

The Effects of Teacher Collective Responsibility on the Mathematics Achievement of Students Who Repeat Algebra

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In this article, the authors use the national High School Longitudinal Study of 2009 (HSL:09) dataset to explore (a) if repeating algebra in the eighth grade was associated with overall mathematics grades and course-taking patterns by twelfth grade, (b) if repeating algebra in the eighth grade was associated with students' final grade in algebra, (c) if the level of teacher collective responsibility of mathematics teachers in school predicted students' who repeated algebra final grade in algebra, and (d) if this association differed by students' gender. The authors' analysis suggests that repeating algebra may bolster mathematics success for certain students; however, in schools with low perceptions of collective responsibility among teachers, final grades in algebra were lower for male students repeating algebra. Implications for achievement and long-term course-taking patterns when students repeat algebra are discussed.

KEYWORDS: algebra, course-taking patterns, mathematics achievement, mathematics policy, teacher collective responsibility

Algebra represents an important gatekeeper to higher-level mathematics and science courses, high school graduation, and entrance into college (Attewell & Domina, 2008; Liang, Heckman, & Abedi, 2012; Schiller & Muller, 2003). Therefore, an increasing number of states are encouraging students to enroll in algebra; this initiative is known, by many, as the *algebra for all* educational reform initiative (Domina & Saldana, 2012). In addition to promoting algebra enrollment, this initiative also pushes students to take algebra earlier in middle school to give more students the opportunity to complete higher-level mathematics courses while in high school (Allensworth & Nomi, 2009).

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Because of the algebra for all initiative, there have been steady increases in eighth- and ninth-graders' algebra course taking over the past several years across the United States (National Center for Education Statistics [NCES], 2005). In California, the percentage of eighth-grade student enrollment in algebra has almost doubled from 32% in 2003 to 59% in 2011 (Liang et al., 2012). These drastic increases in algebra enrollment necessitate more investigation into the implications for students' achievement and potential in mathematics, especially among subgroups of students. Accordingly, the current study examined the characteristics and achievement of an often-overlooked subgroup of algebra students, those who repeat algebra, and the role that teachers play in these students' achievement.

While requiring students to take algebra is important, there is mixed evidence regarding whether there is an achievement benefit of taking algebra during middle school, as opposed to starting algebra for the first time in high school. Some studies have found that exposing students to advanced mathematics curricula early is associated with larger achievement gains (Attewell & Domina, 2008; Domina, 2014; Gamoran & Hannigan, 2000). Other studies document greater enrollment in subsequent advanced mathematics courses for students who take algebra in the eighth grade (Spielhagen, 2006; Stein, Kaufman, Sherman, & Hillen, 2011). On the other hand, competing evidence suggests that increases in algebra enrollment are associated with lowered achievement scores on tests such as the California High School Exit Exam (CAHSEE; Clotfelter, Ladd, & Vigdor, 2012; Domina, McEachin, Penner, & Penner, 2015) and early algebra enrollment does not predict more advanced mathematics course taking (Domina et al., 2015; Loveless, 2008). One explanation for these mixed results could be that this policy has focused on the timing of algebra enrollment and has spent relatively less effort on whether students who take algebra early on receive the same quality instruction, teacher support, or adequately learn the fundamental mathematics skills to move through a higher-level mathematics course trajectory.

Overview of the Literature

Students Who Repeat Algebra

Students who repeat algebra are often overlooked and merit more attention as the algebra for all initiative is implemented nationwide. There are many reasons why a student might repeat algebra, and these reasons largely depend on the student, school, and school district. Despite the myriad reasons for repeating algebra, it is typically a result of low performance in earlier mathematics courses, teacher recommendations, and course grades (Bitter & O'Day, 2010; Fong, Jaquet, & Finkelstein, 2014). It is also likely that recent increases in the number of students who repeat algebra may be a byproduct of the algebra for all initiative. Structural shifts in

schools, such as the reassignment of teachers to accommodate for increases in algebra enrollment, or students' lack of preparedness for higher-level mathematics, could all contribute to increases in the number of students who repeat algebra.

Thus far, limited work has explored the experiences of students who repeat algebra; most existing studies only examine demographic characteristics. A study of 3,400 California students found that nearly 45% repeated algebra and that this percentage was higher for English language learners, Latinas/os, and students in special education (Fong et al., 2014). Fong and colleagues (2014) also examined student achievement outcomes of students who repeated algebra in California. They found that overall student achievement improved for both low- and high-achieving students when they repeated algebra. However, other studies on the achievement of students who repeat algebra showed more discouraging results. Finkelstein, Fong, Tiffany-Morales, Shields, and Huang (2012) found only 21% of ninth-grade students who repeated algebra achieved proficiency on standardized mathematics assessments on their second attempt. Waterman (2010) also found that among students who did well in eighth-grade algebra (i.e., received a grade of B- or better) and had to repeat algebra again in the ninth grade, nearly half received the same or worse grades after repeating the course. The mixed results of prior studies, as well as the limited literature on students who repeat algebra, motivated our investigation of the achievement of students who repeat algebra and factors that could predict this achievement.

A recent study by Howard, Romero, Scott, and Saddler (2015) aimed to better understand students who failed algebra by examining their test achievement after failure, motivation, and readiness for college. Using the High School Longitudinal Study of 2009 (HSL:09), Howard and colleagues (2015) found that students who failed algebra in the eighth grade were similar in terms of mathematics proficiency compared to students who passed lower-level mathematics courses but reported lower mathematics motivation. Although this study provided more information on students who fail algebra and their subsequent motivation, there is still a lack of information about students who repeat algebra in particular. For example, little is known about whether retaking algebra from eighth to ninth grade (the transition to high school) helps mathematics achievement, especially over time. Moreover, although Howard and colleagues' (2015) study documented differential motivational patterns for students who repeat algebra, scant studies have investigated whether these students differ in mathematics achievement or mathematics course enrollment by the end of high school. To help address these gaps in the literature, we used a diverse and national sample of United States high school students and investigated whether students who repeated algebra from eighth to ninth grade differed from students who took algebra for the first time in ninth grade on the following outcomes: (a) advanced placement (AP) mathematics enrollment by twelfth grade, (b) mathematics grade point average, and (c) grade point average in STEM (science,

technology, engineering, and mathematics) courses. The study reported here also extends prior research as we examine the predictive relations of an important teacher-based variable on final algebra grades between students who repeat algebra and first-time algebra takers. Gender was used as a moderator in this association.

The Role of Teachers in Student Achievement

In exploring predictors of mathematics achievement among students who repeat algebra, we specifically focused on the role of teachers in shaping that achievement. Over the last several decades, researchers have found that in addition to students' individual characteristics, such as socioeconomic status (SES) and prior achievement, teacher influences can play a large role in shaping student achievement (Caprara, Barbaranelli, Steca, & Malone, 2006; Goddard, Hoy, & Woolfolk Hoy, 2004; Goddard, LoGerfo, & Hoy, 2004). The ways that teachers view their students' abilities, and their own roles and responsibilities in educating children affect student outcomes. For example, teachers' self-efficacy beliefs are shown to influence students' school success (Caprara et al., 2006; Muijs & Reynolds, 2001). In addition, teachers' expectations for their students influence student learning such that high teacher expectations are associated with gains in student learning (Firestone & Rosenblum, 1988). Here, we are not interested in the specific influence one teacher could have but rather on the collective responsibility mathematics teachers have for students' learning.

Teacher collective responsibility. Teacher collective responsibility is defined as the degree to which teachers feel responsibility for student learning (Lee & Smith, 1996; LoGerfo & Goddard, 2008). Teacher collective responsibility also emphasizes the obligation and trust among teachers and school administrators (Bryk & Schneider, 2002), particularly regarding high accountability for student learning (Bolam, McMahon, Stoll, Thomas, & Wallace, 2005). This construct is distinct from teacher efficacy or individual teacher responsibility because teacher collective responsibility captures school culture, and how teachers perceive their colleagues as accepting responsibility for student learning (LoGerfo & Goddard, 2008). In schools where there is high teacher collective responsibility, teachers have a sense of shared responsibility for the success or failure of their students. On the other hand, in schools with low teacher collective responsibility, teachers might attribute student success and failure, not to themselves, but rather to student characteristics or schooling conditions (Lee & Loeb, 2000).

Although limited research has examined teacher collective responsibility, extant work has found that teachers' collective responsibility is an important factor in shaping student achievement. Lee and Smith (1996) initially found that collective responsibility was positively associated with students' achievement after controlling for SES. More recently, LoGerfo and Goddard (2008) and Lee and Loeb (2000) similarly found that teacher collective responsibility was associated with

increased student learning. Research also suggests that in schools where teachers hold strong beliefs of collective responsibility, student-learning gains are more equitably distributed within the school across, for example, students from different socioeconomic groups (Lee & Loeb, 2000; Lee & Smith, 1996). In other words, schools with higher teacher collective responsibility are not only more likely to have higher teaching effectiveness but also tend to foster a more equitable learning environment for students.

Teacher collective responsibility may be an especially important part of school climate during times of change or reform (Louis, Marks, & Kruse, 1996). Because teacher collective efficacy encourages mutual support and responsibility for students' learning (Kruse, Louis, & Bryk, 1995), research suggests it could potentially act as a protective factor during times of organizational instability or change (Whalan, 2010). As the algebra for all initiative has rolled out in schools, teachers' tasks and responsibilities are being constantly adjusted, such as re-assigning inexperienced teachers to teach algebra (Clotfelter et al., 2012). These constant shifts, new assignments, and new regulatory guidelines likely influence teachers' efficacy and responsibility beliefs. However, little is known about how mathematics teachers perceive their collective responsibility in the context of the algebra for all initiative and whether these beliefs affect student achievement. Thus, our second aim of this study explored whether mathematics teachers' perceptions of collective responsibility played a role in predicting algebra repeaters' final grade in algebra.

In conceptualizing the study reported here, we drew on ideas rooted in social cognitive theory (Bandura, 1977). Teacher collective responsibility is an extension of research on teacher beliefs and attitudes, stemming out of research on teacher self-efficacy and locus of control (LoGerfo & Goddard, 2008). Teacher self-efficacy involves teachers' beliefs in their abilities to effectively engage in instruction and as a result, positively influence student learning (Tschannen-Moran & Woolfolk Hoy, 2001). In addition, teacher locus of control refers to teachers' tendency to attribute student success or failure to their own performance (Ross, 1995). The construct of teacher collective responsibility extends these ideas, yet is distinct from teacher self-efficacy and locus of control. Teacher collective responsibility is a willingness to be proactive after efficacy beliefs are constructed and a locus of control is attributed to internal, rather than external, factors (LoGerfo & Goddard, 2008). Therefore, teacher collective responsibility is defined as exhibiting collective agency, or the shared beliefs of a group of people that they can collectively work to produce desired effects (Goddard, Hoy, & Woolfolk Hoy, 2000). Because more teacher collective responsibility establishes a school culture where teachers assume the joint responsibility to help students succeed, we expect that more perceived teacher collective responsibility might motivate teachers to work harder to ensure that all students learn and excel in mathematics. More teacher collective responsi-

bility might be especially important for students attempting to pass a gate-keeper course like algebra because of its implications for future mathematics course taking and mathematics motivation (Finkelstein et al., 2012; Howard et al., 2015).

Gender and Mathematics Achievement

We also investigated the role that gender played on the associations among algebra enrollment status (i.e., whether a student repeats algebra or is taking it for the first time), algebra achievement, and teacher collective responsibility. Gender gaps in performance on both school-based and national mathematics assessments are now virtually nonexistent (Agger & Meece, 2015). Despite these gains, stereotypes and perceptions about gender gaps in mathematics performance are still prevalent at all levels of schooling. For example, girls' lower performance and ability in mathematics still permeate the beliefs of students and teachers (Beilock, Gunderson, Ramirez, & Levine, 2010; Cvencek, Meltzoff, & Greenwald, 2011; Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Nosek et al., 2009). Also, boys continue to report more positive mathematics attitudes and affect when compared to girls (Else-Quest, Hyde, & Linn, 2010). Given the more favorable ability beliefs, motivation, and stereotypes regarding the mathematics achievement of boys, we predict that having to repeat algebra may be more detrimental for boys than girls.

The aforementioned gender-related stereotypes that surround mathematics performance and ability are often ingrained in teachers. Teachers have been found to overrate mathematics ability, have higher expectations, and more positive attitudes about male students in mathematics (Li, 1999). As a result of these nuances in student and teacher perceptions of mathematics ability and performance, we argue that gender is an important consideration when studying students' mathematics trajectories. Although boys seem to be stereotyped as more competent in mathematics, little is known about whether teacher collective responsibility differentially affects students based on gender, particularly among those who repeat algebra.

Research Questions

The study reported here used a large, United States nationwide sample that allowed for exploration of both student and teacher factors that predict short- and long-term mathematics outcomes among diverse students repeating algebra or taking it for the first time in the ninth grade. The research questions that guided the inquiry were:

1. Does repeating algebra between eighth and ninth grade predict mathematics grade point average, grade point average in STEM courses, and/or AP mathematics enrollment trends by the twelfth grade?

2. Is repeating algebra associated with receiving a higher final grade in algebra compared to not repeating algebra, when controlling for student demographic characteristics (e.g., race, gender, etc.)?
3. Do mathematics teachers' perceptions of collective responsibility play a role in the achievement of students who repeat algebra?
4. Do these associations differ by student's gender?

Based on prior research, we hypothesized that students who repeat algebra will look significantly different from students who do not repeat the course in terms of their mathematics and STEM grade point average and in their AP mathematics enrollment by the time they are in twelfth grade. In addition, we hypothesized that repeating algebra would be associated with lower final grades in algebra and that teacher collective responsibility would moderate this relation. To be more specific, given that high collective responsibility for students is associated with increases in student learning and more equitable learning environments (Firestone & Rosenblum, 1988; Goddard et al., 2000; Lee & Smith, 1996), we posited that for students repeating algebra, lower levels of teacher collective responsibility would be associated with poorer student achievement in algebra grades. However, predictive relations between gender and teacher collective responsibility remained exploratory.

Methods

Data Source, Participants, and Sampling

Participants included students who took part in the High School Longitudinal Study (HSLs:09). The HSLs:09 dataset, housed by the United States Department of Education, National Center for Educational Statistics (NCES), includes an ethnically diverse sample of students from throughout the country. HSLs:09 employed a two-stage, random sample design where schools were the primary sampling units (PSU). After public and private schools were randomly sampled (1,889 schools were eligible and 944 schools participated), a random sample of ninth-grade students within the PSUs was selected to participate. Of the 25,206 students who were eligible to participate, 21,444 were surveyed (about 27 per school). In the base year students were surveyed in the ninth-grade year (2009), then the spring of their eleventh-grade year (2012). A follow-up data collection occurred in 2013, during the students' expected graduation year, which collected information on students' post-secondary and occupational plans. The current study uses information from all three waves of data.

The sampling pattern employed in HSLs:09 resulted in an ethnically diverse sample consisting of American Indian/Alaska Native 0.73% ($n = 163$), Asian 3.46% ($n = 1,673$), Black/African American 13.52% ($n = 2,214$), Hispanic (no race

specified) 1.69% ($n = 204$), Hispanic, race specified 20.51% ($n = 3,311$), More than One Race 7.74% ($n = 1,912$), Native Hawaiian/Pacific Islander 0.50% ($n = 110$), and White 51.85% ($n = 11,837$). This sample was evenly divided by gender, with 10,887 (50.8%) male students and 10,557 (49.2%) female students.

Procedures. In the base year of the survey, in the fall of their ninth-grade year (2009), students were administered a mathematics assessment and survey component. The first follow-up study was conducted in the spring of most students' eleventh-grade year (2012). There is also a 2013 follow up that collected high school transcripts, a second follow-up which occurred in 2016, and a follow-up planned for 2021 to gather information about students' postsecondary enrollment and later adulthood experiences.

Measures

Algebra course pattern. Using students' eighth- and ninth-grade self-reported mathematics class, two groups were created: (1) *first-time algebra students* who took algebra for the first time in the ninth grade and took either Math 8, Advanced or Honors Math 8, or Pre-Algebra in the eighth-grade ($n = 8,327$); and (2) *students repeating algebra* who took algebra in the ninth grade and in the eighth grade ($n = 1,805$).

Mathematics teachers' collective responsibility. This variable (X1TMRESP) was a composite consisting of seven items that measured mathematics teachers' perceptions of collective responsibility (e.g., *teachers at this school feel responsible that all students learn*) among fellow teachers, $\alpha = .65$. Responses ranged from *strongly agree* to *strongly disagree*, with higher values representing greater collective responsibility. The scale was created by NCES using principal components factor analysis and was weighted and standardized to a mean of 0 and standard deviation of 1.

Final grade in algebra. Students reported their final grade in Algebra I (S2ALG1GRADE) in the first follow up of the HSLS:09 study, in the spring of participants' eleventh-grade year. Grades ranged from: 1 = A (between 90–100), 2 = B (between 80–89), 3 = C (between 70–79), 4 = D (between 60–69), and 5 = Below D (less than 60).

Grade 12 GPA in STEM courses. Students' Grade 12 GPA in STEM related courses (X3TGPASTEM) was calculated using high school transcript information. STEM courses were defined as courses in mathematics, science, computer and information sciences, and engineering and technology. GPAs ranged from 0.25 to 4.00.

Grade 12 GPA in mathematics courses. Students' Grade 12 GPA in mathematics (X3TGPAMAT) was calculated using high school transcript information. GPAs ranged from 0.25 to 4.00.

Grade 12 AP mathematics course enrollment. Students reported whether they were taking or have taken an AP mathematics course by the twelfth grade (S3APMATH). Response options were 1 = Yes and 0 = No.

Gender. Participants' gender (i.e., either male or female) (X1SEX) was collected from one of the following: student questionnaire, parent questionnaire, or school-provided sampling roster. If any responses were inconsistent, a review of the student's first name was conducted.

Control variables. Race (X1RACE), socioeconomic status quintile (X1SESQ5), locale (X1LOCALE), and mathematics test achievement (X1TXMSCR) were used as control variables. Race was taken from participants' self-report and consisted of eight categories (described in the *participants'* section). Locale was measured by identifying whether students were from a city, suburb, town, or rural area. The SES quintile variable was a composite capturing parent/guardian's education, occupation, and family income. Mathematics test achievement was measured in the fall of 2009 by estimating the total number of items that a participant would have answered correctly if they responded to all 72 items in the HSLs:09 mathematics assessment. An (item response theory) IRT-based estimate score was then created for each participant using ability estimates and item parameters derived from the IRT calibration.

Analysis Plan

To address our first research question, separate independent samples t-tests were run to investigate whether students repeating algebra (when compared to students who took algebra for the first time in the ninth grade) had significantly higher (a) grade point averages in mathematics, (b) enrollment in AP mathematics courses, and (c) grade point averages in STEM courses by the twelfth grade. To address the remaining research questions, multiple regression analysis models were run. Model 1 tested the main effect of teacher collective responsibility, algebra enrollment status (students repeating algebra as the reference group), gender (males as the reference group), and several control variables (i.e., mathematics test score in the ninth grade, SES, locale [city as the reference group], and race [White as the reference group] on final grade in algebra. Model 2 further tested if the effect of algebra enrollment status was conditional on either gender or teachers' ratings of collective responsibility, while adjusting for all control variables. Our final model, Model 3, tested the three-way interaction between gender, algebra course status, and teachers' perceived ratings of collective responsibility.

Our analysis utilized both analytic and balanced repeated replication (BRR) weights provided by NCEs (Ingels et al., 2014). Because our analysis incorporated both student and teacher data, we used the base year mathematics course enrollee weight (W1MATHTCH). The analytic weights were used because they accounted for the complex survey design of HSLs:09 and accordingly, generated appropriate

estimates for the target population, with properly adjusted standard errors. In addition, all 200 base year student-level BRR weights (W1STUDENT001-200) were included in the analysis. The BRR weights were used for variance estimation, through calculating standard errors that accounted for the random sampling of students clustered within schools.

Analytic Sample

The current study focused on students who self-reported taking algebra in the ninth grade and who also took one of the following courses in the eighth grade: Algebra, Pre-Algebra, Math 8, or Advanced or Honors Math 8 not including Algebra ($n = 10,132$). Participants who did not fit these criteria were excluded from the analysis. We were also interested in students' final grade in algebra, thus, of the 10,132 students eligible for the study, students who were in non-graded algebra courses ($n = 11$) or courses in which students did not receive a grade ($n = 65$), were omitted from analyses. The total sample eligible for this study consisted of 10,056 participants.

From the sample eligible, missing values were found for only two measures: teacher collective responsibility and final algebra grade. These missing data resulted from participants either not responding to the overall questionnaire (i.e., unit non-response) or because they omitted one or more related questions (i.e., item non-response). To account for missing data due to unit non-response, two adjustments were applied to each set of base weights to reduce bias (Ingels et al., 2014). Additionally, listwise deletion was used in each regression model to drop cases that were missing due to item non-response ($N = 1,131$). After addressing missing data, the final analytic sample included a total of 8,140 students.

Results

Figure 1 shows ninth graders' final grade in algebra by comparing students repeating algebra to first-time algebra students (i.e., students taking algebra for the first time in the ninth grade). An independent samples t-test was run to determine if there were any initial differences in algebra grade by algebra course status (i.e., whether the student was enrolled in algebra for the first time or was repeating the course). The descriptive results suggest that by the end of the ninth grade, students repeating algebra earned significantly higher final grades in algebra ($M = 3.94$; $BRR SE = 0.05$) when compared to first-time algebra students ($M = 3.77$; $BRR SE = 0.03$), $t(8,908) = 3.19$, $p < .01$. Figure 1 illustrates this pattern, suggesting that the biggest difference between grades occurred when there was higher achievement, which was less the case for students with lower mathematics grades.

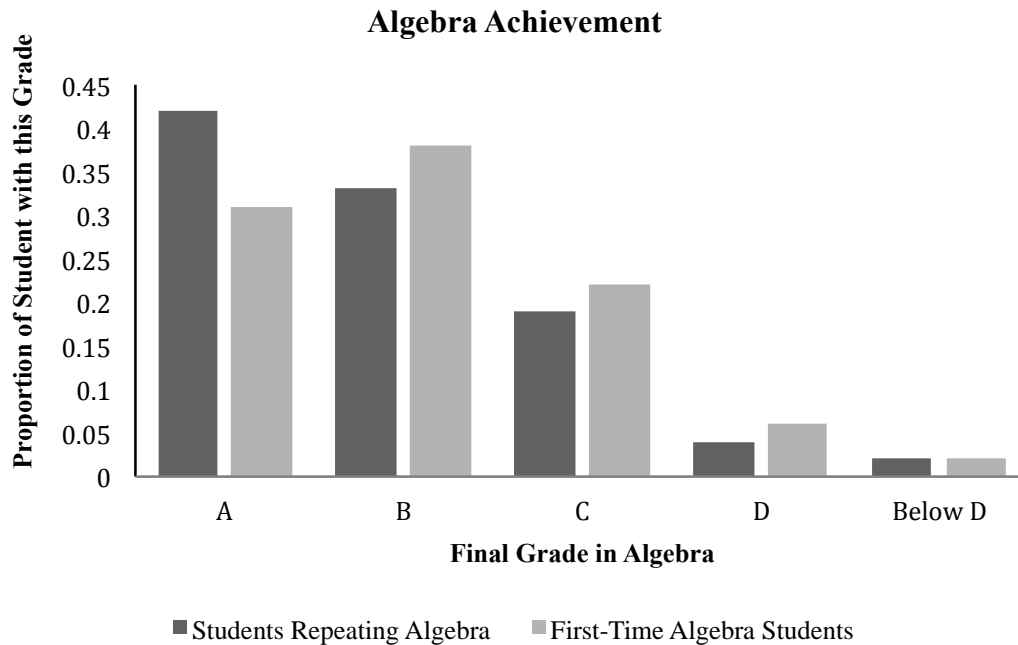


Figure 1. The distribution of students repeating algebra when compared to first-time algebra students across final grades in algebra.

We also wanted to examine how students repeating algebra, relative to students who were taking algebra for the first time, fared in overall mathematics grade point average, grade point average in STEM courses, and AP mathematics enrollment by the time they reached the twelfth grade. Our descriptive analyses showed that students repeating algebra attained significantly higher grade point averages in STEM courses ($M = 2.34$; $BRR SE = 0.04$) by twelfth grade when compared to students who took algebra for the first time in the ninth grade ($M = 2.18$; $BRR SE = 0.02$), $t(9,677) = 3.82, p < .001$. Additionally, students repeating algebra showed higher grade point averages in mathematics by twelfth grade ($M = 2.26$; $BRR SE = 0.04$) than students who took algebra for the first time in the ninth grade ($M = 2.08$; $BRR SE = 0.02$), $t(9,690) = 3.70, p < .001$. Of the respondents eligible for this study who took an AP course, only $N = 1,406$ reported taking an AP mathematics course. Chi-squared analyses in Table 1 demonstrated that the percentage of participants that repeated algebra when compared to students who took algebra for the first time differed significantly on whether or not they took an AP mathematics course by the twelfth grade, $\chi^2(1, N = 1,406) = 6.24, p < .01$.

In addition to the descriptive analyses, our main research question involved testing the interaction between algebra course status, teacher collective responsibil-

ity, and gender. Because results in Table 2 for Models 1 and 2 were conditional on the results in Model 3, only Model 3 findings are presented and discussed. Model 3 findings suggest that the predictors in the model explained 16% of the variance in mathematics achievement ($R^2 = .16$, $F(19, 181) = 24.48$, $p < .001$). Beginning with the control variables in Model 3, we found that when all variables were held constant, an increase in students' SES ($\beta = .04$, $p < .05$) and standardized mathematics test score ($\beta = .03$, $p < .001$) significantly predicted a decrease in final mathematics grade in algebra.

Table 1
Cross-Tabulation of Algebra Course Status and AP Enrollment

AP Enrollment	Algebra Course Pattern		χ^2
	Repeating	First Time	
No	246	757	6.24*
Yes	125	278	

Note: * $p < .05$.

Furthermore, there were significant differences among ethnic groups in terms of final grades in algebra. Table 2 indicates that Asian students' final grade in algebra was significantly higher than White students' ($\beta = .22$, $p < .05$), whereas Hispanic students' final algebra grade ($\beta = -.18$, $p < .01$) was significantly lower than White students' final grade in algebra.

Table 2
Multiple Regression Results for Final Grade in Algebra

Parameter	Final Grade in Algebra		
	Model 1	Model 2	Model 3
Constant	2.34 (.14)***	2.36 (.15)***	2.36 (.15)***
Suburb	.05 (.06)	.05 (.06)	.05 (.06)
Town	.09 (.08)	.10 (.08)	.10 (.08)
Rural	.15 (.08)	.15 (.08)	.15 (.08)
Socioeconomic Status	.04 (.02)*	.04 (.02)*	.04 (.02)*
Mathematics Test Score	.03 (.00)***	.03 (.00)***	.03 (.00)***
American Indian and Alaska Native	-.40 (.22)	-.40 (.22)	-.40 (.22)
Asian	.22 (.09)*	.22 (.09)*	.22 (.09)*
Black/African American	-.13 (.08)	-.13 (.08)	-.13 (.08)
Hispanic (no race specified)	-.35 (.23)	-.36 (.22)	-.35 (.24)
Hispanic	-.18 (.08)*	-.18 (.09)*	-.18 (.08)*
More Than One Race	-.17 (.09)	-.17 (.09)	-.17 (.09)
Native Hawaiian and Pacific Islander	-.21 (.29)	-.20 (.30)	-.20 (.30)
Taking Algebra for the First Time	-.08 (.07)	-.10 (.10)	-.09 (.10)
Female	.26 (.04)***	.21 (.10)*	.23 (.10)*

Teacher Collective Responsibility	.02 (.02)	.04 (.06)	.14 (.07)*
Taking Algebra for the First Time x Teacher Collective Responsibility		-.04 (.05)	-.17 (.07)*
Taking Algebra for the First Time x Female		.06 (.11)	.04 (.11)
Female x Teacher Collective Responsibility		.04 (.04)*	-.19 (.09)*
Taking Algebra for the First Time x Female x Teacher Collective Responsibility			.27 (.10)**

* $p < .05$; ** $p < .01$; *** $p < .001$

Note: White, Male, and City are the reference group.

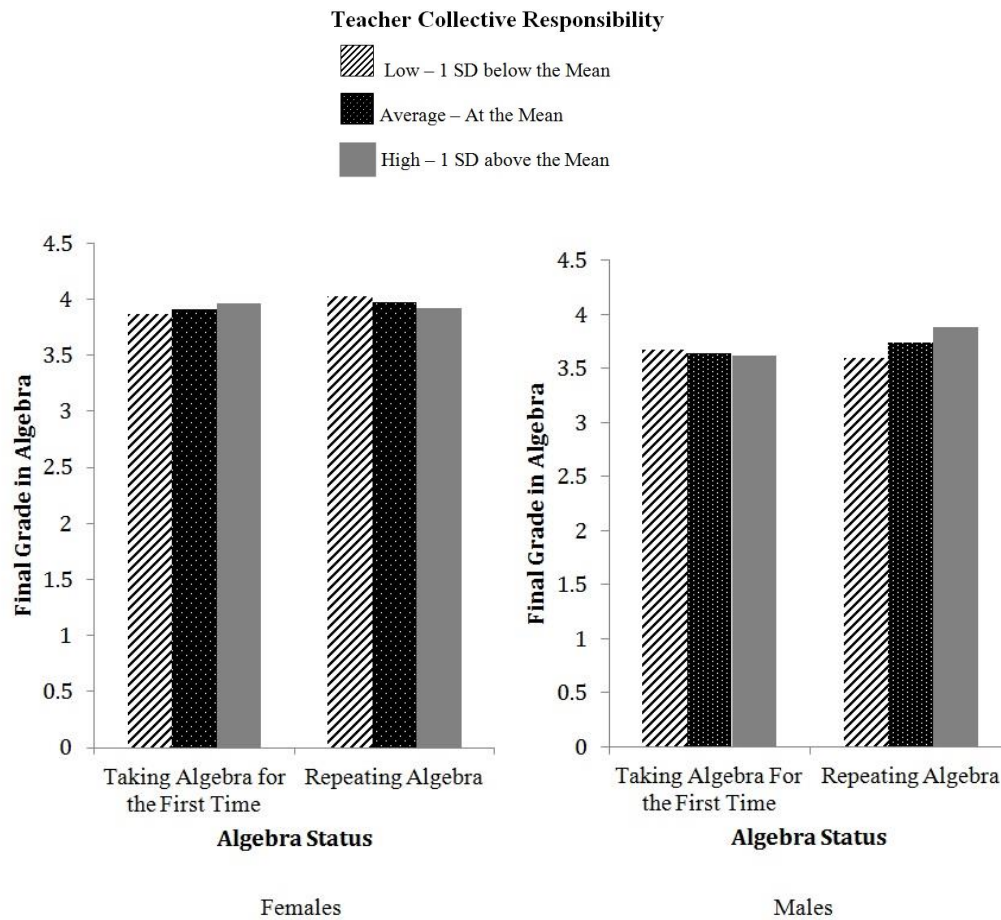


Figure 2. The three-way interaction between algebra course type, teacher collective responsibility, and gender. (left panel = female students; right panel = male students)

The main finding, however, was a significant three-way interaction between the algebra course type, participant's gender, and ratings of teacher collective responsibility ($\beta = .27, p < .01$). This interaction is illustrated in Figure 2.

Across all levels of teacher collective responsibility and algebra course type, female students (Figure 2, left panel) held a higher expected algebra grade when compared to male students (Figure 2, right panel). The biggest difference between male and female students' algebra grades, however, was when teacher collective responsibility was low (i.e., 1 standard deviation [SD] below the mean); in this case, male students repeating algebra showed significantly lower grades in algebra than female students repeating algebra ($b = -.42, z = -2.63, p < .01$). Furthermore, (Figure 2, right panel) when teacher collective responsibility was high, male students repeating algebra had significantly higher grades in algebra than male students who were taking algebra for the first time ($b = .27, z = 2.56, p < .05$). Lastly, male students repeating algebra who were low on teacher collective responsibility also had lower grades in algebra ($b = -.29, z = -2.06, p < .05$) when compared to male students repeating algebra with high ratings of teacher collective responsibility.

Discussion

The recent rise in algebra course taking across the United States (Liang et al., 2012; NCES, 2005) has spurred increases in the incidence of students repeating the course. Using a nationwide sample of contemporary high school students, the study reported here sought to compare students who repeated algebra to students who took it for the first time in ninth grade on various mathematics success indicators. Our descriptive results suggest that repeating algebra was associated with a higher GPA in mathematics and STEM courses, as well as an increase in the number of AP mathematics enrollment by the twelfth grade. While repeating algebra initially holds students back from taking the next mathematics level, our findings suggest that in the long term, taking algebra a second time does not hinder students' future in mathematics and in STEM course pathways. On the contrary, these findings are consistent with prior work suggesting that repeating algebra can bolster later mathematics achievement and future mathematics success (Attewell & Domina, 2008; Fong et al., 2014; Gamoran & Hannigan, 2000).

Preliminary results also show differences in final algebra grades in the ninth grade. Although the number of students who earned lower grades (e.g., grade C or below) was more similar between algebra status groups, students who repeated algebra tended to earn more "A" grades than first time algebra takers. It is important to caution that it remains unclear whether the achievement benefits associated with repeating algebra are truly a function of repeating the course or instead partly explained by the potential benefits of already starting on a more advanced curriculum

(i.e., starting algebra in the eighth grade). Prior research has suggested that being placed in an advanced curricular track tends to be associated with higher motivation and teacher engagement (Oakes, 2008). Therefore, it could be that students who repeat algebra (especially those who tend to earn higher grades) may already have adaptive tools (e.g., motivation) to succeed; consequently, they may be better inclined to reap the benefits of retaking the course. It may also be the case that increased exposure to algebra material, through taking the course a second time, could boost motivation and confidence in that subject. More research is needed to understand how repeating courses is linked to motivation, achievement, and curricular track.

The results from our main analysis also show that students who repeated algebra significantly differed from first-time course takers in their final algebra grade; however, differences in final algebra grade depended on teacher-rated collective responsibility and students' gender. As an example, for male students who were repeating algebra, as teacher collective responsibility decreased so did their final grade in algebra. Additionally, when looking at differences between male and female students, male students who repeated algebra when compared to female students who repeated algebra with low collective responsibility had significantly lower grades in algebra. These findings are consistent with prior evidence showing that lower teacher collective responsibility is associated with poorer achievement (Lee & Smith, 1996). Although our descriptive results suggest that repeating algebra may not be detrimental for mathematics success, the results from our main analysis highlight that in schools with low mathematics teacher collective responsibility, mathematics grades for students repeating algebra may suffer, especially for male students.

Why would being a male student repeating algebra (compared to a female student repeating algebra) in a school with lower teacher collective responsibility be more harmful for final algebra grades? We posit two different explanations. First, we know from the literature on grade retention that repeating a grade contributes to poor mental health, negative attitudes about school, and lower gains in achievement, which can create a stigma of failure (Feldman, Smith, & Waxman, 2014). Given that male students are historically stereotyped as better in mathematics, having to repeat algebra (regardless of the reason) makes them deviant from this stereotype, which could activate a stigma of failure and lead them to disengage in the course. We expect this to be the case in schools with low teacher collective responsibility, because this context tends to have teachers who are less willing to feel responsible for student learning. Thus, a disengaged mathematics teacher and disengaged student (as a result of repeating a course) could be a double-edged sword. For female students, however, teacher collective responsibility level matters less for their final grade in algebra, regardless of whether girls are repeating algebra or taking it for the first time. Collectively, these findings indicate that for male students,

attending schools where there is more teacher collective responsibility, could serve as a buffer of achievement particularly for male students who are taking algebra a second time.

Another interpretation of these findings could be framed using an attribution theory of achievement motivation (Weiner, 2000). Research on attribution theory suggests that boys who experience failure in mathematics tend to attribute their failure to external forces (e.g., the teacher), whereas girls tend to attribute their failure to their lack of ability (Stipek & Gralinski, 1991). Given these achievement attribution patterns, we might expect that boys will tend to view the teacher as less of a support system and more of a contributor to poor performance in algebra. This tendency may be particularly salient in the case of students who repeat algebra, given that they tend to already report lower interest and utility in mathematics (Howard et al., 2015). Thus, having teachers in the school who feel less responsible for student learning might exacerbate these negative feelings and in turn affect achievement. Alternatively, when teacher collective responsibility is high in schools, male students repeating algebra may be more motivated to try because higher teacher support in the classroom may be encouraging for future success.

Prior research on the role of teachers in the classroom has focused predominantly on the positive implications (e.g., better academic performance and engagement) of more teacher support (Goodenow, 1993; Puklek Levpušček & Zupančič, 2008); however, our research draws particular attention to the collective influence that mathematics teachers play within a school. In our study, teacher collective responsibility is something that students have no control over, yet it was associated with students' success in the classroom. Given the present findings, it is noteworthy to recognize that in addition to the direct influence of teachers in the classroom, the overall practices and school culture teachers follow within a school could play an important role on students' achievement.

Limitations and Future Research

There are several limitations to the study reported here that are important to address. First, although we examined the influence of teacher collective responsibility, we only assessed this phenomenon from the teachers' perspectives and not from the students' points of view. Future research should compare whether students' perceptions of teacher collective responsibility in mathematics could differ from the effect that teachers' perceptions of collective responsibility has on achievement. Moreover, it would be interesting to examine whether a mismatch in these two perceptions of teacher collective responsibility could weaken the direct association on student achievement. Second, although we could account for differences between schools by using weights in the analyses, we were not able to conduct multilevel analyses due to restrictions from the public-use data. Public-use data suppresses information on the identity of responding schools and the individuals within them. As a result, we were

not able to use hierarchical linear modeling, which would allow for tests of whether differences between schools exist in the effect of teacher collective responsibility on final algebra grades. This more advanced statistical approach could have also provided relevant information about students' mathematics course-taking patterns, mathematics rigor in the school or classroom, and mathematics culture within departments that often differ between schools or even districts. Missing data on both teacher collective responsibility and students' final grade in algebra also posed a limitation in our research.

Another limitation was that despite administering important controls in our analysis, there could have been some variation in the type of students who repeated the course that we did not consider. For example, we did not explicitly investigate why the students repeating algebra retook mathematics. Some could have repeated algebra due to a poor grade while others could have repeated algebra due to poor school policies that do not accurately place students in the next level of mathematics. Although this concern is beyond the scope of this research, this is an important issue to consider in future research that explores algebra repeaters.

Finally, although our research focused on the importance of teacher collective responsibility as a moderator of mathematics achievement, we recognize that many other teaching-related factors could also shape students' algebra learning. In the present study, teacher collective responsibility captured the collective mathematics teacher investment and obligation teachers feel for student learning (LoGerfo & Goddard, 2008). However, more proximal measures of teacher influence (e.g., teaching style) also shape algebra achievement. For example, mathematics classrooms that featured more engaging instructional techniques, better class organization, and more emotional support are associated with higher student achievement, even after accounting for baseline achievement (Allen et al., 2013). Active engagement with mathematics has also been found to serve as a protective factor of interest in mathematics (Martin, 2009). More active engagement in the classroom may be of utmost importance when students struggle in mathematics, especially when they are forced to retake a course. To illustrate, Boaler and Sengupta-Irving (2016) administered a 5-week teaching intervention focusing on active engagement, challenging algebraic problems, and student collaboration with students who previously failed in mathematics. These student-focused teaching techniques helped improve mathematics grades, engagement, and overall interest in mathematics. Collectively, these studies highlight the importance of studying proximal teacher influences. Future research should delve into how these other variables relate to performance in algebra.

Closing Thoughts

Despite the caveats in our study, our findings provide novel information on the short- and long-term benefits of repeating algebra. Furthermore, the results of

this study shed light on the importance that teacher collective responsibility could play on algebra grades when students (particularly male students) repeat algebra. To help foster a culture of more collective responsibility among teachers, we recommend encouraging teacher collaboration and emphasizing responsibility for student learning, especially for male students who may be overlooked due to stereotypical beliefs that they are higher achievers in mathematics (Beilock et al., 2010; Nosek et al., 2009). Drawing on the results of our study, we also recommend providing professional development opportunities where the school administration could help increase teacher morale and emphasize the critical role that teachers play on mathematics achievement. While a shift toward more teacher collective responsibility could benefit all students and teachers, this has important implications for male students who are re-taking an important gate-keeping course (i.e., algebra) related to STEM pathways.

Shifting educational policies in mathematics may also shape the curricular landscape for teachers and students that could consequently alter when students take algebra and what teaching approach is used. For a few years now, the algebra for all initiative has been a prominent force in mathematics educational policy that has accelerated algebra placement; however, the change toward emerging policies like the Common Core State Standards may create a deceleration of mathematics placement in algebra courses. One of the key shifts in Common Core Standards for Mathematical Practice¹ is to focus less on racing to cover all the material and instead focus on assuring an understanding of the depth of the material. With rising changes in mathematics policy and the uncertain future of Common Core, there may be direct implications on the conversations and collective teamwork mathematics teachers partake within their schools. As an example, the new Common Core Standards in Mathematics require a gradual progression and connection of content from grade to grade; for these connections to happen, mathematics teachers must be willing to work together, to communicate, and to embed a collective effort to help students build on previous grade material. As these standards change, it is important that researchers capture whether any changes in teacher collective responsibility result from these new policies and how these changes may affect student learning, especially for students struggling in mathematics (e.g., students who repeat algebra).

Lastly, although closing the gender mathematics achievement gap has been somewhat at the forefront of mathematics policy discussions since the 1970s (Jacobs, 2005), it is essential that teachers and policymakers recognize that male students (especially those struggling in mathematics) also need a strong support system. These findings are particularly relevant given new data suggesting that the gender mathematics achievement gap is closing, and that female students are per-

¹ See <http://www.corestandards.org/Math/Practice/>.

forming at similar rates as male students (Hyde et al., 2008). Thus, for students (especially male students) who repeat algebra, teacher support in the classroom is especially vital in helping students persist and succeed in mathematics.

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