1996). The predictor variables were grouping arrangement (whole-class, within-class, between-class) and curricular adjustment (regular textbook, revised, or differentiated). Grade was entered into the analysis as a covariate due to pretest differences between students in grades 4 and 5 (i.e., students in grade 5 scored significantly higher than students in grade 4 on the pretest). A Bonferroni adjustment was used to adjust for multiple comparisons. A more stringent alpha level of .01 was used to adjust for potential nonindependence of observations.

Results

The research findings are discussed in two sections: the findings related to the effects of revised curricular practices with whole-class instruction, and the findings related to the effects of differentiated curricular and grouping practices on students' mathematics achievement.

The Effects of Revised Curriculum With Whole-Class Grouping

A repeated measures (pretest to posttest) analysis of variance (RM-ANOVA) was conducted to evaluate the effects of the revised curriculum with whole-class grouping on the dependent variable, students' posttest mathematics scores for the unit, Data Representation and Analysis. Results indicated that there were significant differences between students enrolled in different grade levels (4 or 5) and between treatment groups (comparison or revised) on the posttest. Effect sizes ranged from small to medium (Cohen, 1988).
Treatment Groups. There were significant differences between treatment groups (comparison or revised) on the dependent variable, student posttest score on the curriculum-based assessment in mathematics, F (5, 246) = 22.62, $p < .001$. Results from the repeated measures analysis of variance for the comparison and revised groups are summarized in Table 4.

Effect sizes ranged from -.10 *SD* for the revision-low group, .10 *SD* for the revision-middle group, to .49 *SD* for the revision-high group; when compared to their corresponding comparison subgroup (low, middle, or high), all were within the range of small to medium effects (Cohen, 1988). Effect sizes calculated from *unadjusted* means indicated greater gains for the three revision subgroups: .18, .25, and .81 for the low, middle, and high groups, respectively (see Table 6). Research has consistently supported the use of enhanced or revised curriculum to advance student achievement (Cawelti, 1999; Erickson, 1998; Flanders, 1987; Gardner, 1999; Levin, 1987; Maker, 1982; Paul et al., 1990; Renzulli, 1988, 1994; Wiggins & McTighe, 1998). These results support that literature.

Differences Over Time. There were significant omnibus differences among groups over time and significant interactions between time and treatment groups, F (5, 246) = 4.81, $p < .001$ (see Table 4). Students enrolled in the revision-high group experienced the greatest gains among treatment subgroups.

Table 4
Analysis of Variance Results for Treatment and Time Variables for Comparison and Revision Groups

Source	*df*	*SS*	*MS*	*F*	η^2
		Between subjects			
Grade	1	1198.58	1198.58	47.16**	.161
Treat	5	2874.37	574.87	22.62**	.315
Error 1	246	6252.43	25.416		
		Within Subjects			
Time	1	39.05	39.05	5.33*	.021
Time X Grade	1	7.26	7.26	.992	.004
Time X Treat	5	176.03	35.21	4.81**	.089
Error 2	546	4951.13	14.71		

*p <. 05. **p <. 001.
Note. η^2= effect size.

The Effects of Curricular Differentiation With Between- and Within-Class Grouping

Repeated measures analysis of variance (ANOVA) was conducted to evaluate the effects of grade (4 or 5) and treatment group membership (comparison, revision, differentiated) on students' posttest mathematics scores. Results are summarized in Table 5. There were significant differences among treatment groups, F (11, 673) = 41.548, p <. 001, on the posttest. The revision-high ($p < .01$), within-class-high ($p < .001$), and between-class-high ($p < .001$) treatment groups had significantly higher posttest means than their corresponding comparison-high groups.

Effect sizes ranged from .28 *SD* for the within-class-low and -.13 *SD* for the between-class-low groups, .42 *SD* for the within-class-middle and .10 *SD* for the between-class-middle groups, and .83 *SD* for the within-class-high and .30 *SD* for the between-class-high groups; all were within the range of small to medium effects (Cohen, 1988). Data from students in the high subgroups are highlighted within the table of results (see Table 6).

Table 5
Analysis of Variance Results for Treatment and Time Variables All Treatment Groups

Source	*df*	*SS*	*MS*	*F*	η^2
Between Subjects					
Grade	1	1010.45	1010.45	45.21**	.063
Treat	11	10215.52	928.68	41.548**	.404
Error 1	673	15042.91	22.35		
Within Subjects					
Time	1	47.09	47.09	5.84*	.009
Time X Grade	1	.246	.246	.031	.000
Time X Treat	11	583.96	53.09	6.59**	.097
Error 2	673	5424.86	8.06		

*p <. 05. **p <. 001.
Note. η^2= effect size.

Table 6
Descriptive Statistics and Effect Sizes by Treatment Groups

Treatment group	Subgroup ID	*M* (*unadj*)	*SD*	*ES* (*SD*) (*unadj M*)	*M* (*adj*)	*ES* (*SD*) (*adj M*)*	Variance explained (η^2)
Comp-low	1	14.65	4.50		12.79		
Comp-mid	2	16.14	5.22		14.83		
Comp-high	**3**	**17.43**	**5.41**		**17.04**		
Rev-low	4	15.44	4.91	.18	12.33	-.10	.03
Rev-mid	5	17.36	4.55	.25	15.32	.10	.03
Rev-high	**6**	**21.21**	**3.87**	**.81**	**19.32**	**.49**	**.17**
FSG-low	7	15.83	4.22	.26	14.07	.29	.10
FSG-mid	8	17.69	4.23	.32	16.83	.42	.14
FSG-high	**9**	**21.32**	**4.34**	**.73**	**21.09**	**.83**	**.28**
Joplin-low	10	14.00	4.61	-.11	12.20	-.13	.04
Joplin-mid	11	17.44	4.40	.28	15.31	.10	.03
Joplin-high	**12**	**19.78**	**5.23**	**.48**	**18.62**	**.30**	**.1**

Note. *Means adjusted for initial differences between students in grades 4 and 5. Highlighted results are data from high subgroups.

Discussion

The Effects of Revised Curriculum With Whole-Class Grouping

Results of this study indicated that students in the revision groups (treatment subgroups 4–6) demonstrated significantly higher posttest scores than comparable students in the comparison groups (treatment subgroups 1–3) without adjustment for grade level differences. Students who scored highest on the pretest (placed into the high subgroups) made the most significant gains among the low, middle, and high groups (*ES* = .49 *SD*). Research has indicated that textbooks lack sufficient depth and complexity to engage students in authentic learning processes (Flanders, 1987; Reis et al., 1993). Further, textbooks focus on behavioral and skill objectives rather than overall learning goals (i.e., goals that reflect the "big ideas" or main principles and concepts of a discipline: "what are the big ideas students should know and understand when they've finished this unit?"), activities, and authentic resources and products (Schunk, 1996). For example, each lesson plan introduced a list of major concepts and principles to be addressed, as well as essential questions to be answered by students upon completion of the experimental unit. Additionally, the culminating unit project was introduced early in the teaching of the unit and provided a curricular lens through which students could focus their attention and learning. Lou et al. suggested that effective and authentic whole group instruction can demonstrate significant gains without the additional need for ability grouping. These results support the research of Lou et al. (1996) and suggest that students who receive an enhanced and revised curriculum can demonstrate gains in student achievement over students who receive instruction from a comparable textbook unit *without additional grouping practices*.

The Effects of Curricular Differentiation With Between- and Within-Class Grouping

Students who were exposed to differentiated curriculum, combined with within- and between-class ability grouping, experienced significantly higher mathematics achievement than students exposed to their regular textbook unit on data representation and analysis from pretest to posttest. Students in the middle and high subgroups of all treatment groups (revised, within-class, and between-class groups) demonstrated significantly higher mathematics achievement than students in the comparison groups who completed their regular textbook unit after 3 weeks of instruction. Students in the highest three subgroups, revised-high, within-class-high, and between-class-high (those considered to be high-ability students), also experienced significant gains over the 3-week mathematics unit. It is difficult to assess the gains made by the low groups as the comparison-low groups had higher pretest scores than their peers in the treatment groups, however, the negative effect sizes would be consistent with the literature on grouping and less-ready students. In this study, results for students in the low treatment groups were trivial and negative. In light of the No Child Left Behind legislation (U.S. Department of Education, n.d.), this may prove troublesome for educational decision makers. However, when results are not adjusted for initial differences between students in different grade levels, students in the revision- and within-class-low treatment groups experienced small, but substantial gains (*ES* = .18 and .35 respectively). Additionally, in anecdotal interviews with between-class treatment teachers, and in examining their treatment component checklists, it was revealed that students in the between-class-low subgroups frequently lost instructional time and were not exposed to all components of the treatment unit due to movement between classrooms. Between-class grouping can be an effective method of flexible, between-class ability grouping, but these logistical concerns must be addressed.

Research on ability grouping has consistently demonstrated significant results for high-achieving students enrolled in between- or within-class flexible grouping arrangements (Kulik & Kulik, 1992; Rogers, 1993; Slavin, 1987). Results have been more controversial with respect to normal-achieving and low-achieving students. The results of this study support the research on high-achieving students, indicating that grouping by ability for specific instruction may result in significant achievement gains. These results also suggest that other students (those with middle or average levels of prior knowledge) can sustain significant gains, as well. Therefore, these results indicate that a revised or differentiated mathematics unit can create significant student achievement gains over the students' regular textbook unit especially if supplemented by flexible within-class ability grouping.

Limitations

This section discusses the factors that may have affected the internal and external validity of the findings. Potential threats to internal validity were testing, instrumentation, statistical regression, experimental treatment diffusion, and compensatory equalization of treatments by teachers in the comparison groups. Potential threats to external validity were population validity, treatment fidelity, statistical conclusion validity, the novelty effect, and pretest sensitization. These potential threats may have distorted the results of the study and limited the generalizability of the study.

Threats to Validity

Internal Validity. With respect to internal validity, four threats were considered: testing, instrumentation, experimental treatment diffusion, and compensatory rivalry by the comparison groups (Cook & Campbell, 1979). First, because identical forms of the curriculum-based assessment were used for the pretest and the posttest, there was a concern that students learned from taking the pretest. This did not seem to be the case as the pretest proved very difficult for students, and there was a fairly lengthy time span between pretest and posttest. The curriculum-based assessment created for this unit was based on mathematics objectives designed for students in grades 4–8 to avoid reaching a ceiling effect on the pretest for high-ability students. Because of the high level of objectives used and the need for a psychometrically sound instrument, the curriculum-based assessment was too difficult for most students, thereby reducing potential alpha reliability levels, as well as achievement gains over time. The researcher reminded teachers within the same schools not to discuss implementation of the mathematics unit with their colleagues, but there is evidence that this may have occurred in several instances. Several teachers within each treatment condition collaborated and shared materials from the differentiated units. Additionally, teachers in the comparison groups often supplemented their textbook unit with additional resources, which may have contaminated their results. A fourth major limitation of the study related to the compensatory strategies employed by the comparison teachers as they implemented their regular textbook unit. Two comparison teachers expressed frustration with the lack of materials in their textbooks regarding data representation, so they freely substituted and added supplementary manipulatives and materials to their textbook unit. Because they actually modified and enhanced their regular textbook unit, their class achievement gains were significant when compared to those comparison teachers who strictly followed the regular textbook unit.

External Validity. Factors that may have affected the external validity of this study were population validity, treatment fidelity, statistical conclusion validity, the novelty effect, and pretest sensitization. Because teachers and administrators volunteered for the study, population validity was a potential threat, and generalizability cannot be assumed. The random assignment of teachers to comparison or treatment groups, however, may have tempered the potential threat due to sample selection. The researcher assessed the equality of groups through an analysis of pretest scores prior to implementation of the experimental mathematics curriculum unit and found them to be generally equivalent. Additionally, the sample was drawn from school districts within the Northeast, so results may not generalize to other geographic regions. Finally, the sample included students from mathematics in grades 4 and 5 only, so results may not be generalizable to other subjects or grade levels. A potential threat to treatment fidelity was the suggested timeframe of the experimental unit. Most teachers indicated that 3 weeks was not sufficient for completing all components of the unit, and those who did complete the unit in 3 weeks indicated that they eliminated some of the activities from their instruction. One key to the success of the revision and within-class treatment groups may have been that teachers were able to adjust the suggested timeframe within their regular classroom settings. A majority of lesson components were completed, but these percentages dropped off as the unit grew to a close. Another threat to treatment fidelity concerned the logistics and classroom management of the various grouping arrangements. Teachers in the between-class grouping arrangement had to contend with time and logistical limitations (e.g., instructional time was lost as students were escorted between homeroom and mathematics classrooms). Additionally, some master schedules only allowed for exchanges two or three days a week, which added an additional time burden for between-class teachers. Teachers in the within-class grouping arrangement had classroom management issues that did not arise under whole-group instruction. Additionally, several teachers indicated that because they had not prepared far enough in advance of the implementation, they were not prepared to deal with several small groups of students working on separate assignments within their classrooms. They suggested that, had they spent more time in advance preparation, they could have set up learning or interest centers and used some of the materials in the mathematics unit as "anchor" activities (i.e., activities that all students could complete independently). This could reflect a potential limitation of the treatment.

Finally, the published effect sizes must also be read with caution as there is evidence that a short, highly compacted curriculum unit may demonstrate greater gains than a more lengthy unit (Kulik, 1992). It is important to examine whether or not these gains are sustainable before making generalized statements concerning the long-term results. For these reasons, statistical results should be interpreted with caution.

Conclusion

Despite the limitations, the results of this study suggest that adapting pedagogy from gifted education, including revised or differentiated curriculum, combined with appropriate and temporary types of flexible grouping, may have a significant positive impact on students' mathematics achievement.

Implications for Gifted Education

For decades in gifted education, researchers and theorists alike have proposed that revised and differentiated curriculum combined with appropriate grouping strategies could improve the achievement of high-ability or gifted students while addressing their academic and intellectual differences. This study was one step forward in demonstrating to colleagues in the classroom that these long held beliefs are substantiated.

There are three major implications of this study for teachers. The teacher's role in curriculum development becomes even more critical in light of these results. First, because this research indicated that a short, 3-week revised or differentiated curriculum unit can impact students' achievement, it is important that regular and gifted classroom teachers examine their current curriculum and make important decisions about what is important to teach and what can be left out. Second, it is important for teachers to be aware of students' different levels of prior knowledge and cognitive abilities. To ascertain these individual differences, they must assess their students prior to implementing a new curriculum unit, then group and teach them accordingly. Further, teachers must stress the need for learning goals rather than behavioral objectives (i.e., what they want the students to learn rather than what the students will do), which Schunk (1996) has shown can have a significant effect on achievement. This is especially true for teachers of the gifted. For many years, teachers in gifted or enrichment classrooms have come under attack from general educators for teaching "fluff." It is vitally important that gifted, talented, and creative students, whether they reside in enrichment, honors, or regular classrooms, work with curriculum that is challenging and concepts that are enduring. The need for a critical analysis of existing curriculum and enrichment activities, especially if they stem from a textbook, creates an extra imperative in these days of high-stakes state achievement testing that places additional stress on educational decision makers and fails to adequately assess the real learning gains of gifted and talented students.

It is imperative for researchers to continue to pursue this line of inquiry. It is imperative for teachers to examine their current curricular or enrichment practices to assure authentic, original, and challenging learning experiences. It is also imperative that the academic and intellectual learning needs of high-ability and gifted students are addressed so educators truly leave no child behind.

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Appendix
Comparison of Textbook, Revised, and Differentiated Unit

Lesson component	Textbook	Revised	Differentiated
Introduction	Introduce concept; provide examples. Cooperative groups explore examples of graphs (data) in newspapers or magazines. Demonstrate how to calculate probability of single event.	Pose problem or controversy to spark student's interest. Discuss importance of topic in real-world situations.	Pose problem or controversy to spark student's interest. Discuss importance of topic in real-world situations.
Teaching activities	Demonstrate sample problems in data analysis. Demonstrate how to create different graphs (line, bar, pictograph). Discuss why certain graphs (data) would be used in certain examples. Demonstrate examples of probability of single event.	Lead discussion of issues involved in problem or controversy raised. Demonstrate how to graph, calculate statistics, and calculate probability using hands-on, interactive examples. Vary grouping arrangements during discussion and demonstration (whole class, pairs, small groups).	Same as revised, plus target differentiated questions to students with different levels of prior knowledge, that is, provide more information/scaffolding to less-ready students; more complex, abstract questions that may ask for generalizations to more-ready students.
Learning activities	Students complete graphs or tables of data in textbook. Work in cooperative groups to graph newspaper data. Students use manipulatives to calculate probability of single event.	Students complete journal prompts that connect activities to concepts. Students complete hands-on activities that demonstrate concepts. They create tables and graphs to publish their results. Students share original hypotheses and results orally with class. Students work in various grouping arrangements (whole class, pairs, small groups, individuals).	Same as revised, plus students with different levels of prior knowledge will work on leveled materials. Less-ready students will complete fewer problems at less complex level. More-ready students will work with materials from higher grade level. Some students may be accelerated into more complex work, for example, probability of multiple events or factorials; double bar or stem-and-leaf graphs.

Lesson component	Textbook	Revised	Differentiated
Resources	Textbook, graph paper, newspaper, calculators, manipulatives for probability.	Textbook, graph paper, supplementary materials, calculators, video clips, computer program, manipulatives.	Textbook, graph paper, supplementary materials, calculators, video clips, computer program, manipulatives, learning centers
Products	Worksheet or homework pages.	Journal prompts, original graphs, worksheets, original survey instrument with hypotheses, graphs, and conclusions.	Tiered journal prompts, original graphs, worksheets, original tiered survey instrument with hypotheses, graphs, and conclusions.
Assessment	Skill quiz; end-of-unit multiple-choice test.	Students use research rubric to complete original survey research project.	Students use tiered research rubric to complete original survey research project.