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The Impact of Communal Learning Contexts on Adolescent Self-Concept and Achievement: Similarities and Differences Across Race and Gender

Nilanjana Dasgupta[1], Kelsey C. Thiem[2], Alice E. Coyne[1], Holly Laws[1], Marielena Barbieri[1], and Ryan S. Wells[3]

[1] Department of Psychological and Brain Sciences, University of Massachusetts Amherst
[2] Department of Counseling Psychology, Social Psychology, and Counseling, Ball State University
[3] Department of Educational Policy, Research and Administration, University of Massachusetts Amherst

Misalignment between students' communal values and those expressed in classrooms is an obstacle to academic engagement, especially in mathematics, and especially for racial ethnic minority and female students. Using 10 schools across the United States, we conducted a longitudinal field study in 8th grade mathematics classes to investigate: (a) how perceptions of communally oriented classrooms influence student outcomes in early adolescence, (b) what psychological processes mediate these relations, and (c) whether the influence of perceived communal practices in classrooms have similar or different effects on students with varying social identities based on race, ethnicity, and gender. Results showed that middle school classes that emphasize communality (both social relevance of math and peer collaboration) significantly predicted stronger math self-concept, more behavioral engagement, and better performance in math. These associations were mediated through three psychological processes—belonging, challenge, and self-efficacy. Among racial ethnic minority adolescents, feelings of belonging and challenge in math class were key psychological processes that enhanced math learning outcomes. These processes were activated when classes connected communal values to math. Finally, communal learning contexts benefited girls and boys equally. In sum, communal values practiced by emphasizing social relevance of academic content and using collaborative learning practices engage all students, especially students of color, at a formative period of academic learning in mathematics.

Keywords: communal goals, motivation, self, social identity, STEM

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People gravitate toward some activities, social roles, contexts, and occupations and away from others. What influences our interests and choices? Several psychological theories converge on a common answer pointing to the importance of alignment between personal values central to one's self-concept and prominent aspects of the social context. This person-context alignment satisfies individuals' core needs and increases their interest, approach motivation, and persistence in the given social context (Diekman et al., 2017; Eccles, 1987, 1994; Eccles et al., 1983; Harackiewicz & Sansone, 1991; Higgins, 2006; Higgins & Scholer, 2009; Sheldon & Elliot, 1999; Schmader & Sedikides, 2018; Stephens et al., 2012). Applied to educational contexts, increasing the alignment between personal values and learning environments influences individuals' intellectual interests, motivation, persistence, and occupational choices (Diekman et al., 2017; Eccles, 1987, 1994; Eccles et al., 1983; Stephens et al., 2019).

One core value that attracts individuals toward activities, roles, and aspirations is communality. Communal values, which have two components, refer to an interest in prosocial endeavors in the real world (e.g., motivation to help people) and an interest in relational activities (e.g., motivation to work collaboratively with others). Individuals sometimes satisfy their communal values by pursuing activities that have an altruistic purpose and at other times by pursuing

Nilanjana Dasgupta https://orcid.org/0000-0003-1438-6066
Kelsey C. Thiem https://orcid.org/0000-0002-3837-7028
Marielena Barbieri https://orcid.org/0000-0002-0809-3390
Ryan S. Wells https://orcid.org/0000-0002-6265-825X

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Nilanjana Dasgupta designed this research study and acquired funding. Kelsey C. Thiem and Marielena Barbieri collected data and managed project implementation with supervision from Nilanjana Dasgupta. Alice E.Coyne and Holly Laws analyzed data. All authors wrote parts of the manuscript, reviewed, and edited it.

In keeping with open science practices, our data, syntax, measures, and supplementary results are publicly available through Open Science Framework: https://osf.io/6srf7/?view_only=e61b3065a1724dca97566869846d3b33.

Correspondence concerning this article should be addressed to Nilanjana Dasgupta, Department of Psychological and Brain Sciences, University of Massachusetts Amherst, Tobin Hall, 135 Hicks Way, Amherst, MA 01003, United States.Email: dasgupta@psych.umass.edu

activities that involve working cooperatively with others (Brown, Smith et al., 2015; Diekman et al., 2017). The personal importance of communal values and the perception that this value is not aligned with science, technology, engineering, and mathematics (STEM) is a critical obstacle that keeps young people away from activities, academic pursuits, and careers in STEM (Corbett & Hill, 2015; Morrell & Parker, 2015; National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2010).

Unlocking solutions to enhance young people's interest in, and pursuit of, STEM education and careers is of urgent national interest given the national demand for a 21st century workforce with scientific and technological skills and a lagging supply of STEM graduates. The undersupply of STEM students is particularly pronounced for women, African Americans, Hispanics/Latinx, and Native Americans compared with White and Asian men (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2010; National Science Foundation, 2017). Fewer women and non-Asian people of color occupy jobs in STEM relative to their proportion in the U.S. population, even though these jobs are lucrative and growing rapidly. Helping to explain this gap between demand and supply is evidence that women and underrepresented students of color are strongly committed to communal values and goals (Boykin, 1986; Dasgupta & Stout, 2014; Fryberg & Markus, 2007; Gaines et al., 1997; Gray et al., 2020; Harper, 2005; Smith et al., 2014; Su et al., 2009; Torres, 2009), and the perceived misalignment between these values and STEM is a key deterrent that keeps them away from pursuing STEM education and careers (Boucher et al., 2017; Brown, Smith et al., 2015; Corbett & Hill, 2015; Diekman et al., 2017; Smith et al., 2014; Thoman et al., 2015).

Indeed, math and science education is typically *not* framed in terms of satisfying communal goals of helping people and benefiting society. Instead, it is framed as satisfying goals of personal curiosity, interest in new discoveries, solving puzzles, and creating new knowledge for its own sake (Conrad et al., 2009; Henrion, 1997). Mathematics, even more than the sciences, is an abstract discipline whose applications in the real world are often not obvious to young people unless explicitly framed in such a way. Because math is the common foundation of all STEM disciplines, students' perception that learning math is misaligned with their communal values is likely to carry over to other quantitatively intensive academic subjects, leading to less interest, curiosity, and motivation in these fields. Put differently, when the link between math and its social utility is not emphasized, students with prosocial and relational interests are likely to view math as an unappealing obstacle to overcome.

Most of the burgeoning research on the impacts of the misalignment between communal values and STEM has been conducted with young adults, with a focus on gender (Boucher et al., 2017; Casad et al., 2018). Extant work often uses hypothetical scenarios to assess whether imagining STEM classes or lab groups that are communally oriented influence the opinions of psychology undergraduates who may not have any real intention to engage with natural sciences, computer sciences, or engineering (e.g., Belanger et al., 2017, Studies 2–3; Belanger et al., 2020, Studies 3–4; Diekman et al., 2011). Other studies use correlational surveys with adults from a mix of STEM and non-STEM backgrounds asking them to recall past experiences from STEM classes (e.g., Belanger et al., 2017, Study 1; Belanger et al., 2020, Study 1). These studies provide evidence that past experience with communally oriented STEM classes is associated with retrospective reports of greater belonging in those classes and more positive attitudes toward STEM majors and careers. Finally, different from most adult samples, one pretest-posttest study examined adolescent girls' experiences during a one-day "women and science" event (Belanger et al., 2020, Study 2). Results showed no change in girls' interest in STEM careers from preevent to postevent. However, correlationally speaking, girls who thought that female scientists behaved communally in their careers and believed that STEM careers afford communal goals, felt greater belonging in math and science, which in turn was associated with greater interest in pursuing STEM careers (Belanger et al., 2020, Study 2).

Although the above-mentioned bodies of research collectively point to the benefits of person-context alignment for young adults, it also exposes critical knowledge gaps. First, it is unknown whether and what types of communally oriented learning contexts influence youth and adolescents earlier in development, when academic and career interests are more malleable, and when formal education is less stratified into specialized pathways. The one adolescent study we were able to find (Belanger et al., 2020, Study 2) did not find prepost changes in adolescent outcomes after exposure to a learning context. Second, because most of the research on communal values in the context of STEM focuses on gender, surprisingly little is known about whether and how perceived alignment between communal values and STEM influence racial ethnic minority students as compared with their White peers (for an exception see Thoman et al., 2017). Third, there is a paucity of research examining person-context alignment in naturally existing learning contexts without relying on retrospective recall or hypothetical scenarios constructed in laboratory studies, raising the concern that research using hypothetical scenarios or past recollections may not generalize to students' current experiences in real STEM classrooms as reliably as assumed.

Addressing these knowledge gaps is critical to expand and revise theories about how person-context alignment influences young people's self-concept, motivation, and learning in STEM well before adulthood. Filling these knowledge gaps promises to clarify how such alignment impacts racially diverse groups compared with their White peers and students of all genders. Moreover, embedding research in naturally existing educational contexts where learning occurs allows an easier translation from theory-driven research to interventions on student engagement in STEM.

The purpose of the present research is to address the three knowledge gaps identified above. First, our research taps into communal values in math classes in early adolescence (middle school), informed by prior research that shows emergent interests in this particular developmental period persists longitudinally through high school and well into college years to predict college majors (Loveless, 2013; Maltese & Tai, 2011; Simpkins et al., 2006; Stein et al., 2011; Tai et al., 2006). Second, we investigate whether student perceptions of classroom contexts in mathematics that vary in communal orientation influence adolescent participation, math self-concept, and performance. We also shed light on intervening psychological processes through which classroom contexts influence these outcomes. Third, we illuminate how adolescents of varying races, ethnicities, and genders respond to communally oriented math classes in terms of behavior, self-concept, and achievement in math, and through which psychological mechanisms.

Values Influence Academic and Career Interests

Several theories in psychology converge on the common message that the fit between individuals' values and their social context promotes greater satisfaction, motivation, and less stress, including expectancy value theory (Eccles, 1987, 1994; Eccles et al., 1983), utility values (Harackiewicz & Sansone, 1991; Sheldon & Elliot, 1999), goal congruity theory (Diekman et al., 2017), SAFE model (State Authenticity as Fit to the Environment model; Schmader & Sedikides, 2018), cultural mismatch theory (Fryberg & Markus, 2007; Stephens et al., 2012), and regulatory fit theory (Higgins, 2006; Higgins & Scholer, 2009).

For example, the SAFE model articulates how social identities motivate the situations that people approach or avoid. The model outlines three types of person–environment fit: self-concept fit, goal fit, and social fit, that facilitate cognitive, motivational, and social fluency to promote a personal sense of authenticity and drive approach or avoidance behaviors. Social contexts subtly signal social identities in ways that implicate each type of fit, eliciting state authenticity for advantaged groups but state inauthenticity for disadvantaged groups. Because people are most comfortable being their authentic selves, these processes lead to self-segregation among groups, reinforcing social inequalities. This is a general model, not specific to any particular context or to any developmental stage in life. Yet, applied to education, it is more likely to be relevant to adult experiences in higher education where individuals have the choice to opt into some institutions, learning environments, and subject matter and the choice to avoid others. It is less applicable to earlier stage of development—childhood and adolescence—where there is little or no choice to approach or avoid particular schools, classes, and subject matter.

Another person-fit theory specifically oriented toward higher education and working class students is cultural mismatch theory (Fryberg & Markus, 2007; Stephens et al., 2012). Cultural-mismatch points out that American institutions of higher education are built around middle- and upper-class cultural norms that value independence—realizing one's individual potential, thinking independently, finding oneself, following one's own passions, and striking out on one's own. The emphasis on independence is misaligned with working class cultural emphasis on interdependence, community learning, connecting with others, following the footsteps of accomplished others, developing the ability to support one's family, and giving back to one's community. The misalignment between the values of American higher education institutions and the cultural values of working class students systematically disadvantages these students (Dittmann et al., 2020; Stephens et al., 2019). This theory is oriented to higher education and the experience of working-class adult students in those spaces. It is less applicable to children and adolescents in K–12 learning environments, and its generalizability to STEM learning contexts is unknown.

More closely applicable to STEM educational and career choices is expectancy-value theory (Eccles, 1987, 1994; Eccles et al., 1983), which was an early proponent of the notion that personal values shape academic achievement. Leveraging expectancy-value theory, utility value interventions in college science classes—which asked students to write about the personal relevance of a science course in their lives—found increased motivation and performance, especially for racial minority students who were the first in their families to attend college (Canning et al., 2018; Harackiewicz et al., 2016). Similarly, goal congruity theory argues that the alignment between individuals' value preferences—to be communal or agentic—makes them gravitate toward other-directed or self-directed roles and preferences, respectively. When social roles align with individuals' values and goals, that person-context alignment (or goal congruity) enhances motivation and persistence whereas when alignment is poor, individuals seek to reduce incongruity, often by exiting the role (Diekman et al., 2010, 2011, 2017).

Past research has attempted to increase alignment between values and STEM engagement in three ways. First, some studies have emphasized the personal relevance of a set of skills for oneself and one's future career (Eccles, 2009; Eccles et al., 1983; Gaspard et al., 2015; Harackiewicz et al., 2016; Hulleman et al., 2010, 2017; Rozek et al., 2015). This work found that when personal relevance of STEM was emphasized, students saw greater value in the work (Harackiewicz et al., 2012) and reported stronger self-efficacy, motivation, and achievement (Brisson et al., 2017; McKellar et al., 2019). Second, other studies emphasized the communal value of a set of skills or tasks to help other people, community, and society (Brown, Smith, et al., 2015; Brown, Thoman, et al., 2015; Diekman et al., 2017; Gray et al., 2020; Rodriguez et al., 2013). Communality, in this context, has been variously referred to as communal utility values, communal goal affordances, communal responsibility, or communal learning opportunities (Gray et al., 2020). This work found that when communal goals are emphasized, students express greater motivation and career interest in STEM (Brown, Smith et al., 2015; Brown, Thoman, et al., 2015; Gray et al., 2020; Weisgram & Bigler, 2006). Third, yet other studies have emphasized collaborative learning practices such as connective instruction or cooperative learning (see Martin & Dowson, 2009, for a review), that promote shared goals, shared resources, working together to attain mutual rewards, relatedness among learners, and lead to more positive outcomes than competitive environments (Diekman et al., 2017; Gray et al., 2020; Oakes, 1990; Qin et al., 1995).

Values Enacted in Real STEM Classrooms

The importance of communal values has been explicitly recognized and encouraged in mathematics teaching standards; teachers are encouraged to see their classrooms as communities rather than simply a collection of individuals (National Council of Teachers of Mathematics, 1991, 2000). When asked about these communal practices, teachers respond overwhelmingly positively about valuing communal aspects of learning as indicated by their attitudes and beliefs (Antil et al., 1998; Banilower et al., 2013, 2018). However, observations of *real* classroom practices reveal a different story. Student collaborations and drawing explicit connections between curriculum and real-world problems are often not implemented in real classrooms (Antil et al., 1998; Pietsch, 2020; Wilburne et al., 2018), as illustrated by observational studies of STEM classrooms (Weiss et al., 2003).

Weiss et al. (2003) observed classroom practices of over 300 math and science teachers in K-12 schools; roughly 30% of these classes were in middle schools and 20% were math classrooms in middle school. They assessed two aspects of communality: drawing connections between learning content and social impact as well as collaborative or relational aspects of learning. In terms of real-world applications of course content, they observed that almost 20% of teachers did not draw any connections between STEM course material and real-world connections and only 5% of teachers did so to a great extent. The average frequency with which teachers emphasized real world applications in STEM classes was lower than the midpoint of the observational scale (less than "some of the time"). In terms of encouraging peer collaboration in class, 29% of teachers did not do so at all and only 7% did it to a great extent. The average rating for collaboration was well below the midpoint of the observational scale. These findings confirm that despite teachers' support of communal values and teaching practices in principle, its implementation in real STEM classrooms is far less common (Antil et al., 1998; Pietsch, 2020; Wilburne et al., 2018). Despite recommendations for collaboration, it "remains the exception in mathematics classrooms rather than the rule" (Pietsch, 2020, p. 5).

Psychological Mechanisms

STEM learning contexts that emphasize communal values are likely to enhance young people's STEM engagement and performance through multiple psychological mechanisms. First, highlighting communal values in achievement contexts is associated with increased sense of belonging in that context (Calabrese Barton, & Tan, 2018; Gray et al., 2020; Smith et al., 2014). This is especially likely for students who experience negative stereotypes and marginalization in these achievement contexts (Martin, 2005; Phillips et al., 2020; Walton & Brady, 2017). For example, a youth enrichment program with relatedness as a central theme attributed part of its success to the climate of cooperation and the resulting sense of belonging (Martin, 2005). As a corollary, Native American students with high communal value orientations experienced greater belonging uncertainty in STEM in college most likely because their value orientations were not aligned with their classes (Smith et al., 2014).

Second, communal values may also influence student engagement by enhancing self-efficacy or self-confidence. Although self-efficacy is often viewed as an intrapersonal trait, interpersonal features of social settings such as cooperative classrooms are important boosters of self-efficacy (Bandura, 1997; Martin, 2005; Martin & Dowson, 2009). Specifically, students' beliefs in the altruistic value of science and the perceived alignment between STEM and their own communal values predict the development of self-efficacy (Nugent et al., 2015; Weisgram & Bigler, 2006). Indeed, an intervention focused on the relevance of mathematics not only improved students' math achievement, but also their self-efficacy, suggesting a possible mediating influence (Brisson et al., 2017).

Third, approach motivation in response to challenging activities is likely to be another mediator between communal practices and academic outcomes. Observational research shows that increasing the fit between students' values and math tasks predicts greater motivation, aligning with theories of goal congruence and regulatory fit (Rodriguez et al., 2013). Similarly, when communal values or personal values are emphasized in interventions, students show greater motivation to pursue STEM majors and careers (Brown, Smith et al., 2015; Harackiewicz & Priniski, 2018). Importantly, emphasizing the personal relevance of STEM predicts greater motivation for racial minority students (Canning et al., 2018; Harackiewicz et al., 2016) and women students (Diekman et al., 2017; McKellar et al., 2019). Overall, belonging, self-efficacy, and motivation are likely to be proximal psychological processes through which adoption of communal values in STEM classrooms impact student self-concept, classroom behavior, and performance in STEM. This is consistent with the SAFE model that increased self-concept fit, goal fit, and social fit between communal learning environments and students' valued goals fuels motivation and a sense of belonging (Schmader & Sedikides, 2018).

Communal Values in STEM Contexts Across Development

Adulthood

A growing literature reveals gender differences in adults' preference for communal goals, with women being substantially more interested in communality than men, placing more value on prosocially oriented careers that help people (Abele & Spurk, 2011; Diekman et al., 2011) and involve reciprocal relationships (Schwartz & Rubel, 2005). Gender differences in communal value orientation also translate into women's lower interest in STEM fields (Diekman et al., 2010; Ferriman et al., 2009; Lubinski et al., 2001) that are typically perceived as involving abstract ideas and objects (Su et al., 2009; Webb et al., 2002) and seen as less social (Hill et al., 2010). Several studies show that increasing the perceived fit between young adults' endorsement of communality and STEM subjects by integrating communal messages into descriptions of science or engineering increases interest in STEM (Brown, Smith et al., 2015; Brown, Thoman et al., 2015; Clark et al., 2016; Diekman et al., 2011, 2017; Fuesting et al., 2017). More recent research on goal congruity finds greater gender similarity between adult women and men in terms of communal values and the benefits of communal opportunities on young adult students. That said, when gender differences emerge, they tend to show stronger effects for women than men (Diekman et al., 2020).

Although these studies show strong and consistent results, they have some notable limitations. First, they focused solely on young adults. What is missing from this literature is attention to childhood and early adolescence when children's values, competencies, and the perceived compatibility of the two start getting formulated (Tai et al., 2006). Typical pedagogy in math and science starts with foundational preparation in middle and high school, absent which entry into STEM pathways in young adulthood is virtually impossible (Tyson, 2011). To keep talented students in STEM pathways, it is important to identify intellectual and psychological levers in middle school years that predict later career choice (Ceci et al., 2014; Maltese & Tai, 2011). A second gap in extant research is the scarcity of attention to racial ethnic diversity in the context of person-context fit in STEM. Gender has been the focal identity of most of the previous research in this area. It is critical to broaden the focus of attention to race, ethnicity, and other identity groups, because psychological and contextual factors that enhance person-context fit for girls and women may not generalize to underrepresented racial ethnic minority (URM) students. A third gap is that surprisingly little research has been done in real classrooms to identify how pedagogical practices, educational emphases, and activities influence students (Osborne et al., 2003). The near exclusive focus on abstract attitudes toward STEM fields overlooks the fact that students' attitudes toward science, math, and so forth in a global sense may diverge significantly from their lived experiences in classrooms where these subjects are taught. Indeed, although most students have positive attitudes about science as an endeavor, they do not hold positive views about the science they experience in the classroom (Osborne et al., 2003). Ultimately, experiences in STEM classes are likely to be more important in predicting who chooses to remain in, or leave, STEM (Cleaves, 2005; Munro & Elsom, 2000; Oakes, 1990; Ware et al., 1985). In sum, the values communicated through classroom practices, teaching styles, and activities, and their alignment with students' personal values, likely influence students' interest, motivation, and future aspirations, perhaps especially so in early adolescence when occupational values are in active development (Johnson, 2001; Schulenberg et al., 1993; Weisgram & Bigler, 2006). Thus, investigating middle school children's experiences in STEM classrooms and how it impacts their motivation and persistence is critical.

Childhood and Early Adolescence

When asked to indicate how much they would like to have a job that incorporates each of four values (money, power, family, altruism), girls and boys in middle childhood (7–8 year olds) endorsed altruistic values equally often (Weisgram et al., 2010). Gender similarity in altruistic values was evident in another study focused on middle to late childhood (6–11 year olds; Hayes et al., 2018). By adolescence however, girls endorsed altruistic values significantly more than boys (Weisgram & Bigler, 2006; Weisgram et al., 2010). Replicating the middle childhood findings, Beutel and Johnson (2004) also found that prosocial values were perceived to be equally important to girls and boys across races and ethnicities in childhood and in early adolescence. Group differences emerged in high school among older adolescents, but importantly, this difference was largely a product of White boys endorsing weaker prosocial values at older ages compared with White girls and Black adolescents of both genders. These results point to the importance of considering multiple identities (race and gender, for example, and in earlier periods of development to understand the importance of prosocial values among children and how it affects their academic interests (Rosenfield et al., 2000).

Early adolescence is a critically important developmental period that strongly shapes individuals' academic pathway for the next decade of life. Research shows that students' academic interests in middle school predicts their interests in high school and college (Eccles et al., 2004; Maltese & Tai, 2011). Using a national longitudinal dataset, Maltese and Tai (2011) followed a nationally representative cohort of students from 8th grade through 10th and 12th grade to college graduation. They found that early indication of interest in math and science in 8th grade and the personal belief that science is useful during the same development period significantly increased the likelihood of completing a STEM degree in college. This finding complements other research (Loveless, 2013; Simpkins et al., 2006; Stein et al., 2011; Tai et al., 2006) showing the importance of early interest and ability in subsequent persistence in mathematics and science.

Given the critical importance of early adolescence, it is surprising that no published research has targeted the perceived alignment between early adolescent values and student experiences in math and science classrooms to investigate the extent to which person-context alignment influences adolescents' academic identity and performance, and if so, through what psychological processes. Moreover, no published research has investigated whether values-context alignment has differential impacts on adolescents as a function of their race, ethnicity, and gender. The goal of the present research is to shed light on these important unanswered issues.

Race, Ethnicity, and Communal Orientation in STEM

Research across social, developmental, and educational psychology suggests that communal values are endorsed more strongly by racial ethnic minority Americans than White Americans (Fryberg & Markus, 2007; Gaines et al., 1997; Harper, 2005; Smith et al., 2014; Torres, 2009). Applied to education, some researchers have argued that Black, Latinx, and Native American students are drawn to educational activities for communal benefits, not simply for self-oriented reasons (Boykin, 1986; Gray et al., 2020; Markus & Conner, 2013). Boykin (1986) refers to communalism as "a commitment to social connectedness which includes an awareness that social bonds and responsibilities transcend individual privileges" (p. 61). Communalism involves an emphasis on working with others (a relational orientation) as well as helping others (prosocial orientation). Consistent with this idea, one study examining associations between communal learning opportunities and student engagement in an engineering design class for 6th graders found that children, especially Black children, reported being more engaged in class during weeks when they perceived their lessons to be more relevant for serving humanity (Gray et al., 2020).

Similarly, among young adults, a utility-value intervention in a college biology class that invited students to reflect on the personal relevance of a science class in their lives helped all students but was particularly powerful for racial ethnic minority students who were first in their families to attend college (Harackiewicz et al., 2016). Outside of classrooms, in the context of research labs, peers' beliefs about prosocial opportunities provided by science research influenced students' motivation and career interests; racial ethnic minority undergraduates were particularly sensitive to this information (Thoman et al., 2017). Specifically, this longitudinal study showed that immersion in research labs where fellow lab mates believed that science provides opportunities to fulfill prosocial goals predicted racial ethnic minority students' own beliefs as well as their subsequent interest and motivation to pursue a science career, suggesting that research labs serve as microcultures of information about the science norms and values that influence racial ethnic minority students' motivation and career interests.

The frequent misalignment between values and STEM subjects for students of color is emblematic of a more general cultural misalignment between schooling practices and values of many students (Boykin et al., 2005). Culturally responsive teaching and/or culturally relevant pedagogies have been promoted for decades as ways to address such misalignment and to engage marginalized students, particularly students of color, and increase their academic success (for example, Gay, 2000; Ladson-Billings, 1995, 2009). Although often discussed in separate research literatures from psychological theories of achievement motivation, such as goal congruence or expectancy value theory, there are clear connections between the two (Kumar et al., 2018). Whereas math is often seen as value- or culture-neutral, this is not the case, and the role of culture is vitally important in these classrooms specifically (Leonard, 2018; Nasir et al., 2008). Despite this, and despite psychological research suggesting that instructional messages that emphasize social relevance positively impact Black and Latinx adolescents (Matthews, 2018), surprisingly few studies have directly assessed the types of classroom practices that enhance learning, motivation, and persistence among racial and ethnic minority learners.

Overview of the Present Research

We conducted a longitudinal field study to address important gaps in past research by examining how experiences of communal practices in real classrooms in middle school influence student outcomes in early adolescence. Three research questions guided this work. First, to what extent do communal pedagogical practices in math classes influence student achievement self-concept, behavior, and performance in mathematics? Second, what psychological processes mediate the influence of classroom practices on student self-concept and performance? Third, do communal practices in classrooms have similar or different impacts on students based on their social identities—specifically race and gender?

We operationalized two components of communality separately: (a) the degree to which students perceived that the math they learned in class was associated with prosocial endeavors, and (b) student perceptions of the frequency of collaborative activities with peers in class. Three psychological processes—belonging, self-efficacy, and motivation—were assessed via student self-reports of their psychological experiences in math class. Students also self-reported their race and gender identity.

Based on extant theory and empirical research reviewed earlier, we proposed three hypotheses. First, we hypothesized that middle school classes where students perceived a connection between prosocial values and math and where they reported multiple opportunities to collaborate with peers would have significantly positive impacts on their achievement self-concept, behavioral engagement in class, and end-of-year performance in math. Second, we hypothesized that experiences of belonging, self-efficacy, and motivation would be proximal mechanisms through which perceived communal practices in math class impact student self-concept, classroom behavior, and performance. By examining multiple mediators simultaneously, our goal was to assess whether these psychological processes have independent additive effects on student outcomes or if some processes stand out as most important. Third, based on past research suggesting that students of color and female students often express stronger preference for communality, we predicted that the mediational pathways between perceived classroom contexts and student outcomes would be moderated by student's self-reported social identity, namely their race/ethnicity and gender. In other words, we expected that racial ethnic minority students and girls, more so than other students, would show stronger links between communality in class and math outcomes mediated through belonging, motivation, and self-efficacy. We explored whether race and gender moderation effects would emerge for pathways linking perceived classroom contexts and psychological mediators and/or pathways linking psychological mediators to end-of-year student outcomes.

Method

Participants

Ten private middle schools were selected as data collection sites. These were located in various geographic regions across the United States including California, Delaware, Pennsylvania, and Texas. Five of these schools were coeducational (coed) and five were single-sex (all girls). All coed and single-sex schools were similar in racial and ethnic composition (37% students of color, on average) and similar in family socioeconomic status. Eighth-grade students and parents from each school were invited to participate in the study. Over a span of five years, data were collected from 2,947 8th-grade students from 317 math classes taught by 58 math teachers. Each teacher taught an average of 51 math classes across 5 years. Five participants were excluded from analyses due to missing data on all study variables, and three participants were excluded due to experimenter error. A total of 2,939 students were included in the primary analyses. In terms of race and ethnicity, 62% of the student sample identified as non-Hispanic White (n = 1819); 12% Asian or Asian American (n = 349); 7% Hispanic (non-Black Hispanic: n = 178, Black Hispanic: n = 21); 5% Black or African American (n = 151); <1% American Indian or Alaska Native (n = 1) or Native Hawaiian or Pacific Islander (n = 1); 13% multiracial (multiracials that include Black, Hispanic, American Indian, or Alaskan Native identifications, n = 146; multiracials that exclude Black, Hispanic, American Indian, or Alaskan Native identifications, n = 236); and 1% other (n = 35). Two students did not report their race or ethnicity. We created a binary variable labeled URM status to indicate students who self-identified as members of racial ethnic groups whose representation in science and engineering education and professions is substantially lower than their representation in the American population using National Science Foundation standards (NSF, 2017). By this definition, the following racial and ethnic groups—Blacks, Hispanics, American Indians or Alaska Natives, Native Hawaiians or other Pacific Islanders—are underrepresented in science and engineering. Asian students were excluded from this variable because although they are a numeric minority group in the U.S. population, their representation in science and engineering exceeds the representation in the general population. In terms of gender, 75% of the sample identified as girls (n = 2,196), 24% identified as boys (n = 712), and 1% identified as nonbinary or other gender (n = 31).

Procedure

Participants completed an online survey about their experiences in their 8th grade math class, once at the beginning of the 8th grade school year (September-October; Time 1) and once at the end (March-May; Time 2). The survey assessed (a) student reports of communal instruction in their math class (i.e., instruction connecting math concepts to its prosocial relevance in everyday life, collaborative learning with peers); (b) students' psychological experiences in math class and their math self-concept; and (c) class participation. All surveys were completed on individual personal computers. At the end of each academic year, students' final course grades in math were obtained from the school registrar with parental permission.

Measures

Student Perception of Communal Instruction in Math Class

Social Relevance of Math. Four items (α = .87), adapted from the Trends in International Mathematics and Science study

(TIMSS; Mullis et al., 2005), assessed the degree to which the math learned in class was connected to socially relevant issues and was personally relevant to student lives. These items were: "In your math class, how often do you discuss real-world applications of math that are important to you?" "In your math class, how often do you learn about the ways in which math can help people?" "In your math class, how often do you learn about how you can use math to solve problems you care about?" and "Does your teacher tell you why math is important in everyday life?" The items were presented in random order, and participants responded on a 5-point scale ranging from 1 = *never* to 5 = *almost every day* for the first three items, and from 1 = *not at all* to 5 = *very much* for the last item. A principal component analysis (PCA) using oblique rotation revealed that these four items loaded onto 1 factor that explained 71.71% of the variance with factor loadings ranging from .836 to .858. Owing to the single factor loading on the PCA, all items were combined into a single index, averaged to correct for missing values, and multiplied by total possible items (scale range 4–20).

Collaborative Learning. Three items (α = .69) assessed students' perceptions of the frequency of group work in their math class. Items were modified from the Promoting Collaboration Subscale of the Classroom Environment Measure, a well-validated measure of student perception of classroom climate (Eccles et al., 1997; Mac Iver, 1988; Midgley et al., 1989a, 1989b). The following items were presented in random order: "In your math class, how often do you work with each other in small groups," "In your math class, how often do you discuss your work with classmates," and "In your math class, how often do you share ideas with one another?" Participants responded on a 5-point scale ranging from 1 = *never* to 5 = *every day or almost every day*. Items were averaged to correct for missing values and multiplied by total possible items (scale range 3–15).

Psychological Process Measures

Belonging. Six items (α = .84) were modified from the Sense of Belonging Scale (Good et al., 2012) to assess students' feelings of belonging in their math class: "I feel like I belong in this math class," "I feel a connection with this math class," "I feel accepted in this math class," "I feel comfortable in this math class," "I feel like an outsider in this math class" (reverse-coded), and "I feel that I am not good enough in this math class"[1] (reverse-coded). Items were presented in random order, and participants rated the degree to which they agreed or disagreed with each statement on a 5-point scale ranging from 1 = *strongly disagree* to 5 = *strongly agree*. Items were averaged to correct for missing values and multiplied by total possible items (scale range 6–30).

Self-Efficacy. Students' appraisal of their math ability was measured with 5 items (α = .77). Three items were adapted from a study by Stout, Dasgupta, Hunsinger and McManus (2011): "Do you think math is one of your strengths or weaknesses?" rated on a scale from 1 = *definitely a weakness* to 5 = *definitely a strength*; "How confident do you feel about math?" rated on a scale from 1 = *not at all* to 5 = *very much*; and "In thinking about your math class, what grade do you expect to get in this class at the end of this year?" on a scale from 1 = *A* to 10 = *F* (reverse-coded). Two additional items included "Do you think you're talented in math?" rated on a scale from 1 = *definitely not* to 5 = *definitely yes*, and "Do you work hard to do well in math class?" on a scale from 1 = *not at all* to 5 = *very much*. All items were presented in random order. Items required rescaling to be averaged and used as a total score, with higher values reflecting higher math self-efficacy (possible range 2.5–25).

Challenge. Two items (α = .79) assessed students' approach motivation in math class (feeling positively challenged; adapted from Dasgupta et al., 2015; Dennehy & Dasgupta, 2017; Jamieson et al., 2010; Tomaka & Blascovich, 1994; White, 2008). Specifically, students were asked: "Do you think that you have what it takes to handle your math class?" and "Do you think you will be able to overcome any challenges you might experience in your math class?" Items were presented in random order, and participants responded on a scale from 1 = *not at all* to 5 = *very much*. Items were averaged to correct for missing values and multiplied by total possible items (scale range 2–10).

Student Outcome Variables

Math Self-Concept. Participants' math self-concept was measured with four items (α = .79) adapted from Stout et al. (2011): "How much do you care about doing well in math?" "How valuable is math to you for your future?" "How useful do you think the math you are learning now will be for you in high school?" and "How important is it for you to do well in math?" Participants responded to each item on a 5-point scale ranging from 1 = *not at all* to 5 = *very much*, and items were presented in random order for each participant. Items were averaged to correct for missing values and multiplied by total possible items (scale range 4–20).

Class Participation. Students' self-report of their participation in math class was measured with two items (α = .82; adapted from Asgari et al., 2010). Students responded to "Think of your everyday experiences in math class; how often do you speak up in class discussions?" on a 5- point scale ranging from 1 = *never* to 5 = *very frequently* and "Do you enjoy being an active participant in class?" on a 5-point scale ranging from 1 = *not at all* to 5 = *very much*. Items were averaged to create a total score (scale range 1–5).

Final Math Grade. Students' performance in math was measured with their final math course grade. Schools had different grading systems; Five schools gave students an overall final grade for the year whereas four schools gave students separate grades for each semester or trimester, which we averaged into one end-of-year grade. Some schools provided final grades as a percentage, whereas others used letter grades. One school followed a nontraditional grading format in which students were evaluated on 3–5 learning skills on 8-point proficiency scales (1 = *low* to 8 = *high*). To calculate an overall final grade for students at this school, proficiency ratings were averaged across skills. That average was converted to a percentage score using the grade conversion scale provided by the school. Final grades that were provided in letter grade form were converted to a percentage score by using the midpoint of a typical grade-point range on a scale (i.e., A+ = 97–100, A = 93–96, A- = 90–92 and so on, to F = 0–59); for example, an A+ was converted to 98.5, A to 94.5, and so forth. If a school

[1] "Inadequate" was used instead of "not good enough" during the first year of data collection.

used a different system to convert letter grades to a percentage score, we used their specific conversion system. Through these computations, all final grades were converted to the same 0–100 scale.

In keeping with open science practices, we have made our data, syntax, measures, and code book publicly available through a project folder in the Open Science Framework (OSF) website (see https://osf.io/6srf7/?view_only=e3ed53efeb244bb4828bc23f58644cb3).

Data Analytic Plan

Data analyses focused on two communal pedagogical practices in math classes as predictors (student perceptions of the social relevance of the math they learned in class to real world issues and collaborative learning in math class); three mediators (belonging in math class, self-efficacy in math, and challenge motivation); and three outcome variables (class participation, math self-concept, and end of year math grades). Prior to testing our research questions, we first examined descriptive statistics and distributions for all study variables. Any variables that were not acceptably symmetrical (skewness of > 1 or < -1) were numerically transformed. Owing to the nested structure of the data (students nested within classrooms nested within teachers nested within schools) and our interest in testing mediation, we used multilevel structural equation modeling (MSEM; Preacher et al., 2010) as estimated by the Mplus 8.4 program (Muthén & Muthén, 2017). MSEM was well suited to our research questions because it combines the advantages of multilevel modeling (e.g., accounting for dependencies in the data due to nesting) and structural equation modeling (e.g., allowing for multiple outcome variables that are necessary in mediation). Additionally, MSEM allows for the use of full information maximum likelihood estimation to handle missing data, which enabled us to retain all students with data on at least one of our study variables.

Prior to testing our primary research questions, we first calculated intraclass correlations (ICCs) to determine the amount of variability in the predictors, mediators, and outcomes that was accounted for at the student, classroom, and teacher levels of nesting. Given that the present study only includes 10 schools, we were unable to accurately quantify or model school-level variability. Therefore, the school level of nesting was controlled for by using a setting in Mplus that corrects the standard errors to account for this additional level of nesting (Muthén & Muthén, 2017). This method meant that we calculated ICCs from a three-level (students nested within classrooms nested within teachers) rather than a four-level (students nested within classrooms nested within teachers nested within schools) model. Results indicated that for all variables except challenge, teachers accounted for more variance than classrooms. Moreover, after accounting for nesting within teachers, classrooms accounted for a very small (~1%) and statistically nonsignificant amount of variance in two of our three outcome variables (see Supplemental Table 1).[2] Therefore, we chose to fit two-level random intercepts models with students (level 1) nested within teachers (level 2), controlling for school effects.[3] Additionally, across all models, we group-mean centered the predictor variables, which allows for the examination of pure student-level associations by removing average teacher effects (across all students in their classrooms).[4]

To test our primary research questions, we fit four student-level MSEM models, which simultaneously estimated the effects of communal pedagogical practices in math classes on student outcomes. The first model tested the total effects or *c* paths, which represent the effects of the predictor variables (social relevance and collaborative learning environment) on the outcome variables (participation, math self-concept, and grades), without mediators in the model. All outcome variables' residuals were allowed to correlate. The second model simultaneously tested whether the three hypothesized psychological mechanisms (i.e., belonging, self-efficacy, and challenge) mediated these predictor-outcome associations at the student level (i.e., a 1-1-1 mediation; Preacher et al., 2010). As is typical in mediation, these models include *a* paths (i.e., the association between the predictor and mediator), *b* paths (i.e., the association between the mediator and the outcome, controlling for the predictor), and *c'* paths (i.e., the direct effect of the predictor on the outcome, controlling for the mediator). Additionally, all outcome and mediator residuals were allowed to correlate.

Because indirect ($a*b$ paths) effects are typically not normally distributed, standard significance tests are considered overly conservative (Hayes, 2017). Therefore, to test the significance of indirect effects, we used the Monte Carlo method for assessing mediation (MCMAM; Bauer et al., 2006; MacKinnon et al., 2004) as implemented in an online tool (Selig & Preacher, 2008).[5] This method uses the asymptotic variances and covariance of the relevant *a* and *b* paths to generate a simulated sampling distribution (based on thousands of random draws from the joint distribution of *a* and *b*) that can be used to estimate a 95% confidence interval (CI) around the indirect effect (Bauer et al., 2006). Importantly, this method allows for asymmetrical confidence intervals, which offer the most appropriate tests of significance for indirect effects. A 95% CI that does not contain zero is considered statistically significant.

The third and fourth models tested for moderated mediation by examining student race/ethnicity (0 = White/Non-URM; 1 = URM) and student gender (0 = boys; 1 = girls), respectively, as moderators of all *a* and *b* paths. In other words, these models simultaneously tested whether the classroom communal characteristic predictors had differential effects on the psychological mechanisms based on student identity groups (*a* path moderation) and/or whether the psychological mechanisms had differential effects on the outcomes based on student identity groups (*b* path moderation). Across both moderated mediation models, to determine the extent to which the social identity groups differed, we calculated simple slopes (i.e., the size of the moderated *a* or *b* path for each group) and simple indirect effects (i.e., the size of the entire moderated indirect effect for each group)

[2] All supplemental tables are available in this Open Science Framework (OSF) website: https://osf.io/6srf7/?view_only=e3ed53efeb244bb4828bc23f58644cb3

[3] Importantly, omitting an additional upper level of nesting (in this case the classroom level) simply results in teacher and classroom variability being combined but does not impact the student-level variability. Thus, our primary student-level results remain virtually identical when estimated in a two- vs. three-level framework.

[4] Note that all outcome variables are automatically parsed into their latent student- and teacher-level components by the MSEM model (Preacher et al., 2010). Thus, group-mean centering was only necessary for exogenous (predictor) variables.

[5] Although bootstrapping would also provide a more appropriate test of indirect effects, this option was not available in the Mplus program for the types of multilevel models we fit in this study.

for all statistically significant interactions. To determine the significance of these simple indirect effects, we again used the MCMAM method. Across all models, in addition to the unstandardized coefficients, we also report the standardized associations in all figures to provide an approximate measure of effect size (Lorah, 2018).[6]

Last, after conducting our primary analyses, we fit two-level Monte Carlo simulations using maximum likelihood estimation in Mplus to estimate power for our primary mediational and moderated mediational models (Bolger & Laurenceau, 2013; Lane & Hennes, 2018). Following published guidelines for this type of multilevel, simulation-based power analysis (Bolger & Laurenceau, 2013), the parameter estimates from this study served as primary inputs for the "population" model, and the "data" are randomly generated from the population model to create sampling variability in the parameter estimates across 5,000 hypothetical studies. Using this method, the percentage of times each association is statistically significant across the 5,000 hypothetical studies approximates statistical power (Muthén & Muthén, 2002). However, owing to the post hoc nature of this power analysis, it was more difficult to determine the statistical power we had to detect *nonsignificant* associations, because low power estimates for these parameters could also suggest that these associations are truly nonsignificant in the population. Therefore, in addition to reporting the power estimates for our primary models, we also summarize the estimated power we had to detect associations that were at least small (i.e., a standardized coefficient that was $\geq .10$).

Results

Preliminary Results

All study variables were acceptably normally distributed except for student grades, which had a negatively skewed distribution (skewness value = -1.74). A series of numeric transformations were applied to the data (Tukey, 1977) and compared for best correction to the skewed variable by examining skewness statistics of each transformed variable. Numerical transformations are techniques commonly applied to skewed measures to meet the statistical assumptions for the outcome in multilevel analysis. The square transformation provided a more symmetrical distribution (skewness value = -1.03). This variable was then rescaled (divided by 100) to approximate the original grades metric). Note that the use of such numerically transformed variables preserves the original rank order of the grades variable, and it is nearly perfectly correlated with grades in the original metric ($r = .994$). This transformed grades variable was used in all analyses (M = 80.27; SD = 11.24). Relevant to our MSEM models, the final sample used in our analyses included 58 teachers who taught a total of 317 classrooms with an average of nine student participants in each (for a total of 2,939 students).[7]

Total Effects: Association Between Perceived Communal Practices in Math Classes at the Beginning of the Year and Student Self-Concept and Performance at the End of the Year

Results indicated that, as predicted, students' perception of classroom teaching about the social relevance of math at the beginning of the academic year was associated with significantly greater class participation, stronger math self-concept, and better grades at the end of the academic year, controlling for collaboration. Additionally, and also as predicted, a more collaborative learning environment at the beginning of the year was significantly associated with greater class participation and better grades at the end of the year, controlling for social relevance. However, unexpectedly, collaborative learning environment was unrelated to students' math self-concept, controlling for social relevance. To demonstrate the impact of communal predictors on each outcome, we calculated the predicted outcome for students who perceived their math class to be low in communality (1.5 SD below the mean on math relevance and collaboration) versus high in communality (1.5 SD above the mean on math relevance and collaboration). Results showed that perceptions of high (compared with low) communality predicted .50 SD higher math grades, .75 SD more class participation, and .50 SD stronger math identification. For the full unstandardized results of the total effects model, see the model 1 column of Table 1. Standardized results of this model are presented in Figure 1.

Mediations: Psychological Mechanisms Mediating the Association Between Perceived Classroom Practices on Student Self-Concept and Performance

Belonging

Learning about the social relevance of math at the beginning of the year predicted a greater sense of belonging in math by the end of the year, which, in turn, was associated with greater end-of-year class participation and stronger math self-concept, controlling for the effects of other mediators and collaborative learning predictor. No significant belonging mediation was found for the link between social relevance and grades (however, see race moderation results below which revealed subgroup effects). Similarly, belonging also mediated two significant associations between collaborative learning and outcomes such that a more collaborative learning environment at the beginning of the year predicted greater belonging at year's end, which, in turn, was associated with greater end-of-year class participation and better math self-concept, controlling for the other mediators and predictor. There was no evidence of a significant mediational process from collaborative learning to math grades through the belonging mediator.

Note that although the total effect of a collaborative learning environment on students' math self-concept was nonsignificant, the indirect effect through belonging as a mediator was statistically significant. This type of indirect effect is often termed inconsistent mediation or a suppression effect (Hayes, 2017; MacKinnon, 2000). In the present context, the result suggests that a collaborative learning environment has both a positive and negative effect on students' math self-concept that together cancel each other out, resulting in the null total effect. Consistent with this explanation, when the indirect pathway through belonging is accounted for, the direct association between a collaborative learning environment and math self-concept becomes negative (though still

[6] Although standardized coefficients are not optimal for mediation analyses (Hayes, 2017), we provide them in figures as an approximate measure of effect size. All significance tests are based on the unstandardized coefficients.

[7] Owing to our coding of URM status, the race/ethnicity moderation models included 2,588 students. Similarly, the gender moderation model included 2,908 students, because the 31 students who identified as nonbinary were excluded.

Table 1
Unstandardized Results of Total Effects and Mediation Models

Fixed effects	Model 1: Total effects		Model 2: Mediation	
	Coefficient (*SE*)	*p*	Coefficient (*SE*)	*p*
Outcomes				
Math grades (intercept)	81.451 (0.857)	<.001	81.773 (0.858)	<.001
Social relevance (*c/c'* path)	0.157 (0.052)	.002	−0.126 (0.068)	.064
Collaborative learning envir. (*c/c'* path)	0.381 (0.141)	.007	0.367 (0.129)	.004
Belonging (*b* path)	—	—	0.044 (0.060)	.461
Self-efficacy (*b* path)	—	—	1.266 (0.133)	<.001
Challenge (*b* path)	—	—	0.223 (0.223)	.316
Participation (intercept)	3.662 (0.044)	<.001	3.676 (0.043)	<.001
Social relevance (*c/c'* path)	0.047 (0.004)	<.001	0.017 (0.003)	<.001
Collaborative learning envir. (*c/c'* path)	0.033 (0.007)	<.001	0.025 (0.006)	<.001
Belonging (*b* path)	—	—	0.064 (0.008)	<.001
Self-efficacy (*b* path)	—	—	0.057 (0.006)	<.001
Challenge (*b* path)	—	—	0.063 (0.015)	<.001
Math self-concept (intercept)	16.669 (0.134)	<.001	16.710 (0.134)	<.001
Social relevance (*c/c'* path)	0.123 (0.017)	<.001	0.051 (0.017)	.003
Collaborative learning envir. (*c/c'* path)	0.005 (0.021)	.828	−0.004 (0.016)	.816
Belonging (*b* path)	—	—	0.057 (0.021)	.006
Self-efficacy (*b* path)	—	—	0.257 (0.017)	<.001
Challenge (*b* path)	—	—	0.112 (0.049)	.023
Mediators				
Belonging (intercept)	—	—	−0.022 (0.008)	.004
Social relevance (*a* path)	—	—	0.224 (0.019)	<.001
Collaborative learning envir. (*a* path)	—	—	0.112 (0.039)	.004
Self-efficacy (intercept)	—	—	−0.058 (0.018)	.001
Social relevance (*a* path)	—	—	0.201 (0.025)	<.001
Collaborative learning envir. (*a* path)	—	—	0.001 (0.045)	.976
Challenge (intercept)	—	—	−0.016 (0.004)	<.001
Social relevance (*a* path)	—	—	0.066 (0.008)	<.001
Collaborative learning envir. (*a* path)	—	—	0.009 (0.014)	.503

Note. *c* path = the total effect of the relevant pedagogical characteristic on the relevant outcome; *c*' path = the direct effect of the relevant pedagogical characteristic on the relevant outcome, controlling for the mediators; *b* path = the effect of the mediator on the relevant outcome, controlling for the other mediators and both predictor variables; *a* path = the effect of the relevant pedagogical characteristic on the relevant mediator, controlling for the effect of the other pedagogical characteristic.

nonsignificant). Despite the complexity of the collaborative learning environment-math self-concept association, though, the present results simply suggest that the positive aspects of this relation are transmitted through the mediator of belonging.

Self-Efficacy

Results indicated that self-efficacy significantly mediated the association between social relevance and each of the outcomes. More learning about the social relevance of math at the beginning of the year predicted a greater sense of self-efficacy at the end of the year, which, in turn, was associated with greater end-of-year class participation, stronger math self-concept, and better math grades, controlling for the other mediators and predictor. In contrast, self-efficacy did not mediate the effect of a collaborative learning on any of the outcomes.

Challenge Motivation

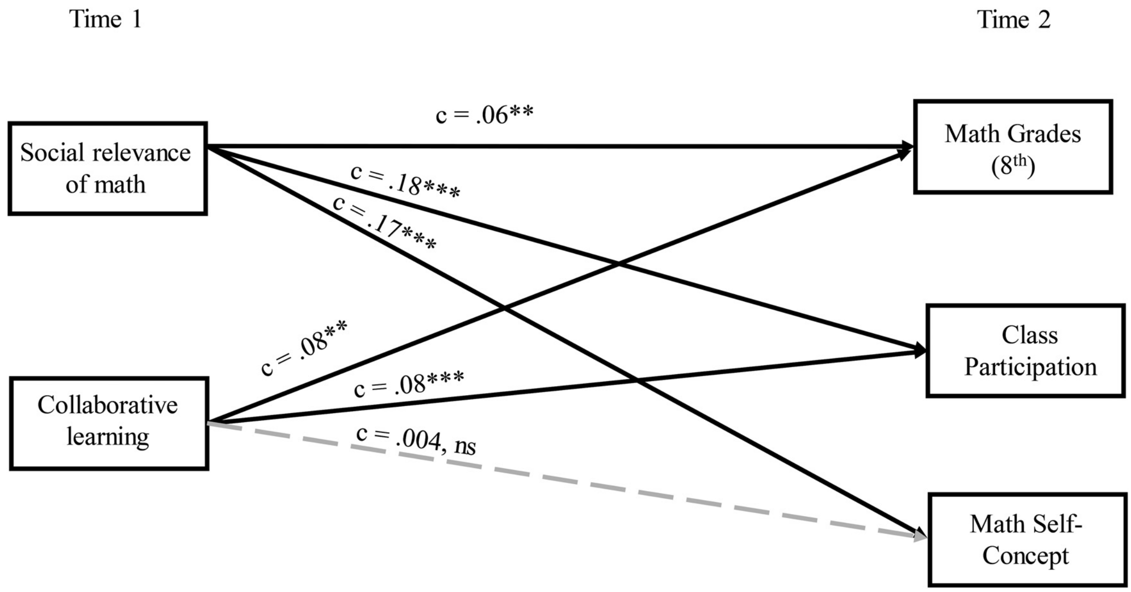
Finally, the results also indicated that challenge significantly mediated the association between social relevance and two of the three outcomes. Learning about the social relevance of math at the beginning of the year predicted greater challenge at the end of the year, which, in turn, was associated with greater end-of-year class participation and stronger math self-concept, controlling for the other mediators and predictor. There was no evidence of a significant mediational process from social relevance of math to math grades through the challenge mediator. Challenge did not mediate the effect of a collaborative learning on any of the outcomes.

In a nutshell, perceived social relevance of math was a more influential predictor of student outcomes than collaborative learning. Both of these perceived classroom characteristics predicted students' feelings of belonging in class, but only social relevance predicted their self-efficacy and challenge motivation. All three mediators predicted end-of-year student outcomes, with self-efficacy and belonging predicting all three student outcomes and challenge predicting two of those outcomes. The unstandardized coefficients from this multi outcome parallel mediation model are presented in model 2 of Table 1, and all indirect effects and associated confidence intervals are presented in Table 2. Additionally, the standardized results are presented in Figure 2.

Follow-Up Analyses Controlling for Lagged Mediators and Outcome Variables

Follow-up analyses were conducted to test whether these associations held when controlling for T1 values of the mediator and outcome. Incorporating these lagged effects guards against the possibility that the observed associations are artifacts of stable associations rather than temporal sequences

Figure 1
Standardized Total Effects of Perceived Pedagogical Characteristics of Math Classes on Student Outcomes



Note. Solid black lines represent significant associations, whereas dashed gray lines reflect nonsignificant associations. For visual simplicity, variances, residual variances, and covariances between the two predictors and among the three outcomes were omitted from the figure. ns = nonsignificant.
* $p < .05$; ** $p < .01$; *** $p < .001$.

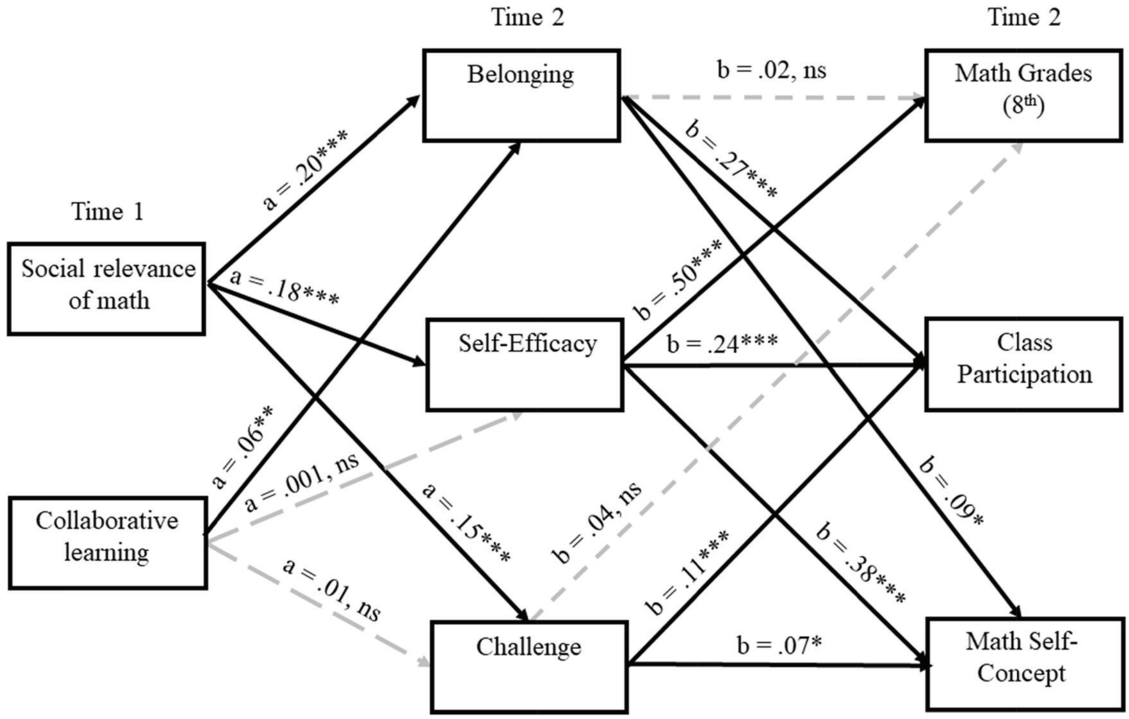
among variables (Kenny & Harackiewicz, 1979). Specifically, in the primary analyses T1 focal predictor variables were associated with T2 mediators and outcomes, whereas in these follow-up analyses the T1 focal predictors are associated with *change* in mediators and *change* in outcomes between T1 and T2. Results of these analyses indicated that a majority of mediations found in the primary analyses remained significant, even when controlling for T1 mediators and outcomes. Only two mediations (social relevance of math to challenge to math self-concept, and collaboration to belonging to math self-concept) fell below statistical significance in these models. All other mediations found in the primary analyses remained statistically significant. Table 2 provides notes where findings were not retained when incorporating lags, and Supplemental Table 2

Table 2
Indirect Effects of Perceived Pedagogical Characteristics of Math Classes on Student Outcomes Through Psychological Mechanisms

Indirect effects	Unstandardized coefficient	[95% CI]
Social relevance → belonging → math grades	0.010	[−0.019, 0.032]
Social relevance → belonging → participation	0.014[a]	[0.010, 0.020]
Social relevance → belonging → math self-concept	0.013[a]	[0.004, 0.022]
Social relevance → self-efficacy → math grades	0.254[a]	[0.159, 0.369]
Social relevance → self-efficacy → participation	0.011[a]	[0.009, 0.014]
Social relevance → self-efficacy → math self-concept	0.054[a]	[0.037, 0.067]
Social relevance → challenge → math grades	0.015	[−0.013, 0.047]
Social relevance → challenge → participation	0.004[a]	[0.002, 0.007]
Social relevance → challenge → math self-concept	0.007[b]	[0.001, 0.015]
Collaborative learning → belonging → math grades	0.005	[−0.006, 0.025]
Collaborative learning → belonging → participation	0.007[a]	[0.003, 0.011]
Collaborative learning → belonging → math self-concept	0.006[b]	[0.001, 0.015]
Collaborative learning → self-efficacy → math grades	0.002	[−0.109, 0.111]
Collaborative learning → self-efficacy → participation	<0.001	[−0.005, 0.006]
Collaborative learning → self-efficacy → math self-concept	<0.001	[−0.024, 0.021]
Collaborative learning → challenge → math grades	0.002	[−0.006, 0.014]
Collaborative learning → challenge → participation	0.001	[−0.001, 0.003]
Collaborative learning → challenge → math self-concept	0.001	[−0.001, 0.007]

Note. CI = confidence interval.
[a] The 95% Monte Carlo CI does not include zero, which indicates that the indirect effect is statistically significant. [b] Indicates an effect that fell below statistical significance in follow-up analyses controlling for lagged effects (T1) mediators and outcomes.

Figure 2
Standardized Mediational Model Depicting the Indirect Effects of Perceived Pedagogical Characteristics of Math Classes on Student Outcomes Through Psychological Mechanisms



Note. All indirect effects represented with black solid lines were statistically significant (see Table 2). Solid black lines represent significant associations, whereas dashed gray lines reflect nonsignificant associations. For visual simplicity, variances, residual variances, covariances between the two predictors, among the three mediators, and the three outcomes were omitted from the figure. Direct effects (between the predictors and outcomes) were also omitted from the figure. Taken together, the predictors and mediators accounted for 28.8% of the variance in math grades, 31.9% of the variance in class participation, and 25.8% of the variance in math identification. ns = nonsignificant.
* $p < .05$; ** $p < .01$; *** $p < .001$.

provides full statistics from the mediational model incorporating lagged mediators and outcomes.

Moderated Mediations: Influence of Student Social Identities on the Association Between Perceived Communal Classroom Practices and Student Outcomes

Experience of Students by Racial Ethnic Minority Status

In terms of *a* path moderators, more learning about the social relevance of math fostered significantly greater challenge motivation for URM adolescents than for White and non-URM adolescents. To quantify the size of this difference, simple slopes were calculated and compared for each group. Although simple slopes were significant for both groups, the association between social relevance and challenge motivation was approximately 1.6 times *stronger* for URM versus White and non-URM adolescents. That is, whereas a one-unit increase in social relevance was associated with a .064 unit increase in challenge for White and non-URM students, it was associated with a .101 unit increase in challenge for URM students. Indirect effects of mediations including this *a* path moderation were statistically significant for class participation and math self-concept outcomes for both groups (see Table 3). No significant indirect effects from social relevance to grades through challenge were found for either group. Student race and ethnicity did not moderate any other *a* path.

In terms of *b* path moderators, significant differences in paths from belonging to both math self-concept and grades were found for URM versus White and non-URM students. Simple slopes of the *b* paths were calculated and compared for each group. Although the simple slopes between belonging and math self-concept were positive and statistically significant for both groups, the association was approximately 3.2 times *stronger* for URM than for White and non-URM adolescents. That is, whereas a one-unit increase in belonging was associated with a .05 unit increase in math self-concept for White and non-URM students, it was associated with a .16 unit increase in math self-concept for URM students. A statistically significant indirect effect through belonging was found for URM students from social relevance and collaboration to math self-concept. The corresponding indirect effect from social relevance was significant for White and non-URM students, but the indirect effect from collaboration fell below statistical significance for White and non-URM students as a result of *b* path differences described above (see Table 3 for all simple indirect effects by URM status).

Table 3
Differential Simple Indirect Effects of Perceived Pedagogical Characteristics of Math Classes on Student Outcomes as a Function of Student Race/Ethnicity

Simple indirect effects	Coefficient	[95% CI]
Under-represented minority (URM) students		
Social relevance → belonging → math grades	0.087[a]	[0.028, 0.156]
Social relevance → belonging → math self-concept	0.032[a]	[0.019, 0.048]
Social relevance → self-efficacy → math self-concept	0.032[a]	[0.015, 0.053]
Social relevance → challenge → grades	0.031	[−0.017, 0.092]
Social relevance → challenge → participation	0.007[a]	[0.004, 0.011]
Social relevance → challenge → math self-concept	0.011[b]	[0.001, 0.023]
Collaborative learning → belonging → math grades	0.055[b]	[0.008, 0.128]
Collaborative learning → belonging → math self-concept	0.020[b]	[0.006, 0.038]
Collaborative learning → self-efficacy → math self-concept	0.004	[−0.016, 0.023]
White and non-URM students		
Social relevance → belonging → math grades	−0.015	[−0.056, 0.020]
Social relevance → belonging → math self-concept	0.010[a]	[0.0,001, 0.020]
Social relevance → self-efficacy → math self-concept	0.243[a]	[0.032, 0.073]
Social relevance → challenge → grades	0.020	[−0.013, 0.053]
Social relevance → challenge → participation	0.005[a]	[0.002, 0.007]
Social relevance → challenge → math self-concept	0.007[b]	[0.0,004, 0.016]
Collaborative learning → belonging → math grades	−0.009	[−0.033, 0.016]
Collaborative learning → belonging → math self-concept	0.006	[−0.0,001, 0.017]
Collaborative learning → self-efficacy → math self-concept	0.006	[−0.026, 0.034]

Note. Simple slopes were calculated when statistically significant URM moderations were found on either mediational pathway in the primary analysis. Unstandardized coefficients are presented. CI = confidence interval.
[a] The 95% Monte Carlo CI does not include zero, which indicates that the indirect effect is statistically significant. [b] Indicates an effect that fell below statistical significance in follow-up analyses controlling for lagged effects (T1) mediators and outcomes.

The association between belonging and math grades was not statistically significant for White and non-URM students (b path$_{\text{White}}$ = −.07, SE = .09, p = .425), although it was positive and highly statistically significant for URM students (b path$_{\text{URM}}$ = .42, SE = .03, $p < .001$). Simple indirect effects for URM versus White and non-URM students for each mediational process that included the belonging—grades b path showed a significant mediational process from social relevance and collaboration to grades through belonging for URM students, and no significant indirect effects on corresponding mediations for White and non-URM students.

Finally, results showed a significant negative interaction effect between URM status and the path from self-efficacy to math self-concept. URM students had a weaker association between self-efficacy and math self-concept than White and non-URM students, although simple slopes analyses indicated that both pathways were statistically significant. The simple slope between self-efficacy and math self-concept was approximately 1.6 times *stronger* for White and non-URM adolescents than for URM adolescents. That is, whereas a one-unit increase in self-efficacy was associated with a .28 unit increase in math self-concept for White and non-URM students, it was associated with a .17 unit increase in math self-concept for URM students. No other statistically significant b path moderations were found.

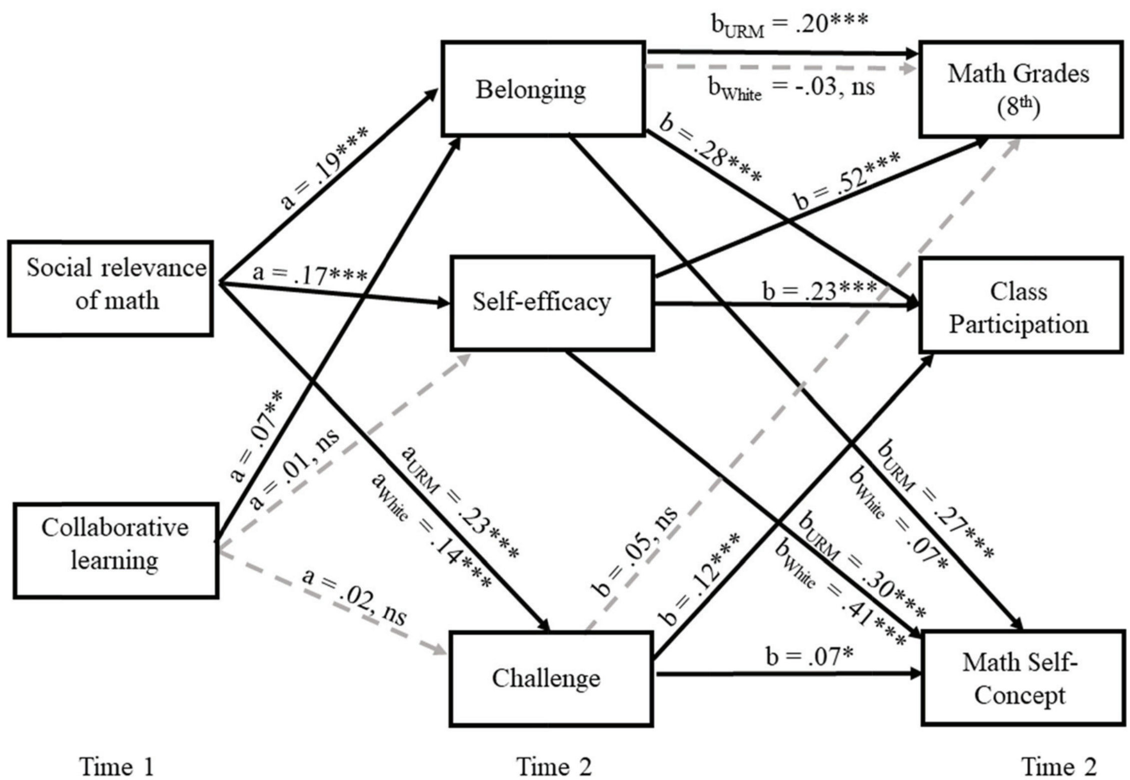
In summary, for URM adolescents, feeling a sense of belonging in math class and challenge motivation were two key psychological processes that enhanced learning outcomes. These processes were activated when students perceived math to be socially relevant to people and community and when classroom learning involved collaborative activities. Specifically, emphasis on the social relevance of math in class was associated with challenge motivation more strongly for URM than White and non-URM students (a path moderation), which, in turn, translated into greater in-class participation and stronger math self-concept. Second, greater belonging (as a result of both social relevance and collaborative learning) was predictive of stronger math self-concept for URM compared with White and non-URM students, and predictive of higher grades *only* for URM students (b path moderations for belonging mediator). Third, and by contrast, White and non-URM students showed stronger math self-concept than URM students when their self-efficacy was boosted (b path moderation for self-efficacy mediator). See Supplemental Table 3 for the full unstandardized results, Table 3 for the moderated indirect effects for each group, and Figure 3 for the standardized results.

Follow-Up Analyses Controlling for Lagged Mediators and Outcome Variables

Follow-up analyses were again conducted to test whether these associations held when controlling for T1 values of the mediator and outcome. Results of these analyses indicated that all of the interaction terms (three b path moderations, one a path moderation) found in the primary analyses remained statistically significant, even after controlling for T1 mediators and outcomes. However, because these significant moderations are on specific mediational paths, they are not a full test of whether mediational sequences were at play for URM and non-URM students. Indirect effects were calculated for URM and non-URM students to test whether the same pattern of mediations emerged in each subgroup as were found in the analyses not incorporating lags. For URM students, lagged analyses indicated that their perception of the social relevance of math at the beginning of the school year predicted changes in all three mediators (belonging, self-efficacy, and challenge) at T2 controlling for T1. Change in belonging mediated to predict better math self-concept at T2 controlling for T1 as well

Figure 3

Standardized Moderated Mediation Model Depicting Significant Differential Effects as a Function of Student Race/Ethnicity Such That More Learning About the Social Relevance of Math Was More Strongly Associated With Greater Challenge for URM Versus White Students (a Path Moderation), and Greater Belonging Was More Strongly Associated With Better Grades and Math Self-Concept for URM Versus White Students (b Path Moderations)



Note. The effect of self-efficacy to math self-concept was significantly stronger for White versus URM students (*b* path moderation). Solid black lines are statistically significant. Dashed gray lines are nonsignificant associations. For visual simplicity, variances, residual variances, covariances between the two predictors, among the three mediators, and the three outcomes were omitted from the figure. Direct effects were included in all models but were also omitted from the figure for simpler presentation. ns = nonsignificant.
$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

as math grades at the end of 8th grade controlling for the 7th grade. Change in self-efficacy mediated to predict a stronger math self-concept at T2 controlling for T1. Finally, change in challenge mediated to predict more in-class participation at T2 controlling for T1. Three other indirect effects fell below significance for URM students when using lagged analyses; these are shown in Table 3. Supplemental Table 3 provides full statistics from the moderated mediation model incorporating lagged mediators and outcomes. Overall, moderated mediation analyses controlling for lagged mediators and outcomes indicated that a majority of effects held, but some were lost.

Experience of Students by Gender

Results indicated that, contrary to prediction, student-level mediational pathways did not significantly differ for girls and boys. That is, student gender did not moderate any of the indirect effects of social relevance and collaborative learning on class participation, math self-concept, and math grades (for the full results, see Supplemental Table 4). Put differently, communal pedagogical practices in math classes predicted stronger belonging, challenge motivation, and self-efficacy equally for girls and boys, which in turn predicted positive outcomes equally for both genders. In addition, we performed follow-up intersectionality analyses for each significant URM moderated mediation to explore whether these effects differed for URM girls versus boys. No significant gender differences emerged in the URM moderations, although given the exploratory nature of these analyses, these null results should be interpreted with caution. Possible reasons for the lack of gender moderation are discussed in the Discussion.

Statistical Power

The power analysis for our primary mediational model revealed that all *a* or *b* paths for which the standardized coefficient was $\geq .10$ were significant in $> 99\%$ of the simulations. In terms of indirect effects, all statistically significant indirect effects were significant in $\geq 79\%$ of the simulations, suggesting that we were also well-powered to detect mediational effects. All nonsignificant indirect effects were significant in only a small proportion of the simulations (ranging from 1% to 34%). Overall, these results suggest that this study was well-powered to detect mediational pathways in which both the *a* and *b* paths were at least small effects (i.e., $\geq$ .10). Similarly, the post hoc power analysis for our student race/ethnicity moderated mediation analyses suggested that we were well powered ($>$ 99%) to detect interactive effects that at least approached a small effect size (i.e., those that rounded up to .10). In terms of the conditional indirect effects, all statistically significant simple indirect effects for URM students were significant in $\geq$ 73% of the simulations (average power estimate of 92%). Overall, these results suggest that the present study was fairly well-powered to detect moderated mediational effects in which there was at least a small difference between the size of the relevant path for URM compared with non-URM students.

Discussion

The present research sought to identify key moments in the educational experience of early adolescents that have far-reaching implications for their later academic pursuits in young adulthood in fields of national importance—mathematics, science, engineering, and technology. We targeted educational contexts in mathematics given its foundational importance in science, technology, and engineering learning. It is widely accepted in educational research and policy that solid grounding in math in early adolescence is necessary for the future pursuit of any STEM pathway later in development (Berwick, 2019; Loveless, 2013; Stein et al., 2011). Even more specifically, performance in 8th grade algebra is a critical lever that influences students' future academic and professional trajectory (Loveless, 2013; Stein et al., 2011). A strong foundation in terms of both interest and performance in middle school algebra catapults adolescents to successfully navigate high school math and science, such that upon entry into college they are well-prepared and motivated to pursue STEM majors. Lower interest and weaker performance in 8th grade algebra handicaps students in high school math and science, such that upon entry into college they are likely to lag behind in prior preparation, struggle, and lose motivation to pursue STEM majors. Given that 8th grade math experiences are pivotal determinants of future academic pursuits, a major strength of the present research is its focus on this key period of adolescent development. The present research is also noteworthy because it is the first to demonstrate that adolescents' perceptions of the pedagogical characteristics of their ongoing math classes predict their psychological states which, in turn, influence granular learning outcomes in math. This work complements past research that has often focused on abstract attitudes toward STEM disciplines not embedded in particular contexts where learning happens.

We addressed three overarching hypotheses through a longitudinal study of 10 middle schools across the nation, from which we recruited adolescents in 8th grade, following them for one year right before their transition to high school. First, we investigated whether adolescents' perceptions of communal practices in math classes strengthen their academic self-concept, promote in-class behavioral engagement, and enhance their math performance. Second, we examined social psychological processes that mediate the impact of communally oriented classroom perceptions on adolescent outcomes. Third, we explored whether student perceptions of math classes as communally oriented have unique benefits for adolescents from identity groups that are underrepresented in STEM, especially racial ethnic minority adolescents and girls. Our attention to the perceived communal characteristics of STEM classrooms that support the learning of racial ethnic minority adolescents fills an important gap in knowledge. Past research on communal learning environments in STEM has mostly focused on gender.

Two Communal Practices in Math Educational Contexts Enhance Adolescent Outcomes

Results revealed that student perceptions of two expressions of communal values in math classrooms had substantial benefits: (a) emphasis on the social relevance of math as helping people, community, and society, conveyed through instruction and (b) emphasis on relational activities in class through collaborative group work. Perceptions of each of these communally oriented instructional practices influenced student outcomes, controlling for the other. Relatively speaking, perceived social relevance of math had stronger and more consistent effects on learning outcomes than collaborative group work. Specifically, students' understanding of the social relevance of math at the beginning of the academic year was significantly associated with stronger math self-concept, greater class participation, and better math grades at the end of the academic year. Student reports of collaborative learning in class at the beginning of the year were significantly associated with class participation and better end-of-year grades, but not math self-concept.

Our findings make several new contributions that extend past research. First, we expand beyond a narrow focus on grades to show the impact of classroom contexts on the value of math in adolescents' self-concept and behavioral engagement in class, both of which are related to math interest, known to be a critical predictor of persistence over time (Maltese & Tai, 2011). Second, we expand beyond the heavy reliance on undergraduate student samples. Virtually all past studies reviewed in meta-analyses targeted undergraduate classes in STEM; none involved K-8 classes with early adolescents or children (Freeman et al., 2014; Ruiz-Primo et al., 2011; Springer et al., 1999; Walker & Warfa, 2017). The absence of a robust literature on children and adolescents within STEM classroom contexts is surprising given evidence that academic interest developed during middle school is a critical lever that influences later outcomes in high school and college (Loveless, 2013; Maltese & Tai, 2011; Stein et al., 2011). Our findings address this key knowledge gap.

Psychological Processes Through Which Classroom Contexts Impact Academic Outcomes

The present results highlight the importance of three social psychological processes in predicting student outcomes: sense of belonging, challenge motivation, and self-efficacy. When classroom practices allowed students to perceive math as relevant to helping people and society, they expressed greater belonging in math classes across the year, felt more efficacious in their math ability across the year, and reported more challenge motivation to keep trying even when the content was difficult across the year. Two of these processes (change in belonging and self-efficacy) predicted strengthening of math self-concept and class participation from beginning to end of the year for all students, and better grades in math in 8th grade compared with 7th grade for URM students in particular. Challenge motivation predicted increased class participation but not change in self-concept or higher grades for all students. Because these results incorporated lagged effects, measuring changes in psychological mediators and changes in student outcomes in response to beginning of year perceptions of classroom characteristics, we have greater confidence that the observed associations are not artifacts of stable associations, but rather temporal sequences illustrating how perceptions of learning contexts at the beginning of the school year change psychological experiences and student outcomes over the course of the academic year.

Just as students' impressions of the social relevance of math class had benefits on their outcomes, so too students' impressions of in-class collaboration predicted enhanced belonging in math class across the school year, which in turn predicted stronger math self-concept for URM students and class participation for all students. However, perceived collaboration did not influence self-efficacy or challenge motivation, suggesting again that social relevance of math had stronger and more consistent effects on students' psychological states and learning outcomes than collaborative group work.

The present findings are conceptually aligned with prior research on targeted interventions that address specific psychological processes at crucial time points in students' educational journey, producing longer-lasting outcomes (for a review see Harackiewicz & Priniski, 2018). Targeted interventions are theory-driven, pinpoint a specific problem (e.g., educational disparities), address psychological processes hypothesized to underlie the problem, and make predictions about who should benefit from that intervention and what outcomes should reveal those benefits. Extant research on targeted interventions involve writing and reflection tasks inserted into classes to draw attention to task values or personal values (e.g., Brown, Smith et al., 2015; Cohen et al., 2006; Harackiewicz et al., 2016; Miyake et al., 2010; Walton et al., 2015).

Our research makes three contributions in terms of theory and data that are new. First, we highlight students' perceptions of pedagogical practices in the classroom and measured their impacts on specific psychological processes and subsequent outcomes. These pedagogical practices are evidence-based and supported by many teachers, though surprisingly rarely implemented in real classrooms. Second, we expanded the set of psychological processes beyond those examined in the past. Past work targeted task values, personal values, belonging, and growth mindset as drivers of student outcomes (see Harackiewicz & Priniski, 2018, for a review). In addition to belonging, we targeted self-efficacy and challenge motivation as underlying processes that drive learning outcomes in classroom contexts. We predicted and found that when adolescents perceived math classes to be taught by enacting communal values, they felt a greater sense of belonging in class, felt more confident about their math ability, and more motivated to persist. These three processes put in motion early in the academic year yielded dividends at the end of the year, enhancing the value of math in students' self-concept, predicting greater class participation, and higher achievement at year's end, as students approached high school. Third, whereas most social psychological interventions utilized in past research targeted college students, we targeted an earlier period of development: early adolescents in middle school.[8] Translating research into practice, our findings offer actionable steps for K–12 schools and teachers on how to nurture greater confidence, motivation, and achievement in middle school STEM education to propel adolescents onto a trajectory of success in high school and college. Given evidence that middle school interests are strong early predictors of educational outcomes in high school and college (Berwick, 2019; Loveless, 2013; Maltese & Tai, 2011; Stein et al., 2011), we suggest that introducing interventions in this critical period of social and educational development and weaving them into classroom pedagogy is an important early lever for student success in the long-term.

Special Role of Belonging and Challenge Motivation for Racial Ethnic Minority Adolescents

Our results revealed that students' perceptions of communal classroom practices had special benefits for Black, Latinx, and Native American adolescents. First, understanding the social relevance of math at the beginning of the school year strengthened belonging in math across the year. Increased belonging, in turn, predicted significantly better math grades in the 8th grade compared with the 7th grade for URM students but not for White and other non-URM students. Second, greater belonging also predicted enhanced math self-concept three times more strongly for URM students than White and non-URM students. Third, when students understood the social relevance of math learned in class, that experience enhanced challenge motivation more strongly among URM compared with White students, which, in turn, translated into stronger math self-concept and greater class participation.

Our findings highlighting the importance of belonging for Black, Latinx, and Native American adolescents in STEM classes are consistent with social identity threat theory which proposes that social contexts where individuals are a small numeric minority and that activate negative stereotypes arouses social identity threat and belonging uncertainty (Calabrese Barton & Tan, 2018; Gray et al., 2020; Smith et al., 2014; Walton & Brady, 2017). This is often experienced by racial ethnic minority students in STEM classes at predominantly White schools. Applied to our finding, contextual communal cues that amplify social relevance, and to a lesser extent collaborative learning, allay social identity threat and strengthen adolescents' belonging in math spaces, which in turn, pays dividends by strengthening URM students' math self-concept and grades across the academic year. Our findings are consistent with past research showing the special benefits of communally oriented teaching for URM students through increased belonging. Aligning pedagogy with personal values of prosociality that are endorsed more strongly by racial ethnic minority Americans than White Americans (Fryberg & Markus, 2007; Gaines et al., 1997; Harper, 2005; Smith et al., 2014; Torres, 2009) helps fulfill the need for belonging among URM students.

What is new in our work, and missing from past research, is evidence of communal practices in naturally existing classrooms that differentially benefit the learning and engagement of racial ethnic minority learners together with data on underlying mechanisms

[8] As exceptions, Harackiewicz et al. (2012), Rozek et al. (2017), and Yeager et al. (2016) tested interventions in high school. To the best of our knowledge, no studies have examined interventions in classes with younger age groups.

explaining why. We find both belonging and challenge motivation are critical psychological levers that, when put in motion by socially relevant classroom practices, provide an extra boost to URM students' math self-concept, in-class behavior, and end-of-year grades. A clear future direction is to apply lessons learned from the present findings to K–12 schools by designing educational interventions that amplify social relevance of STEM and collaboration. Because our research was conducted in naturally existing classes, no additional translation is needed between the context in which this research was conducted and the contexts in which it could be applied.

Communal Classroom Contexts Benefit Girls and Boys Equally

A notable finding in our research, contrary to our original prediction, is that perceptions of communal classroom practices—both collaborative learning and emphasis on the social relevance of math—benefited girls and boys equally, increasing behavioral engagement in math class, strengthening their math self-concept, and increasing their end-of-year math grades. These influences of communal classroom practices on adolescent outcomes were mediated through greater sense of belonging in class, self-efficacy, and increased challenge motivation. Our finding of gender similarity (rather than gender difference) is at variance with literature that shows adult women express more interest in communality and prosocially-oriented careers than men (Diekman et al., 2017; Ferriman et al., 2009; Lubinski et al., 2001). However, recent research on gender and communality points to greater nuance, sometimes revealing gender similarity such that adult men and women endorse communal goals equally, while at other times revealing gender differences such that women endorse communal goals more than men (e.g., Diekman et al., 2011; Diekman et al., 2020). Given these recent gender similarity findings and other work showing that communal affordances of a context can affect woman and men in similar ways (e.g., Fuesting & Diekman, 2017), the gender similarities that emerged in our data—contrary to our original predictions—may be less surprising.

An additional explanation for the lack of gender differences within our data centers on the developmental period at the focus of past research on communality and gender (young adulthood) and our work (early adolescence). Consistent with this developmental explanation, our findings are similar to social developmental research on children's values that found girls and boys in late childhood (7–8 years of age) to be equally likely to endorse altruistic values when asked how much they would like to have a job that incorporates specific types of values (money, power, family, altruism; Weisgram et al., 2010). By taking a social developmental approach and attending to an earlier period of development than is typical in social psychology, our research discovered that communally oriented learning contexts that emphasize prosociality and collaborative learning enhance learning outcomes of all genders equally.

A third explanation for our gender similarity finding in adolescence as compared with past gender difference findings in adulthood is a contextual one, having to do with variations in STEM learning contexts at each period of development. The gender composition of math learning contexts for young adults in college is heavily male dominated with far more male students than female students whereas the gender composition of math learning contexts in middle school has equal proportions of male and female students (in coed schools) or all female students (in girls' schools). The context-specific experience of being a small minority in math classes in higher education may increase the salience of gender for young women, motivating the former to seek communality even more, and to align their belonging needs with the learning context. In comparison, the experience of being at gender parity or gender majority in middle school math classes may reduce the salience of gender and equalize the importance of communality for both girls and boys. The increased salience of gender in college STEM classes compared with its reduced salience in middle school STEM classes is another possible reason for our findings of gender similarity and prior findings of gender differences.

Limitations and Future Directions

One limitation of this study affecting the generalizability of these findings stems from our sampling method. We collected data from 10 schools—a relatively small number that limited our ability to detect between-school differences. Thus, there may be school-level variables not explored here that moderate these effects and ought to be explored with future research. That said, the large sample of students, across a large number of classrooms, collected in varied geographic regions across the nation provide wide variation in classroom contexts which increases confidence in the generalizability of the findings.

A second constraint on generalizability is that our students were recruited from private schools not public schools, which means that most of our participants came from upper-middle class families; there is limited social class variability in our sample and class sizes were small. To the extent that there are shared norms about how math is taught across private and public schools—that is, math is typically not framed as satisfying the communal goals—we anticipate that results ought to generalize across school types. That said, given that private schools are well-resourced, with small class sizes allowing greater attention to student needs, and teachers who have access to more pedagogical resources than many public schools, it is important to test the generalizability and boundary conditions of these findings to public school samples.

Third, our data were collected at predominantly White schools. Although our results are likely to replicate among other schools with similar racial ethnic demographics, it remains an open question as to whether similar findings will emerge in schools with different demographic compositions—especially our findings about the unique experiences of students of color, which may be contextually specific to the experience of being minoritized in predominantly White schools.

Fourth, our conceptual variables related to classroom communality were operationalized in terms of student perceptions, not objective measures or observer assessments of communality. This means we do not know whether student perceptions and objective indicators of classroom communality will converge and yield similar student outcomes or if one operationalization of classroom communality is a better predictor of student outcomes than the other. Social psychology teaches us that different people experience the same objective reality in varied ways and that perceived reality is often a better predictor of social behavior than objective reality. Applied to our research, this suggests student perceptions of their classes may be better predictors of their end-of-year outcomes than objective indicators of classroom communality. Nevertheless, this is an open question that is best answered by future empirical research.

Finally, our research used a longitudinal correlational research design; although this design allowed us to examine how perceived classroom characteristics measured at the beginning of the academic year were associated with change in student outcomes nine months later using time-lagged statistical analyses, this design also limits our ability to draw causal conclusions. To complement and confirm causality, future research could experimentally manipulate communal instructional practices in STEM classes (independent of student perceptions) and examine the causal consequences of such teaching practices on student outcomes. Future research might also expand the longitudinal scope of a future study to assess whether communal instructional practices in middle school STEM classes have long-term benefits at high school graduation. We look forward to future research examining these and other possible boundary conditions constraining generalizability.

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