Paper Presentation for AERA 2021

Title: Marginalized Students' Opportunities to Learn in Integrated Mathematics Courses
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Abstract: Marginalized students face a range of gaps in experience, including fewer opportunities to learn in urban and racially-segregated schools. The objective of the current study was to describe teacher-reported opportunities to learn complex mathematics and whether these opportunities varied between racially-segregated and racially-balanced classrooms. This work was conducted with 41 teachers of Integrated Mathematics II courses taught in schools within a metropolitan school district in the Southern U.S. Teachers reported differences in the level of coverage and cognitive demands between racially segregated and racially balanced classrooms. In particular, they report covering algebra topics less and providing less cognitively demanding lessons. These findings are in line with consistent concerns in mathematics education of lowered expectations for students in segregated settings.

Objective

Marginalized students face a range of gaps in experience, with concerns that there are fewer opportunities to learn in urban and racially-segregated schools. The objective of the current study was to describe teacher-reported opportunities to learn complex mathematics and whether these opportunities varied between racially-segregated and racially-balanced classrooms in the district. This work was conducted with teachers of Integrated Mathematics II courses taught in schools within a metropolitan school district in the Southern U.S.

Perspectives

Students of color and those from low-income homes are often marginalized in schools, facing a range of gaps in experience, including an education gap, opportunity gap, expectation gap, resource gap, teacher quality gap, and funding gap (Darling-Hammond, 2000; Ford, 2016; Ladson-Billings, 2006). For example, these students often have less access to qualified mathematics and science teachers (Akiba et al., 2007). They are also less likely to take more advanced mathematics course work in high school (Riegle-Crumb & Grodsky, 2010). Further, teachers often have deficit views of marginalized students. For example, they attribute students' difficulties with mathematics to traits of the students and/or deficits in their families and communities, rather than to factors under the teachers' control, such as instructional quality (Jackson et al., 2017). Factors such as these contribute to gaps in opportunities to learn (OTL) within classrooms (Milner, 2020). Opportunities to learn in classrooms encompass the extent of coverage of curricular material and the instructional tasks that are used (Covay Minor, 2015; National Research Council, 2004). As an example, teachers of upper-level high-school math classes (e.g., trigonometry) reported differences in how they spent their instructional time, both in terms of topics and instructional tasks, based on whether the classroom was composed of mostly white students or not (Covay Minor, 2015). For instance, teachers in trigonometry classrooms with a predominately White racial composition tended to spend more time on the topic of trigonometry and more time asking their students to perform conceptual instructional tasks than did teachers in trigonometry classrooms with more than 20% students of color.

Examining the content and instruction to which students are exposed helps build our understanding of students' opportunities to learn and better expose potential opportunity gaps.

In the current study, high-school teachers within a metropolitan school district in the Southern U.S. reported on opportunities to learn in their Integrated Mathematics II course, both in terms of content coverage and complexity of instructional tasks. Between-school and within-school segregation may exacerbate differences in opportunities to learn for marginalized students. There are consistent negative effects of racially imbalanced, segregated schools and classrooms on student achievement and teacher qualifications (see Mickelson, 2015 for a review). One goal of the current study was to test for a gap in opportunities to learn in segregated classrooms compared to racially balanced classrooms within the same metropolitan school district.

The district is one of a growing number of districts adopting an Integrated Mathematics curriculum. For instance, Tennessee, Georgia, North Carolina, West Virginia, and Utah have many high schools that have transitioned to Integrated Mathematics in recent years (Will, 2014). In California, half of the 30 largest districts opted to use Integrated Mathematics as of 2015 (Harlow, 2015). This approach is designed to integrate concepts from algebra and geometry every year for three years, replacing a traditional Algebra I-Geometry-Algebra II sequence. The integrated sequence is intended to increase students' understanding and improve connections between math concepts. Initial evidence on the effectiveness of Integrated Mathematics compared to the traditional course sequence is promising (Chávez, Tarr, Grouws & Soria, 2015; Grouws et al., 2013; Tarr et al., 2013). Krupa and Confrey (2017) concluded that there were benefits in "using integrated mathematics in schools with high need and a high percentage of minority students" (p. 213). The district sets the same standards for Integrated Mathematics II courses, so in theory, the same opportunities to learn should be present across classrooms. However, teachers vary in what topics they emphasize and the complexity (e.g., cognitive demand) of the tasks they use within the same course (Schmidt & McKnight, 2012).

Method

Participants. The current study focuses on 41 high-school teachers who taught the same math course, Integrated Mathematics II, in the same metropolitan school district in the southern U.S. The course is required for all students unless specified in an Individual Assessment Plan (IEP). They taught at 23 different schools in the district, including 4 charter schools. They were teachers of participants in a longitudinal study of mathematics development among marginalized students.

Materials. Teachers completed a modified version of the Surveys of the Enacted Curriculum (https://curriculumanalysis.org/products-SEC.asp) for one section of their Integrated Math II course. Teachers were asked to report about the composition of the students in class, including racial composition and the achievement level of most of the students in the class. Then, they were asked about the content covered in the class, with topics covering the domains of (a) numbers and operations, (b) basic algebra, and (c) more advanced content (i.e., functions, advanced algebra, geometric concepts, trigonometry). As shown in Figure 1, they first indicated the level of coverage for each individual topic on a scale from 0 (none) to 3 (more than 5 lessons). Next, for each topic that was covered, they indicated the cognitive demand emphasis for three types of cognitive demand (a) Recall/perform procedures, (b) demonstrate/ communicate understanding, and (c) generalize, including to non-routine or real-world problems (see Table 1 for definitions provided on survey). For each cognitive demand, they rated it on a

scale from 0 (no focus) to 3 (major focus), with the restriction that only one value of 3 (major focus) be selected per topic. Teacher reports on the SEC are well correlated with observations, teacher logs and student reports, indicating it is a valid measure of what teachers do in their classroom (Blank et al, 2001; Porter, 2002).

Data analysis. The average level of coverage was calculated across all of the topics within the 3 domains. The average rating of focus for each type of cognitive demand was averaged for all the covered topics within a domain. Classrooms were classified as racially segregated if a high proportion of the math class was comprised of students from marginalized racial or ethnic groups (defined as above the district average of 70.5%, with a range from 71% to 100% students of color, $n = 28$); otherwise, they were categorized as racially balanced (with a range of 28% to 68% students of color, $n = 13$).

Results. First consider teacher's rating of the achievement level of most students in the target class compared to national norms. Teachers of racially balanced classrooms were much more likely to say most students were average or above average in achievement, rather than low or mixed achievement, compared to teachers of racially imbalanced classroom, 73% vs. 27% of classes, X^2 (2) = 11.957, p = .003.

Next consider teachers' report on level of coverage, as shown in Figure 2. We conducted a repeated-measures ANOVA with content domain as the within-subject factor, class type as the between-subjects factor and rating of level of coverage as the dependent variable. For content domain, we used planned contrasts with algebra coverage as the referent domain. There was a main effect of content domain, with teachers reporting covering algebra more than numbers/operations, F (1, 38) = 12.59, p = .001, or advanced math content, F (1, 38) = 305.65, p < .001. There was no main effect of racial composition of the class, F (1, 38) = 2.11, p = .15, nor domain x class type interactions, F (1, 38)'s < 2.38, p's > .13. However, as suggested by Figure 2, univariate tests suggested that compared to teachers of racially imbalanced classes, teachers of racially balanced classes reported covering algebra more often, F (1, 40) = 6.30, p = .016. This algebra content is considered core to the Integrated Math II course, based on district standards.

Finally, consider cognitive demand, as shown in Figure 3. We first confirmed that ratings for the 3 types of cognitive demand did not differ for the domain number/operations by class type. Our subsequent analyses focused on the other two domains, which were most relevant for the target content of an Integrated Math II course. We conducted a repeated measures ANOVA with content domain (algebra or advanced) and cognitive demand type as within-subject factors, class type as a between-subject factor and rating of demand as the dependent variable. Level 1 (recall/procedure) was the referent category for cognitive demand type. There was a main effect of class type, with average cognitive demand across types and content domains higher in racially balanced classrooms than racially segregated classrooms, F (1, 38) = 5.04, p = .03. For cognitive demand, there was more emphasis on Level 1 than Level 3, F(1, 38) = 7.66, p = .006, but similar emphasis on Levels 1 and 2, F(1, 38) = .045, p = .8. There was no main effect of domain. There was one significant interactions; domain interacted with the contrast between the cognitive demands of recall/procedure and generalize, F(1, 38) = 7.12, p = .011. Inspection of means in Figures 3b and c indicates that the gap in intensity of focus on these two cognitive demands was greater for advanced content than algebra content.

Discussion

The current findings add to concerns about opportunity gaps for marginalized students. Although students were all enrolled in the same course in the same district guided by the same

standards, teachers reported differences in the level of coverage and cognitive demands between racially segregated and racially balanced classrooms. Differences in opportunities to learn, even within courses with the same title, may help to explain why Black students do not show the same academic gains as White students do when enrolled in advanced math courses, especially among Black students in segregated settings (Riegle-Crumb & Grodsky, 2010).

Teachers' perception of the achievement level of most students in the class differed by racial composition of the class. This could reflect actual achievement differences or it may reflect teachers' racial bias. Terminology such as "racial achievement gap" tends to attribute the issue to students' deficits rather than a debt in resource investment (Ladson-Billings, 2006). Data was not available to address the accuracy of teachers' perceptions, a clear limitation of the current study.

Teachers' perceptions, whether true or not, could explain why the teachers of racially segregated classes tended to report covering algebra topics less and to providing less cognitively demanding lessons. Although the current findings are based on teacher reports and teacher self-reports can be biased, there is evidence for the validity of the survey we used (Blank et al, 2001; Porter, 2002). Overall, lowered expectations are a consistent concern in math education, with calls to provide high academic standards for all students (NCTM, 2014). The current study highlights the continued need to work for greater equity in mathematics instruction.

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Figure 1: Excerpts from the modified Survey of the Enacted Curriculum used in the current study

1 *Level of Coverage*		2 *Cognitive Demand Emphasis*		
0 = none, 1 = less than 1 class lesson, 2 = 1 to 5 class lessons, 3 = more than 5 lessons		***0 = no focus, 1 = minor focus, 2 = moderate focus, 3 = major focus (Note: For each topic, only one value of 3 (major focus) may be selected.)***		
		Recall/Perform Procedures	***Demonstrate/ Communicate Understanding***	***Generalize, including to non-routine or real-world problems***
⓪ ① ② ③	**Use of variables**	⓪ ① ② ③	⓪ ① ② ③	⓪ ① ② ③
⓪ ① ② ③	**Formulas, expressions and equations**	⓪ ① ② ③	⓪ ① ② ③	⓪ ① ② ③
⓪ ① ② ③	**One-step equations (e.g., 5x=10)**	⓪ ① ② ③	⓪ ① ② ③	⓪ ① ② ③
⓪ ① ② ③	**Coordinate planes**	⓪ ① ② ③	⓪ ① ② ③	⓪ ① ② ③
⓪ ① ② ③	**Arithmetic or geometric patterns**	⓪ ① ② ③	⓪ ① ② ③	⓪ ① ② ③
⓪ ① ② ③	**Multi-step equations (e.g., 5x+2=12)**	⓪ ① ② ③	⓪ ① ② ③	⓪ ① ② ③
⓪ ① ② ③	**Inequalities**	⓪ ① ② ③	⓪ ① ② ③	⓪ ① ② ③
⓪ ① ② ③	**Linear and non-linear relations**	⓪ ① ② ③	⓪ ① ② ③	⓪ ① ② ③
⓪ ① ② ③	**Functions (e.g., meaning, functions as objects)**	⓪ ① ② ③	⓪ ① ② ③	⓪ ① ② ③
⓪ ① ② ③	**Operations on functions**	⓪ ① ② ③	⓪ ① ② ③	⓪ ① ② ③

Definitions for the cognitive demand emphases

Recall/Perform Procedures	**Demonstrate/Communicate Understanding**	**Generalize, including to non-routine or real-world problems**
-Recall mathematics terms, definitions, facts or formulas -Do computation procedures or algorithms -Follow the steps in mathematical procedures or apply a formula -Solve equations and routine word problems -Execute geometric constructions	-Communicate understanding of mathematical concepts -Use representations to model mathematical concepts, relationships between concepts and/or operations -Develop and explain relationships between concepts and/or operations -Show or explain relationships between models, diagrams, and/or other representations	-Recognize, generate and create patterns -Find a mathematical rule to generate a pattern or number sequence -Apply and extend mathematical properties to new contexts (e.g., extend understanding of the distributive property in whole-number multiplication to multiplication of two binomials) -Apply mathematics to solve non-routine, real-world problems -Apply mathematics in contexts outside of mathematics

Note: The original SEC has 5 cognitive demands, which we collapsed into 3 demands to simplify the survey, collapsing the Recall and Perform Procedures categories and the Generalize and Integrate categories from the original SEC.

Figure 2
Average level of coverage rating for 3 domains, by classroom racial composition

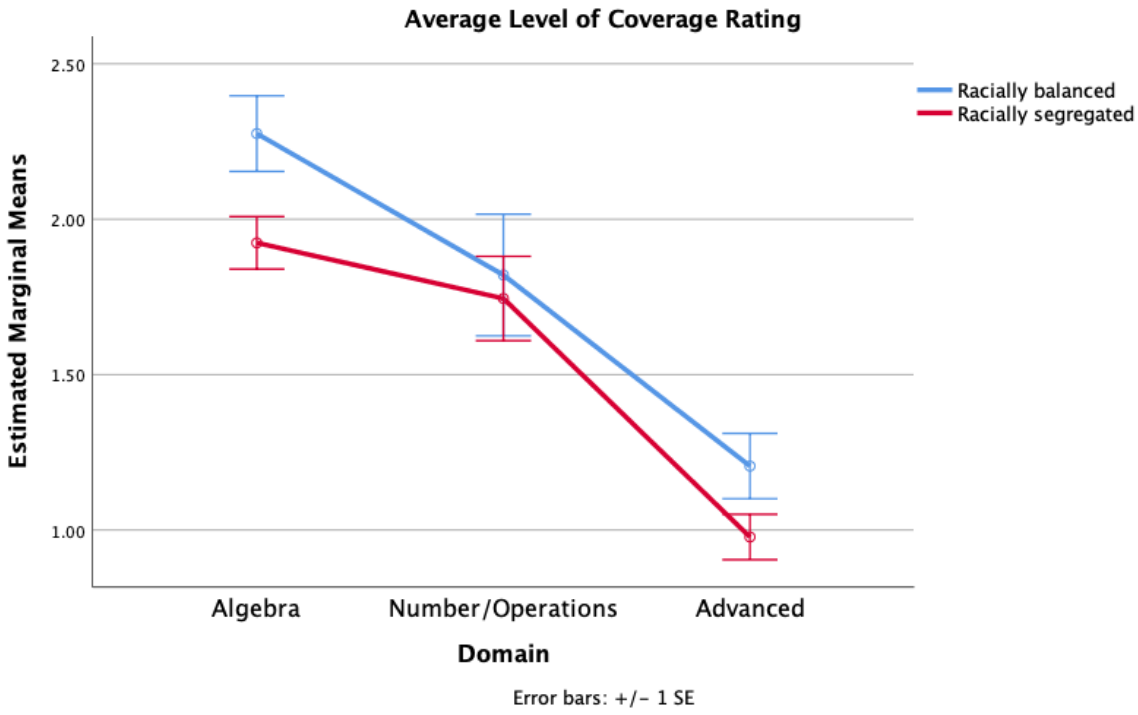
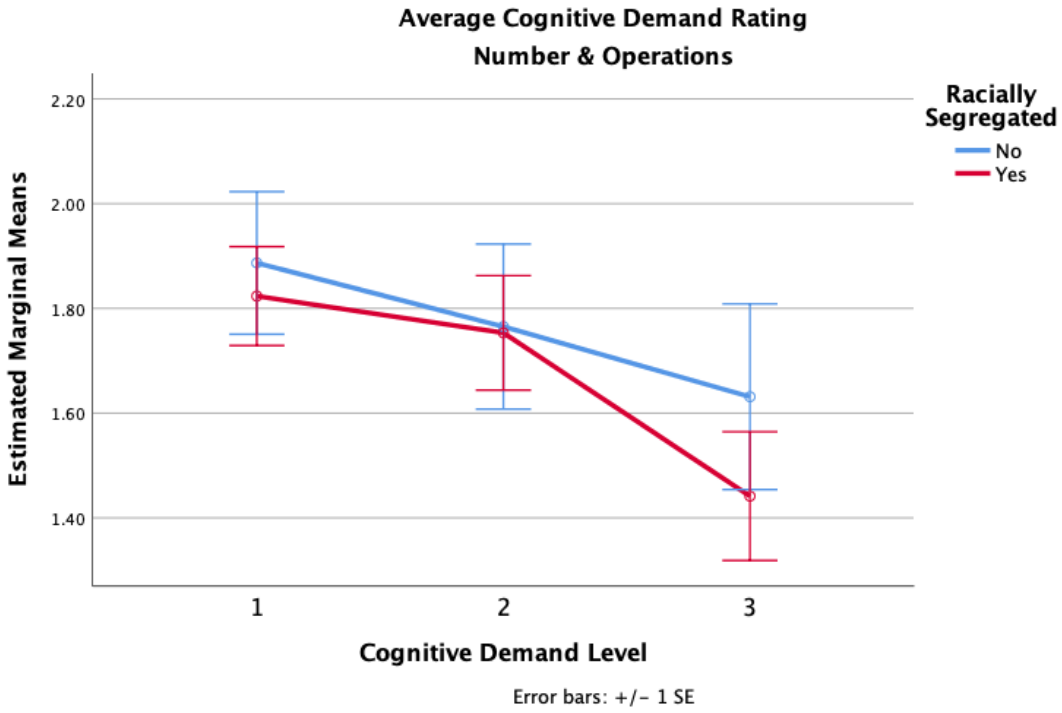


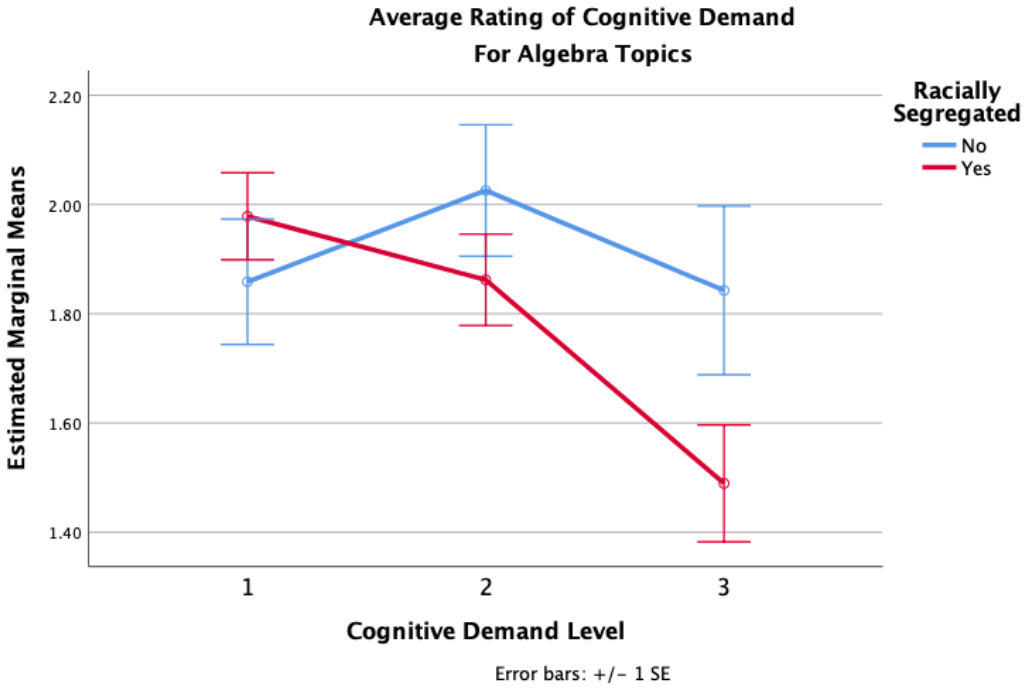
Figure 3

Average Cognitive Demand Rating for Three Cognitive Demand Levels, by classroom racial composition

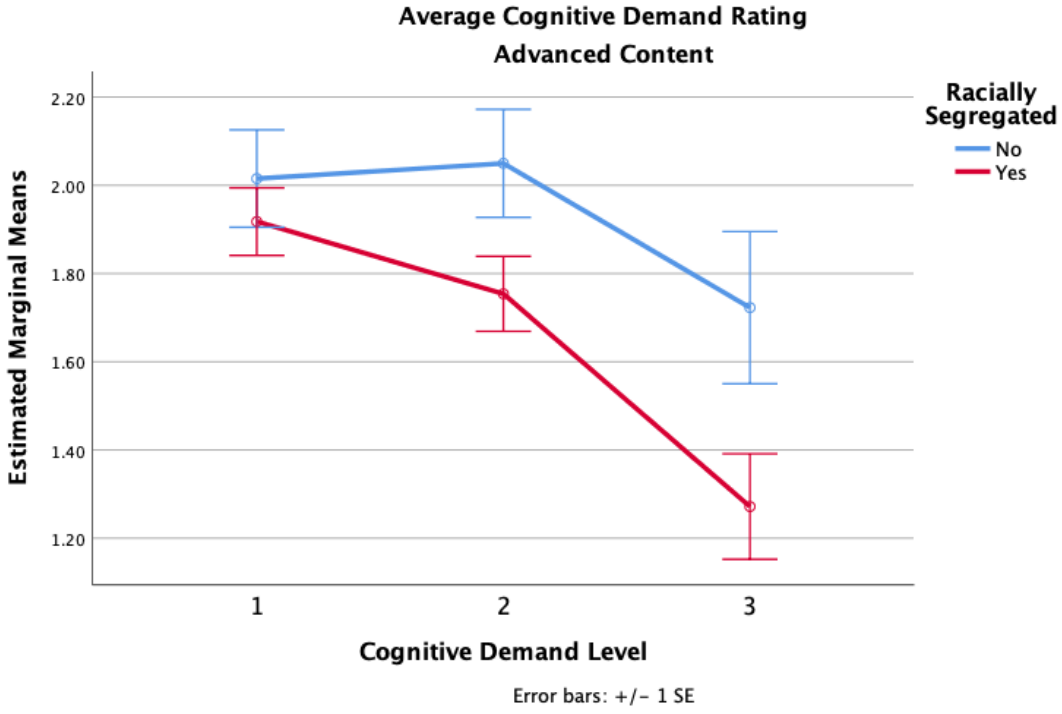
(a) For Number & Operations Topics



(b) For Basic Algebra Topics



(c) For Advanced Math Content



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