CLOSING THE ACHIEVEMENT GAP IN MATH: CONSIDERING EIGHTH GRADE ALGEBRA FOR ALL STUDENTS

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ABSTRACT

Should all students study algebra in eighth grade? Would offering early access to algebra to all students help close the achievement gap among minority populations? Traditional educational policies that provide eighth grade algebra to selected students raise questions about equitable access to advanced opportunities for all students. Even when access appears to be equitable throughout a school district’s population, undetected lapses in equity may occur related to identification procedures. This study addressed the problem of achievement gaps among underrepresented populations by examining the study of algebra in eighth grade and its impact on student performance, achievement, and attainment. The purpose of this study was to explore the policy implications and potential benefits of providing algebra instruction to all students.

BACKGROUND

In the 1990s, the standards reform movement spearheaded by the National Council of Teachers of Mathematics led schools to examine longstanding tracking policies and the issue of grouping for student achievement. Hallinan (1994) concluded that flexible grouping that allows movement between tracks can address potential demographic inequalities in those tracks, but Oakes (1994) responded that “tracking
carries with it class-based damage that can neither be avoided nor compensated for” (p. 91). In an examination of ability grouping in middle school mathematics classes, Bode (1996) characterized the controversy over ability grouping as the struggle between equity and excellence and concluded that within-class ability grouping enhances the performance of high achievers without having negative effects on the low achievers.

Mallery and Mallery (1999) reviewed arguments by proponents and opponents of tracking and concluded that “tracking as practiced today is detrimental to the U.S. educational system” (p.15). Meanwhile, supporters of ability grouping for identified gifted students emphasize that grouping and tracking are not identical practices and must not be equated with each other. Tieso (2003) maintained that gifted students deserve and require the stimulation of studying with intellectual peers in an advanced environment in order to reach their full potential. She warned that the majority of negative research on ability grouping is approximately 25 years old and based on anecdotal rather than statistical evidence. However, opportunities for gifted students and rigorous curriculum for all students should not be mutually exclusive concepts.

At the core of this debate is the timing and delivery of algebra instruction. Two related events prompted renewed discussion of mathematics curriculum design. First, the National Council of Teachers of Mathematics (1989) recommended increased mathematical literacy for all students regardless of perceived ability and prior performance. Five years later, the National Center of Education Statistics reported that effective middle schools offered algebra to eighth grade students (NCES, 1994). Subsequently, Smith (1996) concluded that “early access to algebra has a sustained positive effect on students, leading to more exposure to advanced mathematics curriculum and, in turn, higher mathematics performance by the end of high school and …the question of whether schools should provide advanced coursework to only a select few students remains at the center of this policy debate” (p. 149).

The study of algebra in eighth grade by all students could potentially address the issue of mathematics literacy in the United States. A recent examination of the TIMSS and TIMSS-R concluded that “The 8th-grade mathematics curriculum in the U.S. seems comparable to the average 7th-grade curriculum for other participating countries, putting U.S. students a full year behind their global counterparts at age thirteen” (Greene, Herman, & Haury, 2000, p.2). Subsequently, Cogan, Schmidt, & Wiley (2001) focused policymakers on strengthening mathematics literacy initiatives, particularly in the nation’s middle schools, as a means of providing
the basis for more rigorous work in high school. Schmidt (2003) further decried the U.S. pattern of little or no gain from eighth to twelfth grade as the result of a “middle school curriculum lacking coherence, with little rigor or extreme variability in learning opportunities as a consequence of tracking policies” (p. 278). Since algebra is the gatekeeper course to advanced study in both mathematics and science, offering algebra in eighth grade to all students could begin to address the decline of achievement in high schools in the U.S.

Eighth grade algebra provides both rigor and opportunity. The question of appropriate rigor in learning experiences underlies recent standards-based initiatives throughout the states. In a recent analysis of state high school graduation requirements, Schiller and Muller (2003) noted that “the mathematics courses students take in high school affect their academic achievement and their admission to competitive postsecondary schools and professional programs” (p. 300). If education policymakers consider early access to algebra as a means of increasing mathematics literacy, they must provide equitable access to that literacy.

**METHODOLOGY**

This mixed-methods study used both quantitative and qualitative methods to examine a mathematics tracking policy in a large southeastern suburban school district where some students had access to the study of algebra in eighth grade. The study examined the characteristics of students in each of the algebra pools (eighth grade and post-eighth grade) and the effects of their mathematics course-taking for eighth grade students (n=2,634) in each pool. These students were members of the district’s high school graduating class of 2002.

Longstanding district policy involved a complex nomination system that provided enriched mathematics instruction to some students starting as early as third grade. According to the established policy, in sixth grade, these students took a local instrument that had been designed by teachers to predict readiness for algebraic concepts. Scores on this readiness test, as well as teacher nomination, provided entrance into honors mathematics in seventh grade. Students who successfully completed seventh grade honors level mathematics advanced to Algebra 1 in eighth grade.

Analysis of this policy was conducted in three stages to address three basic research questions: First, “Who got into eighth grade algebra?” Second, “What background circumstances affected the district’s mathematics tracking policy?” Third, “What difference did studying algebra in eighth grade make in student achievement and attainment?”
Statistical analysis explored three ways of looking at the students: first, the characteristics of students in each of the treatment groups (those in Algebra 1 in Grade 8 versus those in Grade 8 Mathematics), then the achievement of students in each group on standardized tests, and finally, subsequent enrollment in local math courses. In addition, interviews with teachers (N=36) from the district’s elementary and middle schools provided insights into the dynamics surrounding the algebra selection process they employed.

**WHO GOT INTO EIGHTH GRADE ALGEBRA?**

In this district, which students gained entrance into eighth grade algebra classes? Descriptive analysis revealed disparity of access according to student ethnicity. Greater percentages of Black and Hispanic students were in Mathematics 8, while a larger proportion of Asian students were in Grade 8 Algebra 1. White students appeared to be evenly distributed into the two mathematics options. Figure 1 shows the breakdown by ethnicity in each of the two mathematics options in eighth grade.

Additional examination of SES (socioeconomic status) data deriving from free and reduced lunch percentages (Table 1) suggests an inverse proportion between the SES of a school and the number of students studying algebra in eighth grade. In the three schools with the lowest percentage of free and reduced lunch students, the ratio of Grade 8 Algebra students to Grade 8 Mathematics students is balanced. However, the schools with the highest percentage of students with free/reduced lunch also had the lowest percentage of students in Grade 8 Algebra.

Who got into Grade 8 Algebra? Since district policy prescribed entrance into Grade 8 Algebra according to prior performance of the students, the next phase of data analysis explored the extent to which
prior test results, as well as background variables such as parent education, gender, or ethnicity predicted selection for eighth or ninth grade algebra. While controlling for prior performance and parent educational background (SES) differences, this analysis revealed that Caucasian students were 1.4 times as likely to get into the early algebra group. On the other hand, Black students were only .84 times as likely as their Caucasian peers (a less than even chance) to get into Grade 8 Algebra.

**How Were Students Selected for Grade 8 Algebra?**

Although district policy prescribed that prior performance of students, as indicated by their scores on standardized tests, was the official gateway for access to the study of algebra in eighth grade, the teachers (n=36) disclosed that other factors affect the official policy. Their interviews revealed three inconsistencies in policy implementation. First, the elementary school teachers reported variations in elementary school experiences across the district. In the third grade, in some of the elementary schools, teachers select students for specific enriched mathematics experiences in
problem solving. However, the teachers reported that not all elementary schools in the district have implemented the prescribed enriched programs. The teachers acknowledged that these early enrichment experiences lay the groundwork for subsequent student performance on the tests that designate entrance into eighth grade algebra. However, they also acknowledged that in some of the elementary schools, students are not receiving the enrichment that might enhance their mathematics performance in later years.

Second, the middle school teachers described additional flaws in the identification process in seventh grade, when they reported that they did not consistently use the district’s official teacher-constructed algebra prognosis test. The policy prescribed the administration of this test in the seventh grade only to those students already in the advanced track. The majority of the students tested ultimately do study algebra in eighth grade. However, over the last decade, the teachers have abandoned the algebra prognosis test as outdated and have relied on their own subjective judgments about student selection (Spielhagen, 2006). The district policy provides no selection criteria for students not already in the enriched math program, some starting as early as third grade. Those students are automatically precluded from Grade 8 Algebra and follow the traditional mathematics 8 curriculum involving reinforcement of arithmetic skills.

Therefore, by district policy, once students are in a particular track, they stay in that track. However, the teachers also reported that parents frequently override the district’s placement of students in the non-algebra track in many of the middle schools, particularly those schools with higher SES and upwardly mobile populations. Moreover, teachers do not often move children from Grade 8 Algebra to the regular Math 8 class, because parents who have lobbied to place their children in algebra want them to remain in the higher track. District level administrators support their requests. The teachers also report that parents in lower SES schools do not often question the placement of their children. Most importantly, once the students gain access to Grade 8 Algebra, they usually succeed, some with difficulty, and the vast majority of them pass the state examination in algebra. This finding prompted a closer examination of student achievement versus their mathematics placement in eighth grade.

**How Did Access to Grade 8 Algebra Affect Further Achievement?**

The next stage of analysis explored two distinct areas: the effects of early algebra access on student achievement and the impact of early algebra study on further involvement in mathematics study. The study defined student achievement using three specific outcome measures: the state
standardized test in Algebra 1 (taken at the end of the course, either in eighth or ninth grade), pre-placement (seventh grade) Stanford 9 mathematics score, and the post-eighth grade Stanford 9 test scores. These three test scores provided the basis for analyzing student performance in terms of their group placement. The use of the Stanford 9 scores was particularly advantageous because they provided an external measure of achievement that is no longer available in the district under study. Recently, state administered tests have replaced the Stanford tests as the annual assessment measure, but at the time of this analysis, the Stanford 9 tests provided an informative means of comparison unrelated to state testing. Performance of students on the Stanford 9 tests strongly supports the hypotheses that restricting access to Grade 8 Algebra does not result in increased achievement.

Not surprisingly, the early access group, Grade 8 Algebra 1, scored higher than their peers who stayed in Grade 8 Mathematics on all measures, but on the state algebra test the scores of both groups were closer in range and overlapped significantly. The Grade 8 Algebra 1 group yielded a mean score of 446.4 (SD=58.2) on this test, while the mean for Grade 9 Algebra 1 group was 401.9 (SD= 28.8). The standard deviations indicate an significant overlap in the range of performance for both groups. These ranges are important to acknowledge. Lower-end performance among students in the Grade 8 algebra group was the same as that of upper end performance of students who were not in the early algebra group. Moreover, additional analysis using multiple regression further revealed that participation in Grade 8 Algebra 1 had only marginal impact in predicting performance on the Stanford post-test.

These important findings corroborate the research of Gamoran and Mare (1989), who determined that most of the observed differences in mathematics achievement among students in different tracks result not from being in the tracks, but from pre-existing differences among the members of the different tracks. If, as this study showed, there is no growth within the tracks, why have the tracks at all? If there is overlap in both predictive data and outcome data, then holding students back from algebra in eighth grade may not be beneficial to them. Ultimately, if the policy of holding some students back from algebra in eighth grade resulted in benefit to those students, then the policy would be sound. However, this study calls into question the soundness of the policy.

**WHAT WERE THE EFFECTS OF STUDYING ALGEBRA IN THE EIGHTH GRADE?**

Long-term attainment emerges as a critical benefit of studying algebra in eighth grade. The simplest and most direct way to examine mathematics
attainment was to determine the number of students who continued to pursue the study of mathematics in eleventh grade. The state’s minimum requirement for mathematics was two years of high school mathematics, including Algebra 1. Most students followed a traditional three-year sequence of Algebra 1, Geometry, and then Algebra 2, completing an extra year beyond the minimum.

Figure 2 provides a snapshot of subsequent course-taking by students within three years of their algebra experience and confirms the advantage of studying algebra in the eighth grade. Because of the sequential nature of the mathematics curriculum, more of the early access Grade 8 Algebra 1 group were in advanced math classes in eleventh grade than were students from the Grade 8 Mathematics group. Most of the Grade 8 Algebra group completed Geometry in ninth grade and Algebra 2 in tenth grade. By eleventh grade, 77% of the Grade 8 algebra students were enrolled in advanced mathematics classes: Trigonometry/Mathematics Analysis (41%), Mathematics Analysis (26%), and Trigonometry/ Advanced Algebra (10%). Conversely, the majority of Grade 8 Mathematics was in Algebra 2 (62%) in eleventh grade.

**DISCUSSION**

Restricting access to Grade 8 Algebra in this district did not increase achievement among students in either of the two tracking groups. This study supports similar studies that question the equity of tracking policies because they do not result in achievement gains for lower performing
students. First, although prior performance was a strong predictor of placement in the Grade 8 Algebra 1 group, for some students, their prior performance was influenced by early school experiences within the control of the district. Despite district efforts at equity, interviews with elementary school teachers revealed that only some schools provided the enriched mathematics instruction that develops understanding of complex mathematics concepts. Moreover, placement into the early algebra group varied according to SES among the schools within the district. Schools with higher SES had more students taking algebra in eighth grade. Students in the lower SES schools had fewer enriched experiences and lower placement rates into algebra in eighth grade.

Regardless of where they were placed, Stanford 9 tests for both treatment groups remained relatively the same in both pre-eighth grade and post eighth grade tests administrations. Moreover, the Grade 7 local scores that were used to determine entrance into Grade 8 Algebra did not significantly predict Stanford post-test performance of those who did not study Grade 8 Algebra. In fact, even after taking into consideration an additional year of adolescent development between eighth and ninth grades, the overlap of achievement on the state algebra test in the two groups suggests that the tracking policy prevents some students from taking Grade 8 Algebra who might have succeeded and derived benefit from that experience. Longitudinal analysis revealed considerable benefit to having studied Algebra in eighth grade because those students had the opportunity to select more math courses and courses of greater complexity.

Interviews with the teachers revealed two potentially biased intervention factors that allowed some students into Grade 8 Algebra who would not have gotten into the class because of their test scores. First, frustration with the non-standardized algebra prognosis test led many teachers to discard the test results and use their own subjective judgments in placing students into Grade 8 Algebra. Second, school administrators in the higher SES schools routinely agreed to override the placement policy at the request of parents who wanted their children in Grade 8 Algebra. Teachers were expected to accommodate the needs of these students and provide curriculum differentiation and support, after school if needed. The teachers reported frustration at parents’ interference and the lack of readiness by the students to study algebra. Nevertheless, the teachers also reported that students who gained access to eighth grade algebra through parent or teacher override of the school’s policy ultimately succeeded in that class.

The success of the students who gained access outside of normal school procedures then focuses the discussion on the benefit of early
algebra placement. By virtue of their study of Grade 8 Algebra, those students had “jumped the tracks” and enjoyed the benefit of further study, i.e., the opportunity to take more math courses. Trying to sort out the issues related to tracking policies, Haury and Milbourne (1999) concluded that “one outcome of tracking, it seems, is a widening of the gap between high achievers and low achievers” (p.2) and supported the early work of Gamoran (1987), who maintained that mathematics achievement actually results more from “greater access to courses of study (i.e., algebra) that produce high achievement” (p.150) than from repetition of basic arithmetic skills. More recently, Smith (1996) showed that, regardless of prior socioeconomic background, early access to algebra had a sustained positive effect of greater math attainment, as evidenced by higher performance and more math courses taken.

This study showed that students enjoyed little or no advantage to being held back from Grade 8 Algebra, while enrollment in Grade 8 Algebra affected the type of courses taken and the likelihood of taking additional mathematics courses. In this district, Grade 8 Algebra students stayed in mathematics longer and necessarily had access to higher-level courses. The state’s minimum requirement for mathematics is two years of high school mathematics, including Algebra 1. Most students followed the traditional sequence of Algebra 1, Geometry, and then Algebra 2. Students in the Grade 8 Algebra 1 class necessarily had a head start on this sequence. A higher percentage of the early access Grade 8 Algebra 1 group were in math classes in eleventh grade than were students from the Grade 8 Mathematics group. The sequential nature of mathematics instruction kept all students in the same track once they embarked on their study of serious courses.

This finding coincides with the work of Ma (2000), who studied the long-term effects of mathematics course selection on subsequent achievement. Using six waves of data (Grades 7-12) from the Longitudinal Study of American Youth (LSAY), she found that Algebra I had the strongest effect on mathematics achievement. The 2000 NAEP Report Card, released in August, 2001 reported a major finding that eighth graders taking first-year algebra scored higher on the NAEP long-term mathematics trend assessments than their peers studying eighth grade mathematics or pre-algebra (National Center for Educational Statistics, 2001).

CONCLUSION

What have we learned from this study? Perhaps we now have additional justification to rework mathematics curricula to provide Grade 8 Algebra
to greater numbers of students, if not all students. Tracking students in mathematics, if employed, should be done with good reason. The results of this study strongly support policies that provide algebra instruction in the eighth grade as a means of closing the achievement gap related to the SES of school populations. While schools cannot change the SES of their populations, they can control the delivery of services to those populations. In this study, restricting access to Grade 8 Algebra made no significant difference in the outcome performance of the students. Moreover, mathematics enrichment experiences starting as early as third grade had provided benefits for some students and resulted in enhanced “prior performance” that determined access into the early algebra group, but those opportunities were more available in the higher SES schools in this district. The use of ability grouping is not at issue here. It is the availability of enriched experiences across the various socioeconomic strata in this district that focuses the discussion on equity. Moreover, whether because of the programs offered through their elementary schools or because of the intervention of their parents in seventh grade, students in the higher SES schools had greater access to Grade 8 Algebra. Ultimately, the Grade 8 Algebra group benefited from their algebra experience through additional mathematics opportunities denied to students not in the advanced track.

In a recent examination of tracking in the eighth grade in a nationally representative sample of U.S. students involved in the TIMSS, the researchers concluded that, “This type of variation in students’ exposure to specific mathematics topics raises concerns about access and equity for students” (Cogan, Schmidt, & Wiley, 2001, p. 325). Raudenbush, Fotiu, and Cheong (1998) had targeted the issue of access of minority students to the study of algebra and found that more affluent districts were more likely to provide algebra instruction to students in eighth grade than districts with fewer financial resources. Their results indicate “substantial evidence of inequality of access to these resources as a function of social background and ethnicity” (p. 265). Smith (1996) also found that “early algebra takers were less likely to be from minority groups and came from families of higher socioeconomic status” (p.145). In this study, the influence of parents in higher SES populations resulted in disparate access to Grade 8 Algebra, corroborating the work of Lareau (2000), who explored parental intervention in elementary schools.

Finally, in this study, those who took Grade 8 Algebra took more mathematics courses in their high school career. This finding corroborates the conclusions of a qualitative study of six schools in New York State
(Spade, Columba, & Vanfossen, 1997) that concluded that students’ course selection is critical for student success and stated that, “Course taking is the most powerful factor affecting students’ achievement that is under the school’s control...Although schools cannot do much about the social class of the students who attend them, they can do something about the patterning of courses and the procedures used to place students in classes” (p.125).

Recent scholarship supports a policy that provides early access to algebra for all students in at least Grade 8. The 1990 NAEP mathematics assessment revealed that less than 20% of the nation’s eighth graders were enrolled in algebra courses (Mullis, Dossey, Owen, & Phillips, 1991). In 1999, the NAEP report card indicated an increase in the number of eighth grade students studying algebra between 1992 and 1996 (from 22% to 29%), but an analysis of that report card revealed inequality of access to algebra for minority students and those in lower socioeconomic groupings (Raudenbush, et al. (1998). This study supports greater access to the study of algebra because of the overlap of achievement among students in the low end of the Grade 8 Algebra group and the high end of the Grade 8 Mathematics group. The essential difference was the loss of opportunity for further attainment by students not afforded early access. Taking into account developmental gains by students who had an extra year of growth before studying algebra is important, but the question remains of how well individual students who were not in the early access group would have fared given the opportunity to try.

Preparation for algebra must also come under scrutiny. The enrichment of all mathematics courses in the elementary grades, as recommended by the NCTM in 1989, provides a firm basis for all students to approach their algebra studies. Therefore, further study of instructional practices in this district is needed to reveal the appropriateness of the math curriculum for all students and to determine a framework for appropriate differentiation for high ability students. Establishing algebra as the benchmark course may be an outdated practice that must be re-examined by policymakers striving to accommodate the demands placed on students in the 21st century.

Appropriate curriculum differentiation for gifted students remains an important issue. Van Tassel-Baska (2000) recommends that curriculum policy initiatives should take into account the needs of high ability learners but should also encourage course-taking access by underrepresented groups. If all students should receive Algebra in eighth grade, then gifted students would be ready by Grade 6 or 7. Flexibility in course-
taking is necessary to ensure learning progress for top students. Therefore, the paths by which students travel to the different tracks deserve scrutiny, as well as the existence and content of the tracks themselves.

Finally, providing eighth grade algebra instruction to all students opens doors to further mathematics study for all students and enhances their achievement in mathematics throughout high school. In this district, early algebra students took more advanced mathematics courses and stayed in the mathematics pipeline longer. Moreover, school officials reported rising pass-rates and success among students who were enrolled in Grade 8 Algebra. It is conceivable that access to Grade 8 Algebra provides an early base for student success in subsequent mathematics courses.

The lesson for district-level education policymakers is clear. School districts certainly cannot change the students’ socioeconomic background, but they can level the playing field by providing algebra instruction to all students by eighth grade. Policies affording early algebra instruction for all students, while resulting in substantial benefits for both the student and the school district, ensure both excellence and equity while addressing potential achievement gaps among minority and low SES populations.

REFERENCES


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