Received: 23 August 2022 | Revised: 8 December 2022 | Accepted: 23 December 2022

DOI: 10.1002/sce.21784

RESEARCH ARTICLE

Science Education WILEY

STEM-related outcomes for adolescents with differing perceptions of school racial climate: A latent class analysis

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Abstract

Racially minoritized groups are underrepresented in science, technology, engineering, and math (STEM) degree programs and careers, warranting the need to examine students' racialized experiences in K-12 settings that may influence their STEM persistence. In particular, the current study explored adolescent perceptions of school racial climate (SRC) as a potential contributor to pre-college racial disparities in STEM. We used latent class analysis to group adolescents based on their SRC perceptions and explored group differences in their interest in a STEM career and their belonging, psychological needs satisfaction, and engagement in STEM courses. Adolescent participants ($N = 412$, 50.2% female, 36.9% male, 12.9% other/not reported, $M_{age} = 15.72$ years, standard deviation = 1.24) attending five high schools in the Southeastern United States, were grouped into five classes based on their perceptions of SRC: Critical SRC (CritSRC), Average SRC, Average with Stereotyping, Positive SRC (PosSRC), and Positive with Stereotyping. Latent class membership differed by race, age, and learning environment. Results revealed that students with more positive perceptions of SRC reported greater belonging, engagement, and needs satisfaction in their STEM courses and more interest in a STEM career compared to students with CritSRC perceptions. Findings also indicated that White students were more likely than Black students to perceive a PosSRC. Recommendations for areas of future research and policy implications are discussed.

KEYWORDS

belonging, engagement, psychological needs, school racial climate, STEM

1 | INTRODUCTION

Racially and ethnically minoritized groups remain underrepresented in science, technology, engineering, and math (STEM) (National Science Board, 2021). Despite similar STEM aspirations and interest for racially minoritized (i.e., Black and Hispanic) students and racially majoritized (i.e., White and Asian) students, salient differences in STEM degree attainment persist (Chang et al., 2014; Y. Ma & Liu, 2015; Whitcomb & Singh, 2021) such that Black and Hispanic undergraduates are less likely to earn a bachelor's degree in STEM compared to their White and Asian counterparts. In 2019, only 15.7% and 8.5% of bachelor's degrees in science and technology were awarded to Hispanic and Black students, respectively, despite these groups comprising 21.3% and 14.2% of the United states population aged 20–34 years old (National Science Board, 2021).

Racial differences in K-12 STEM coursework and academic preparation may contribute to the disproportionate percentage of underrepresented and minoritized STEM majors switching to non-STEM majors or dropping out of college (Chang et al., 2014; Y. Ma & Liu, 2015; National Science Board, 2021; Russell & Atwater, 2005). For example, 12th grade math scores on the 2019 National Assessment of Educational Progress indicated that Black and Hispanic students scored 21–45 points lower than White students and Asian students out of a total 300 points (National Science Board, 2021). Furthermore, Black and Hispanic students were underrepresented as Advanced Placement exam takers in STEM subjects in 2019 (National Science Board, 2021), indicating racial discrepancies in advanced STEM course enrollment. High school may be an especially important time to study these disparities as prior research indicates that high school students become increasingly aware of racial inequities (Seider et al., 2019) and adolescents' early interest and experiences in STEM courses predict their STEM degree achievement (Maltese & Tai, 2010; Tai et al., 2006).

Adolescents' awareness of racial inequality at school is likely reflected in their perceptions of school racial climate (SRC). SRC refers to perceptions of interracial interactions and racial socialization practices in the school setting (Byrd, 2015). Interracial interactions refer to the nature of interactions between different racial and cultural groups at school whereas racial socialization refers to ways in which messages about race, ethnicity, and culture are infused in curricula, policies, and practices (Byrd, 2017). The current paper focuses on components of SRC that align with student perceptions of interracial interactions (i.e., equal status, support for positive interactions, quality interactions, frequent interactions, and stereotyping) as prior research suggests that these components relate to adolescent belonging, competence, and intrinsic motivation in school (Byrd, 2015). Equal status refers to the extent to which different racial/ethnic groups are treated fairly at school. Support for interracial interactions describes personnel's (i.e., teachers and administrator) approval of interracial interactions in the school. Quality interactions refer to how meaningful and how positive/negative the interactions are, whereas frequent interactions describe how often interracial interactions occur. Finally, stereotyping assesses perceptions of prejudicial thoughts (not behaviors) toward racial/ethnic groups at school.

Hostile racial climates harm undergraduate STEM major's first year adjustment (Hurtado et al., 2007); however, associations between SRC and STEM-related constructs have yet to be investigated in high school contexts. The current study addresses this gap by examining underlying patterns of high school students' SRC perceptions and how SRC perceptions might connect to STEM-related outcomes. In particular, we focus on students' psychological needs satisfaction (autonomy, competence, and relatedness), belonging, and engagement in their STEM courses as these constructs are associated with positive outcomes (i.e., increased motivation, achievement, and persistence; Booker, 2006; Froiland & Worrell, 2016; Goodenow, 1993; Osterman, 2000; Patall et al., 2018; R. A. Simon et al., 2015).

SRC is a multidimensional construct with five interrelated components that represent students' perceptions of interracial interactions at school. Thus, we opted to use a person-centered statistical approach which enables us to capture patterns of adolescents' perceptions of SRC. A person-centered approach focuses analysis at the individual level by acknowledging the multiple systems (phenomena) that operate simultaneously in individuals' lives (Bergman & Trost, 2006). Therefore, a person-centered approach allows us to appropriately and holistically identify different features of the school environment that may be more salient to some individuals rather than examining perceptions of SRC as entirely "positive" or "negative" (Byrd, 2017). In particular, we selected latent class analysis (Vermunt & Magidson, 2004), a person-centered approach that aims to uncover underlying patterns amongst individuals in their perceptions of SRC. Thus, the aim of the current study is to explore latent classes of adolescents' SRC perceptions and how these latent classes might relate to students' interest in a STEM career and their belonging, engagement, and psychological needs satisfaction (autonomy, competence, and relatedness) in STEM courses. In doing so, we strive to inform science education practices aimed at reducing racial disparities in high school.

2 | THEORETICAL FRAMEWORK

The current study is informed by an integrated theoretical framework that weaves together tenets of Self-Determination Theory (SDT) and Critical Capital Theory (CCT) to explore factors that contribute to high school STEM racial disparities. The CCT model reframes STEM persistence by arguing that systemic influences (i.e., racism and lack of economic capital) constrain individual forms of social and cultural capital which can ultimately contribute to racial disparities in STEM attainment (Bancroft, 2018). Social capital refers to an individual's social network that can support them through challenging STEM contexts whereas cultural capital refers to individual's intrinsic sense of competence and psychological well-being within STEM settings. Having large social networks containing supportive individuals that know how to navigate institutional power (i.e., social capital) reinforces individuals' STEM identity and belonging (i.e., cultural capital), leading to a greater likelihood of being successful in STEM (Bancroft, 2018). However, racism in the form of inequitable school policies, disparate K-12 opportunities, and hostile institutional climates privileges White students, leading them to have greater social capital both in their blood (i.e., family) and fictive (i.e., STEM peers and mentors) kinships compared to traditionally underserved students (Bancroft, 2018).

CCT was initially conceptualized within higher education settings, with a focus on doctoral education (Bancroft, 2018), but we extend this theory to high school STEM contexts by exploring how perceptions of SRC relate to students' STEM career interest and belonging, psychological needs satisfaction, and engagement in their STEM courses. We conceptualize SRC as representing a systemic influence that contributes to adolescents' social and cultural capital and, ultimately, to the likelihood of their STEM-related success. We conceptualized adolescents' belonging and psychological needs satisfaction as examples of cultural capital because they are indicators of psychological well-being and competence in STEM contexts. Finally, we conceptualize students' engagement in their STEM courses and their interest in a STEM career as important STEM-related outcomes in high school because they predict STEM achievement and persistence (Caspi et al., 2019; Chang et al., 2014). Aligning our constructs of interest with the CCT framework may shed insight into the mechanisms that might underlie the associations between perceptions of SRC and STEM-related outcomes.

We posit that SDT ties closely into Bancroft's (2018) description of cultural capital and explanation of how cultural capital encourages STEM persistence and success. SDT posits that when individuals' three psychological needs of autonomy, competence, and relatedness are satisfied, students are more likely to be intrinsically motivated (Deci & Ryan, 2002) and tend to demonstrate greater academic achievement, engagement, and persistence in STEM (Booker, 2006; Deci & Ryan, 2002; Froiland & Worrell, 2016; Goodenow, 1993; Osterman, 2000; R. A. Simon et al., 2015). Students experience autonomy when they perceive a sense of control in their learning that reflects their choices, interests, and values (De Loof et al., 2021; Stroet et al., 2013), competence when they perceive self-mastery in a topic or skill (Moore et al., 2020), and relatedness when they feel a sense of belonging to individuals or groups (Moore et al., 2020). For example, students can feel autonomous when they choose a project topic, competent when they effectively carry out an experiment, and relatedness when they cooperate with classmates. Moore et al. (2020) suggest that teachers can support underrepresented and racially minoritized students' STEM persistence by fostering inclusive environments through instructional practices that satisfy students' psychological needs. Indeed, Mulvey et al., (2022) demonstrated that students' perceptions of inclusion and discrimination in their STEM classes, relate to their STEM class engagement regardless of their race/ethnicity. Incorporating SDT into our vision of the CCT framework in high school STEM contexts enables us to understand a possible underlying link (i.e., intrinsic motivation) that connects perceptions of SRC to cultural capital (i.e., psychological needs satisfaction) and STEM outcomes (i.e., STEM class belonging, STEM class engagement, and STEM career interest).

2.1 | Perceptions of SRC

SRC is essentially a subset of more general school climate, which Rudasill et al. (2018) define as "the affective and cognitive perceptions regarding social interactions, relationships, safety, values, and beliefs held by student, teachers, administrators and staff within a school" (p. 46). Following recommendations by DeCuir-Gunby and Schutz (2014), who advise scholars to use race-focused constructs when examining issues related to racial inequality in schools, we focused on SRC (as opposed to general school climate) in this study.

Positive perceptions of SRC include high quality and frequent interracial interactions grounded in equal status between racial/ethnic groups, serving to reduce bias and support positive relationships, and fostering students' sense of relatedness to others at school (Byrd, 2015). However, not all students within a school will perceive a positive school climate. Student experiences vary considerably within a school, particularly when considering perceptions of school climate (Mayworm et al., 2021). Byrd (2017) posits that researchers should acknowledge the multidimensionality of SRC, given how students may experience each component of SRC differently.

Adolescence may be a particularly salient developmental period to explore student perceptions of SRC. During this time, youth become more aware of the structural roots of racism and poverty (Seider et al., 2019) and are more likely to identify racism at their school. For example, Martin and Fisher-Ari (2021) interviewed 34 racially/ethnically underrepresented high school students about race and gender underrepresentation in STEM and found that most adolescents used white privilege and patriarchy to explain STEM exclusion. In particular, students described historical and current systemic inequalities restricting access for people of color and the impact of racial stereotypes and implicit bias on entering STEM fields (Mayworm et al., 2021).

We opt to use a person-centered statistical approach (i.e., latent class analysis) to better understand the nuances of student perceptions of SRC. For instance, students may be more aware of limitations in particular components of the SRC. The current study seeks to understand high school students' awareness of racism at school by exploring latent classes representing students' holistic perceptions of SRC and how these classes might differ in (1) criticality by demographic factors such as age and racial/ethnic identity and (2) STEM belonging, engagement, psychological needs satisfaction, and career interest.

To our knowledge, only one study used SRC components in conjunction with other variables in a latent class analysis. In their recent study, Byrd and Ahn (2020) included several SRC components focused on interracial interaction and racial socialization in conjunction with other variables to explore profiles of ethnic-racial socialization from family, school, neighborhood, and the internet. Their analysis resulted in three clusters, one of which they labeled "Positive School" because students perceived a generally positive SRC and average or below average racial socialization from their family, neighborhood, and online (Byrd & Ahn, 2020). White adolescents were overrepresented and Black adolescents were underrepresented in the Positive School cluster. Furthermore, this group reported greater educational aspirations, belonging, engagement, autonomy, and environmental mastery than the other two groups labeled "Average" and "High Discrimination" (Byrd & Ahn, 2020). They also found that adolescents in the "High Discrimination" group were more critically conscious than their counterparts in the Positive School and Average groups (Byrd & Ahn, 2020). Taken together, these findings offer insights into how SRC, broadly, relates to adolescent psychological well-being, academic outcomes, and critical consciousness; however, our study offers a more nuanced exploration of SRC profiles and their relations to STEM-specific outcomes.

A different study used adolescents' perceptions of discrimination in school from different groups, for different reasons, in different forms as latent indicators to explore cluster differences in general school climate and engagement (Byrd & Carter Andrews, 2016). Although this study did not examine SRC per se, it did explore types and sources of racial discrimination in school which are related to multiple components of SRC. Latent classes were labeled based on the primary source of discrimination in school. Results revealed that African American and Multiracial adolescents were less likely to be in the "Low Discrimination" group which perceived a more positive school climate and reported higher rates of academic engagement than the "Peer," "Adult," and "Multiple" groups (Byrd & Carter Andrews, 2016). Results from this study highlighted that students who perceived more discrimination from fictive kinships at school (i.e., peers, adults, and multiple groups) reported worse academic outcomes (i.e., engagement).

Other studies involving adolescents that used general school climate measures (e.g., safety and positive student–teacher relationships) as indicator variables similarly found that (1) Black and Latino/a/e students were more likely than their White counterparts to perceive a hostile climate (De Pedro et al., 2016) and (2) classes that perceive a positive school climate were more likely to report adaptive academic outcomes such as higher educational aspirations and grades than classes that perceive a negative school climate (Shukla et al., 2016). These findings suggest that experiencing racism and perceiving hostile climates may contribute to disparate educational outcomes in high school. The current study explores this further by focusing on the relationship between SRC and STEM interest, psychological needs satisfaction, engagement, and belonging.

2.2 | SRC and basic psychological needs

Students who perceive a positive SRC are more likely to have their basic psychological needs met (Byrd, 2015). In other words, they are more likely to feel competence in school, to feel that they can make autonomous decisions in their classes and to feel connectedness to their peers in school (relatedness). This finding aligns with CCT which posits that perceptions of positive systemic influences (i.e., institutional climates) encourage individual's social capital (i.e., relatedness) and cultural capital (i.e., autonomy and competence), contributing to likely positive outcomes. Indeed, perceptions of peers and staff holding racial stereotypes and prejudices can hinder individuals' sense of relatedness, especially for underrepresented and minoritized students (Brown & Lee, 2005; Hurtado & Carter, 1997) by making them feel less connected to others at school (Dotterer et al., 2009) and less valued (Byrd, 2015). For example, discriminatory tracking systems that filter White students into Advanced Placement and honors courses and underrepresented and minoritized students into less rigorous courses (Legette, 2020), contribute to racialized enrollment patterns in STEM courses, perceptions of inequitable SRC, and reduced needs satisfaction (Dalton et al., 2007; Tyson et al., 2007). Tracking systems can also uphold and reinforce stereotypes of underrepresented and minoritized academic inferiority, hindering underrepresented and minoritized students' ability to feel competent in school (Legette, 2020). However, quality interracial interactions that support equal status among racial/ethnic groups can provide underrepresented and racially minoritized students with positive feedback from teachers and peers, which helps to enhance individual's social capital and support their sense of competence in school (Bancroft, 2018; Byrd, 2015). Thus, SRC can impact individuals' psychological needs satisfaction in positive and negative ways. The current study investigates how student perceptions of SRC relate to their psychological needs satisfaction (feelings of autonomy, competence and relatedness) in high school STEM courses.

2.3 | SRC and belonging

The current study also explores associations between SRC perceptions and students' sense of belonging in high school STEM contexts. Although the constructs of belonging and relatedness share similarities regarding individuals' sense of connection to others in school, the need for relatedness is not synonymous with belonging. We define belonging as a sense of comfort, fit, and social connection in an academic context (London et al., 2011). The need for relatedness is an inherent and universal need which requires a sense of mutual respect, caring, and reliance with others (Deci & Ryan, 2002). Thus, we posit that an individual's sense of belonging contributes to, but does not solely satisfy, their need for relatedness. Similarly, both constructs are context-specific in that one could feel a sense of belonging and satisfy their need of relatedness within their afterschool activities, but not their academic classes. Therefore, the current study explores how student perceptions of SRC relates to both their belonging and psychological needs satisfaction within the context of STEM courses.

Belonging is a key predictor of academic and school success outcomes (Faircloth & Hamm, 2005; Neel & Fuligni, 2013). While much research has focused on the general benefits of school belonging for academic outcomes, research also points to belonging as particularly important for STEM-related outcomes, with much of the prior research centered on underrepresented and minoritized STEM majors in college and university settings (Chang et al., 2014; Lewis et al., 2017; Rainey et al., 2018). For example, Rainey and colleagues (2018) interviewed 201 college seniors in the North Carolina public university system who persisted in or dropped a STEM major. Not surprisingly, they found that students who persisted in a STEM major were more likely to feel a sense of belonging than those who left. Additionally, racially minoritized students were less likely to feel like they belong. Furthermore, their results suggest that competence and interest in STEM are key factors that impact belonging for college students (Rainey et al., 2018).

Limited research has focused on feelings of belonging in high school STEM contexts which may be a key contributing factor in STEM persistence (Morton & Parsons, 2018). However, recent research using path analysis finds that feelings of inclusion shape belonging which then shapes in and out of school STEM engagement (Mulvey et al., 2022). One study documented that greater anticipated belonging to a computer science course predicted higher interest in enrolling in that course for US high school students (Master et al., 2016). Another study found that greater feelings of belonging in an informal STEM learning program predicted greater STEM efficacy (i.e., belief that they could do STEM) and interest for UK and US adolescents (Hoffman et al., 2021). Taken together, these findings suggest that belonging may be a central factor in fostering STEM motivation and interest; however, more research is needed to understand how belonging might function as cultural capital in high school STEM contexts.

Research has long highlighted the importance of general school context and climate for shaping belonging (Baumeister & Leary, 1995; Cemalcilar, 2010; X. Ma, 2003) but more recently, Byrd and Chavous (2011) demonstrated that SRC can shape students' feelings of belonging at school. In particular, their findings suggest that for 11th grade African Americans, experiencing a positive SRC consistent with their positive beliefs regarding their racial group helps them to develop a sense of belonging at school (Byrd & Chavous, 2011). Similarly, Byrd (2015) found that African American adolescents' perception of more positive cross-race interactions at school related to greater belonging. Other research also supports this link, with findings suggesting that diverse school settings that foster positive intergroup contact and cross-group friendships can promote feelings of belonging in students (Hilts et al., 2018). Thus, prior research suggests that an aspect of SRC involving positive interracial interactions supports belonging. We attempt to extend this relationship between positive intergroup contact and belonging in high school STEM contexts by exploring more holistic perceptions of SRC that examine how distinct patterns between the five components involved in interracial interactions might relate to belonging in STEM classes.

2.4 | SRC and engagement

General school climate is an important predictor of school engagement (Cornell et al., 2016), especially for American adolescents (Bear et al., 2018), although research to date has yet to explore how SRC might relate to STEM engagement. However, perceptions of SRC have been shown to relate to general academic engagement in positive and negative ways. A study of African American high school students documented that perceptions of a racially fair school environment and perceptions of lower peer discrimination were related to higher rates of general engagement in school (Griffin et al., 2017). Moreover, this study documented that engagement is a key mediator in the relationship between SRC and academic achievement (Griffin et al., 2017), highlighting the importance of future research exploring the types of SRC that are optimal for student engagement in STEM classes. Other findings suggest that some dimensions of SRC (e.g., stereotyping) may be central in limiting engagement as research suggests that adolescents often hold negative stereotypes associating underrepresented and minoritized peers with less academic engagement (Hudley & Graham, 2001). Finally, research with adolescents in Belgium documented that, while engagement generally decreased across adolescence, classroom diversity (ethnic heterogeneity) predicted less steep declines (Engels et al., 2020), suggesting that diversity can function as a buffer against declining engagement. What is still unknown, and what this study seeks to address, is how differing perceptions of specific aspects of SRC (e.g., stereotyping and positive interracial interactions) relate to high school STEM course engagement.

2.5 | SRC and STEM career interest

High school students' interest in a STEM career is likely to have important implications for their educational and academic trajectories and STEM persistence overtime (Fredricks et al., 2018; Gottfried, 2015). For example, when exploring Israeli middle school students' reasoning to declare a high school major in STEM, Caspi et al. (2019) found that most adolescents cited STEM interest/enjoyment and college/career goals as their primary motivation. To our knowledge, prior research has yet to examine a direct relationship between perceptions of SRC and adolescents' interest in a future STEM career; however, our integrated framework offers theoretical support for this relationship such that students with more positive perceptions of SRC (i.e., greater social capital) would likely report greater STEM class belonging and psychological needs satisfaction (i.e., cultural capital) and greater engagement in STEM classes and interest in a STEM career (i.e., persistence) compared to students with more critical perceptions of SRC.

3 | CURRENT STUDY

The current study seeks to explore associations between adolescent perceptions of SRC and STEM belonging, engagement, psychological needs satisfaction, and career interest. Our specific research questions are:

1. What latent classes of student perceptions of SRC exist?

Hypothesis 1. *We expect that at least one class will perceive a more positive SRC and at least one class will hold a more critical view of SRC.*

2. How might the classes differ in membership regarding race, age, gender, and learning environment?

Hypothesis 2a. *We expect White students to be overrepresented and racially minoritized students to be underrepresented in the more positive SRC class and White students to be underrepresented and minoritized students to be overrepresented in the more Critical SRC (CritSRC) class.*

Hypothesis 2b. *We expect older adolescents to hold more critical perceptions of SRC than younger adolescents.*

Exploratory analyses: Given limited prior research on SRC class differences in gender and learning environments (i.e., online, in-person, or hybrid) we do not have specific directional hypotheses for these variables, but we anticipate that differences will emerge.

3. Do perceptions of SRC relate to students' interest in a STEM career?

Hypothesis 3. *We expect that students with more positive perceptions of SRC will be more likely to report interest in a STEM career.*

4. How are different SRC latent classes associated with belonging, engagement, and needs satisfaction in STEM courses?

Hypothesis 4. *We expect that students with positive perceptions of SRC class will report higher levels of belonging, engagement, and needs satisfaction in STEM courses compared to students with more critical perceptions of SRC. Given the lack of prior research regarding this relationship, we do not have specific hypotheses for other potential classes that may emerge and will explore these relationships.*

4 | METHOD

4.1 | Participants

Participants included 412 adolescents (50.2% female, 36.9% male, 2.4% did not identify as male or female, 1.5% were unsure, 2.7% preferred not to say, and 6.3% did not respond) attending five different Title 1 high schools located in the Southeastern United States. Title 1 schools serve a predominately low-income student population. Participant age ranged from 13 to 20 years old (M_{age} = 15.72 years, standard deviation = 1.24). Most participants were 9th and 10th graders (34.0% 9th graders, 31.3% 10th graders, 17.2% 11th graders, and 17.5% 12th graders). The racial/ethnic background of the sample included 31.8% Black, 35.4% White, 10.9% Latinx, and 14.3% Other participants (3.4% of participants preferred not to say and 4.1% did not respond). In general, the racial/ethnic breakdown of the sample who did complete the measures was reflective of the community and school demographics (see Supporting Information Materials for partner school demographics). Most students reported taking one or two STEM classes at the time of data collection.

4.2 | Procedure

All students between 9th and 12th grade from five schools were invited to participate in a larger survey about STEM experiences in school. IRB approved opt-out informed consent letters were sent home to parents/guardians. In total, 694 students who had parental consent agreed to participate in an online survey administered through Qualtrics between November 2020 and March 2021. Participants completed the survey from home at a time of their choosing. It took students approximately 45 min to complete the entire survey which included approximately 270 individual items. Although 694 students assented to participate, only 412 completed all relevant survey measures, thus the sample size for all analyses was 412. Of these students, due to the COVID-19 pandemic, 51.5% reported that they were attending school virtually, 35.4% reported that they were attending school in a hybrid format and 12.9% reported that they were attending school in person. All participants were entered into a drawing for $10 electronic gift cards.

4.3 | Measures

See the Supporting Information Materials for a list of all items included in this study.

4.3.1 | SRC

Participants were presented with five subscales of the School Climate for Diversity-Secondary Scale (Byrd, 2017). Subscales examined student perceptions of SRC involving interracial interactions using a 5-point Likert scale ranging from 1 (*Not at all true*) to 5 (*Completely true*). The Equal Status subscale (3 items; $\alpha = 0.89$) measured student perceptions of equal and fair treatment at school such as, "Students of all races/ethnicities are treated equally at your school." The Support for Positive Interaction subscale (4 items; $\alpha = 0.87$) measured student perceptions of encouragement for interracial interactions by teachers, principals, and other students and included items like, "Teachers and principals say it is good to be a diverse school." The Quality Interaction subscale (3 items; $\alpha = 0.83$) measured student perceptions of amicable interracial interactions such as, "People of different races/ethnicities get along well." The Frequency Interaction subscale (3 items; $\alpha = 0.89$) measured student perceptions of interracial interactions in various academic contexts such as, "Students of different races/ethnicities work together in class." The Stereotyping subscale (4 items; $\alpha = 0.87$) measured student perceptions of negative stereotypes held against their own racial/ethnic group and other racial/ethnic groups at school and included items like, "Teachers and principals believe stereotypes about your racial/ethnic group."

4.3.2 | STEM belonging

Adolescents' sense of belonging in their STEM courses was measured using an adapted version of the Mendoza-Denton et al. (2002) Institutional Belonging scale. In our adapted version, items were edited to focus on belonging to one's current STEM courses rather than STEM major which was the focus of the original scale as used by London et al. (2011). Our scale included eight items ($\alpha = 0.94$) with Likert-type responses ranging from 1 to 10. For example, participants were asked "How welcome do you feel within your STEM classes?" with response options spanning 1 (*do not feel welcome*) to 10 (*feel very welcome*). Items were averaged to create a mean score of belonging in STEM courses; higher scores indicated higher levels of STEM belonging.

4.3.3 | STEM needs satisfaction

Basic psychological needs in STEM were measured using an 18-item scale featuring three subscales that evaluated participants' feelings of competence, autonomy, and relatedness in their STEM courses. This scale was adapted from a measure used to assess need satisfaction at work in prior studies (Deci et al., 2001; Ilardi et al., 1993). Participants were asked to rate how true each statement was for themselves on a Likert-type response ranging from 1 (*not true at all*) to 7 (*completely true*). Autonomy was measured using six items such as, "I am free to express my ideas and opinions in my STEM classes." Competence was measured using six items, such as "People in my STEM classes tell me I am good at what I do." Relatedness was measured using eight items, such as "People in my STEM classes are pretty friendly towards me." The average of the 20 items was used as the Needs Satisfaction variable ($\alpha = 0.88$) with higher scores indicating greater level of needs satisfaction.

4.3.4 | STEM engagement

Engagement in STEM courses was measured using the Engagement Scale that captured four dimensions of engagement: cognitive, social, behavioral, and emotional (Wang et al., 2016). Items described experiences in school and participants responded to Likert-type responses that ranged from 1 (*strongly agree*) to 7 (*strongly disagree*). Cognitive Engagement was measured using eight questions such as, "I go through the work for STEM classes and make sure that it's right." Behavioral engagement was measured using eight questions, like "I put effort into learning STEM." Emotional Engagement was measured using ten questions, such as "I look forward to STEM classes." Social engagement was measured with seven questions including "I try to understand other people's ideas in STEM classes." A composite measure of STEM Engagement ($\alpha = 0.92$) was created to capture students' overall engagement with STEM.

4.3.5 | STEM career interest

Participants interest in having a STEM career was measured by one, newly developed item. Participants were asked "Are you interested in having a STEM job or not?" and responded by selecting "yes" ($n = 86$), "no" ($n = 82$), or "unsure" ($n = 244$).

4.4 | Data analysis plan

To examine patterns of missingness in the data, Little's Missing Completely at Random (MCAR) test was conducted. This confirmed that data were MCAR (Little's MCAR test: $\chi^2 = 99.145$, $df = 90$, $p = 0.239$). Latent class analysis was necessary to address our first research question. Latent class analysis is a statistical technique that identifies underlying relationships in categorical data (McCutcheon, 1987). It involves categorical variables whereas latent profile analysis involves continuous variables. Given that our variables are not truly continuous, we opted to refer to our approach as latent class analysis as it aligns with recommendations set forth by Vermunt and Magidson (2016). From here forward, we refer to our latent classes as groups to avoid confusion with classes in a school context. We used Latent Gold (version 5.1) to estimate distinct, underlying groups of holistic SRC perceptions within our sample using mean composite scores of the five SRC subscales (i.e., Equal Status, Support for Positive Interaction, Frequent Interactions, Quality Interactions, and Stereotyping) as indicators. Latent class analysis is an advantageous approach compared to traditional clustering methods because it includes estimates of model parameters and diagnostics that are helpful in determining which cluster model is the best fit for the data (Vermunt & Magidson, 2016). Latent Gold uses full information maximum likelihood, automatically applies the estimator, and generates random start values (Vermunt & Magidson, 2016).

We ran a series of Chi-Squared tests to address our second research question, regarding latent group membership differences for categorical demographic variables (i.e., gender, race, and school environment). Age, however, is a continuous variable. Therefore, we conducted a 5-way (Group) analysis of variance (ANOVA) on age to explore mean age differences between latent groups.

To test whether students' SRC perceptions related to their interest in a STEM career (third research question), we ran a multinomial logistic regression involving STEM job interest (i.e., yes, no, unsure) as the categorical dependent variable. Age, dummy coded race/ethnicity, gender, and cluster membership variables were initially included as predictors.

To address our final research question, we ran a 5-way (Group) MANCOVA to examine differences across SRC groups in the three STEM-related outcomes (i.e., belonging, needs satisfaction, and engagement) controlling for students' demographics (i.e., gender and race/ethnicity), learning environment, and STEM career interest. We expected that the STEM-related outcomes would be correlated with one another, making MANCOVA the optimal approach. To fully address our question regarding differences between latent groups in specific STEM-related outcomes, we analyzed the follow-up univariate analyses and adjusted Bonferroni post hoc tests.

5 | RESULTS

5.1 | SRC latent groups

To address our first research question, we first determined the number of latent groups by comparing the model fit for the six latent group models (ranging from 1 to 6 latent groups). We investigated the likelihood ratio Chi squared statistic (L^2) to assess model fit and to make model comparisons, opting for models with lower L^2 as this indicates a better fit to the data. We further explored models with a nonsignificant *p* value ($p > 0.05$), a lower Bayesian Information Criterion (BIC) value and Akaike Information Criterion, a greater entropy, and a bivariate residual (BVR) below 3.84 (Spurk et al., 2020). Taken together, these values indicate a better fit to the data and aided our evaluation of the model's goodness-of-fit (Vermunt & Magidson, 2016).

Summary statistics for the six latent group models are included in Table 1. The five-group and six-group models demonstrated good model fit. To test whether the six-group model provided a significant improvement over the five-group model, we used conditional bootstrapping to compare model fit by assessing the difference in L^2 values for both models. This analysis revealed that the six-group model provided a significant improvement in fit over the five-group model ($p < 0.001$). Thus, the six-group model appeared to be the optimal fit for the data; however, upon further exploration, the model proved problematic. Several groups failed to represent a significant portion of the sample; groups 5 and 6 included an estimated combined 10% of the sample. Additionally, group 6 lacked a theoretical basis (i.e., perceptions of high Support for Positive Interaction, average Quality Interaction and Stereotyping, and low Frequent Interaction and Equal Status). In contrast, the five-group model included theoretically sound SRC profiles with each group estimated to represent a sizable portion of the sample. Further, the five-group model had comparatively low BIC and L^2 values, a nonsignificant *p*-value, high entropy, and BVRs below 3.84. Thus, we opted to select the more parsimonious five-group model.

The first group in the five-group model (31.1%; $n = 128$) is the "Critical SRC" (CritSRC) group because participants in this group perceived below average levels of most SRC variables and average levels of stereotyping,

TABLE 1 Latent group analysis model summary statistics

Model	BIC (LL)	AIC (LL)	L^2	*df*	*p* Value	Max BVR	Entropy
One group	4510.58	4470.37	1249.95	232	<0.001	270.15	1.00
Two group	3888.20	3823.87	591.45	226	<0.001	36.86	0.88
Three group	3628.70	3540.24	295.82	220	<0.001	2.15	0.89
Four group	3635.78	3523.20	266.77	214	0.008	2.41	0.83
Five group	3642.21	3508.02	237.08	208	0.081	2.76	0.84
Six group	3647.84	3487.00	206.57	202	0.40	1.80	0.83

Abbreviatios: AIC(LL), log-likelihood based Akaike information criterion; BIC(LL), log-likelihood based Bayesian information criterion; Entropy, entropy R^2; L^2, likelihood ratio Chi square; Max BVR, maximum bivariate residuals.

see Figure 1 and Table 2. The second group (27.9%; $n = 115$) is labeled "Average SRC" (AvgSRC) because they perceived moderate levels of all SRC variables. The third group (16.5%; $n = 68$) is the "Average with Stereotyping" (AvgSt) group because participants perceived above average levels of stereotyping and average levels of all other SRC variables. The fourth group (15.5%; $n = 68$) is the "Positive SRC" (PosSRC) group because participants below average levels of stereotyping and above average levels of all other SRC variables. Finally, the fifth group (9.0%; $n = 37$) is labeled "Positive with Stereotyping" (PosSt) because participants perceived above average levels of all SRC variables, including stereotyping.

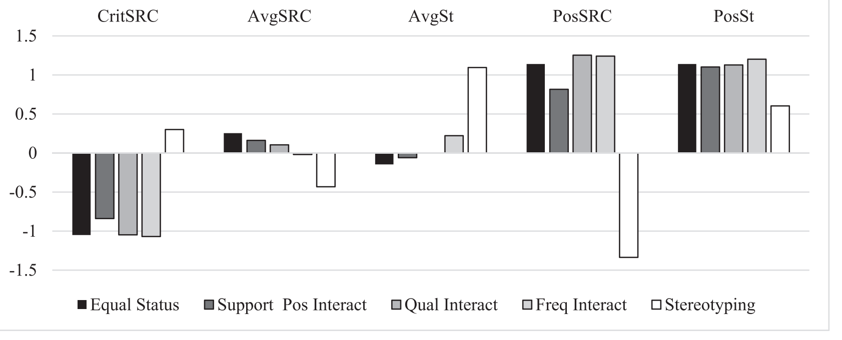

FIGURE 1 SRC groups and standardized means. Support pos interact, support for positive (interracial) interaction; qual interact, quality (interracial) interactions; freq interact, frequent (interracial) interactions.

TABLE 2 Indicator and outcome variable means and standard deviations by latent group

Variables	CritSRC $n = 128$	AvgSt $n = 68$	AvgSRC $n = 115$	PosSt $n = 37$	PosSRC $n = 64$
School racial climate					
Equal status	2.86 (0.51)	3.68 (0.66)	4.04 (0.55)	4.84 (0.30)	4.84 (0.31)
Sup pos interact	2.83 (0.58)	3.50 (0.65)	3.69 (0.61)	4.50 (0.56)	4.25 (0.84)
Qual interact	2.84 (0.46)	3.68 (0.49)	3.76 (0.39)	4.58 (0.49)	4.68 (0.37)
Freq interact	2.97 (0.48)	3.99 (0.44)	3.80 (0.40)	4.77 (0.31)	4.80 (0.28)
Stereotyping	2.91 (0.55)	3.63 (0.42)	2.24 (0.06)	3.18 (0.94)	1.42 (0.42)
STEM-related					
Belong	6.02 (1.81)	6.79 (1.81)	7.24 (1.65)	7.92 (1.67)	8.49 (1.30)
Needs satis	4.03 (0.55)	4.35 (0.66)	4.64 (0.84)	5.11 (0.65)	5.16 (0.81)
Engagement	4.39 (0.71)	4.79 (0.91)	5.01 (0.65)	5.19 (0.85)	5.55 (0.73)
Career interest	12.5% yes	19.1% yes	20.0% yes	21.6% yes	40.6% yes
	28.1% no	14.7% no	16.5% no	32.4% no	7.8% no
	59.4% unsure	66.2% unsure	63.5% unsure	45.9% unsure	51.6% unsure

Abbreviations: AvgSt, Average with Stereotyping; Belong, Belonging; CritSRC, Critical SRC; Freq Interact, Frequent (interracial) Interactions; Needs Satis, Needs Satisfaction; PosSRC, Positive SRC; PosSt, Positive with Stereotyping; Qual Interact, Quality (interracial) Interactions; Sup Pos Interact, Support for Positive (interracial) Interaction.

5.2 | Latent group membership

With regard to our second research question, analyses indicated that some latent groups differed in demographic variables (see Table 3 for demographic information by group membership). First, we explored latent group membership differences by race/ethnicity (Hypothesis 2a). We found that White participants (χ^2 (4) = 35.19, $p < 0.001$) were overrepresented in the PosSRC, PosSt, and AvgSt groups and were underrepresented in the CritSRC and AvgSRC groups. Furthermore, Black participants (χ^2 (4) = 19.29, $p = 0.001$) were overrepresented in the CritSRC and the AvgSRC groups and they were underrepresented in the PosSt group. Latinx participants were not overrepresented or underrepresented in any group (χ^2 (4) = 1.26, $p = 0.867$).

Next, we explored age differences in latent group membership (Hypothesis 2b). A 5-way (Group) ANOVA on age (F (4, 405) = 6.38, $p < 0.001$, $\eta_p^2 = 0.06$) revealed that participants in the CritSRC group were older than participants in the AvgSRC ($p = 0.019$), PosSRC ($p < 0.001$), and PosSt groups ($p < 0.039$). Additionally, participants in the AvgSt group were older than participants in the PosSRC group ($p < 0.026$).

Finally, we ran chi squared tests to address our exploratory analyses regarding gender and learning environment. We did not find gender differences among groups, χ^2 (4) = 7.08, $p = 0.132$. However we found that the type of learning environment (i.e., online, in-person, or hybrid) differed by group (χ^2 (8) = 18.97, $p = 0.015$) such that participants who were attending virtual school were overrepresented in the CritSRC group and underrepresented in the PosSRC group whereas students attending hybrid school were overrepresented in the PosSRC group and underrepresented in the CritSRC group.

TABLE 3 Demographic variables by latent group

Variables	Poor SRC n = 128	AvgSt n = 68	AvgSRC n = 115	PosSt n = 37	PosSRC n = 64
Age	16.07 (1.34)	15.88 (1.32)	15.56 (1.27)	15.70 (1.31)	15.20 (1.06)
Gender	39.8% male, 40.6% female	27.9% male, 61.8% female	34.8% male, 57.4% female	40.5% male, 45.9% female	42.2% male, 46.9% female
Race/Ethnicity	39.8% Black	42.6% Black	27.8% Black	8.1% Black	25.0% Black
	19.5% White	25.0% White	45.2% White	59.5% White	46.9% White
	10.2% Latinx	14.7% Latinx	10.4% Latinx	10.8% Latinx	9.4% Latinx
	17.2% Other	11.8% Other	12.2% Other	18.9% Other	12.5% Other
Grade	23.4% 9th	33.8% 9th	37.4% 9th	48.6% 9th	40.6% 9th
	28.9% 10th	25.0% 10th	32.2% 10th	32.4% 10th	40.6% 10th
	18.8% 11th	23.5% 11th	16.5% 11th	10.8% 11th	12.5% 11th
	28.9% 12th	17.6% 12th	13.9% 12th	8.1% 12th	6.3% 12th
School Environment	59.1% virtual	58.8% virtual	53.0% virtual	40.5% virtual	32.8% virtual
	26.8% hybrid	32.4% hybrid	33.9% hybrid	43.2% hybrid	54.7% hybrid
	14.2% in-person	8.8% in-person	13.0% in-person	16.2% in-person	12.5% in-person

Note: Gender and Race/Ethnicity sections do not sum to 100% because participants who responded as "Other" or did not respond were not included in this table.

Abbreviations: AvgSRC, Average SRC; AvgSt, Average with Stereotyping; PosSRC, Positive SRC; PosSt, Positive with Stereotyping.

5.3 | SRC group associations with STEM-related outcomes

5.3.1 | STEM career interest

To address our third research question, we conducted two multinomial logistic regressions to explore whether student's SRC latent group related to their interest in a STEM career. Initially, we included dummy-coded race/ethnicity, age, and school learning environment as covariates in the model; however, these predictors were nonsignificant so we opt to report the more parsimonious model which included dichotomous gender and dummy-coded cluster variables as predictors. The CritSRC group was the referent group for each logistic regression. First, we compared students who were not interested in a STEM career to students who were unsure and students who were interested in a STEM job (see Table 4). These analyses revealed that, compared to the students in the CritSRC group who were not interested in a STEM career, students in the the AvgSt, AvgSRC, and PosSRC groups were more likely to be interested in and considering (i.e. unsure) a career in STEM. Furthermore, males were more likely to be interested in a STEM job than females.

The second multinomial logistic regression compared students who were unsure of their interest in a STEM career to students who were interested in a STEM career (see Table 5). Results revealed that, compared to students in the CritSRC group who were unsure of their STEM career interest, students in the PosSRC group were more likely to be interested in having a STEM career.

5.3.2 | STEM belonging, engagement, and psychological needs satisfaction

After creating a categorical variable representing latent group membership, we calculated the Intraclass correlation coefficients (ICCs) to examine measures of variance explained by the schools (as students were nested within schools). Results from the fully unconditional models indicated that there was not sufficient between school variability by group for further analyses ($\tau00 = 0.177$, $z = 1.26$, $p = 0.20$) so school membership was dropped from

TABLE 4 Predictors of students' STEM career interest

	Interested versus not interested					
	B	SE	Wald	df	Sig	Exp (b)
Gender	−0.74	0.35	4.428	1	0.035*	0.48
AvgSt	1.39	0.47	8.64	1	0.003**	4.00
AvgSRC	1.54	0.58	7.12	1	0.008**	4.66
PosSt	0.79	0.59	1.79	1	1.81	2.20
PosSRC	2.51	0.60	17.28	1	0.000***	12.33
	Unsure versus not interested					
Gender	−0.36	0.29	1.50	1	0.221	0.70
AvgSt	0.79	0.35	5.06	1	0.025*	2.12
AvgSRC	1.09	0.45	5.92	1	0.015*	2.985
PosSt	−0.26	0.47	0.31	1	0.578	0.77
PosSRC	1.20	0.53	5.12	1	0.024*	3.33

Note: The CritSRC group was the referent group.
*$p < 0.05$; **$p \le .01$; ***$p \le .001$.

TABLE 5 Predictors of students' STEM career interest

	Interested versus Unsure					
	B	SE	Wald	df	Sig	Exp (b)
Gender	−0.38	0.28	1.93	1	0.164	0.68
AvgSt	0.59	0.40	2.18	1	0.140	1.81
AvgSRC	0.45	0.46	0.93	1	0.334	1.56
PosSt	1.05	0.55	3.68	1	0.055	2.85
PosSRC	1.31	0.43	9.47	1	0.002**	3.70

Note: The CritSRC group was the referent group.

**$p \le 0.01$.

TABLE 6 Descriptive statistics, reliabilities, and correlations for STEM outcome variables

	M	*SD*	*α*	Range	1	2	3
1. Belonging in STEM	6.93	1.93	0.94	1–10	-		
2. STEM engagement	4.86	0.82	0.92	2–7	0.66***	-	
3. STEM needs satisfaction	4.50	0.81	0.88	2–7	0.69***	0.72***	-

***$p < 0.001$.

further analyses. The ICC revealed that 10% of the variance in SRC grouping was within-school and 90% was between school.

Means and standard deviations for the STEM-related outcome variables by latent group are included in Table 2. Initially, we explored SRC group differences among all measure subscales; however, a similar pattern of differences amongst SRC groups emerged across the four dimensions of engagement (cognitive, behavioral, social, and emotional) and the three dimensions of psychological needs (autonomy, relatedness, and competence). Given these similarities, we combined the four highly correlated (*r*s ranging from 0.49 to 0.69) engagement dimensions into a unitary composite of STEM Engagement (α = 0.92) and the three highly correlated (*r* ranging from 0.53 to 0.67) psychological needs dimensions into a unitary composite of STEM Needs Satisfaction (α = 0.88). Means, standard deviations, reliabilities, and correlations for the three STEM-related outcome variables are included in Table 6.

To address our fourth research question, we examined differences across SRC groups in the three STEM related outcomes by conducting a 5-way (Group) MANCOVA controlling for age, race (Black, White, Latino/a, and Other), gender (male and female), and interest in a STEM career (yes and no/unsure), and type of schooling environment (online, in-person, and hybrid). We controlled for these four factors because our previous analyses revealed that groups differed by these variables. We also controlled for gender because prior research involving similar STEM constructs revealed significant gender-based differences (Fredricks et al., 2018; Leaper et al., 2012; Perez-Felkner et al., 2012).

MANCOVA results revealed a significant main effect for group, F (12, 750) = 5.74, $p < 0.001$, $\eta^2 = 0.08$. Follow-up univariate ANOVAs for STEM belonging, STEM needs satisfaction, and STEM engagement revealed an overall pattern of results such that the CritSRC group reported lower belonging, engagement, and needs satisfaction than most other groups (see details below) and the PosSRC group reported greater belonging, engagement, and needs satisfaction than most other groups (see details below).

Belonging in STEM

Belonging in STEM courses differed by group (F (4, 250) = 12.60, p < 0.001, η_p^2 = 0.17). The CritSRC group reported less belonging in STEM courses compared to the AvgSRC, PosSRC, and PosSt groups (ps ≤ 0.001). Furthermore, the PosSRC group reported greater belonging in STEM courses compared to the AvgSRC (p = 0.006) and the AvgSt (p = 0.001) groups, see Table 2.

STEM needs satisfaction

Needs Satisfactions in STEM courses differed by group (F (4, 250) = 16.74, p < 0.001, η_p^2 = 0.21). The CritSRC group reported lower needs satisfaction in STEM courses compared to the AvgSRC, PosSRC, and PosSt groups (ps < 0.001). Furthermore, the PosSRC and the PosSt groups reported greater needs satisfaction in STEM courses compared to the AvgSRC (p = 0.012, p = 0.018 respectively) and the AvgSt groups (ps ≤ ≤ 0.001), see Table 2.

STEM engagement

Engagement in STEM courses differed by SRC group (F (4, 250) = 13.84, p < 0.001, η_p^2 = 0.18). The CritSRC group reported lower engagement in STEM courses compared to the AvgSRC, PosSRC, and PosSt groups (ps < 0.001). Furthermore, the PosSRC group reported greater engagement in STEM courses compared to the AvgSRC (p = 0.009) and the AvgSt groups (p < 0.001), See Table 2.

6 | DISCUSSION

The current study, grounded in CCT (Bancroft, 2018) and SDT (Deci & Ryan, 2002), sought to explore potential factors that contribute to racial disparities in high school STEM contexts. Generally, our study found that students with more positive perceptions of SRC reported greater interest in a STEM career as well as greater belonging, psychological needs satisfaction, and engagement in their STEM classes, regardless of their racial/ethnic identity. Furthermore, we found that older adolescents were more likely than younger adolescents and Black students were more likely than White students to have a critical perception of SRC. Taken together, our findings highlight the important connection between pre-college racial climates and STEM-related outcomes, and encourage future researchers to consider taking a broad, school-level approach when attempting to address racial disparities in high school STEM contexts.

6.1 | Perceptions of SRC

Prior research suggests that general school climate matters (Thapa et al., 2013) but our results highlight the importance of school *racial* climate. Our latent class analysis confirmed Hypothesis 1, resulting in five latent groups listed in order of increasing positive perceptions of SRC: CritSRC, AvgSt, AvgSRC, PosSt, and PosSRC. Further, we found that perceptions of stereotyping at school played an important role in distinguishing different latent groups' holistic perceptions of SRC as demonstrated by participants in the AvgSRC and AvgSt groups and participants in the PosSRC and PosSt groups having, respectively, similar perceptions of all SRC components aside from their perceptions of stereotyping in school. The average rates of quality interactions, frequent interactions, support for positive interactions, and equal status were similar within each group. Thus, it appears that these four components of SRC functioned similarly across all latent groups indicating that students' school-based interracial interactions might inform their overall perceptions of racial equality and fairness at school. Within the CCT framework, our finding suggests that perceptions of interracial interactions at school may play an important role in fostering individuals' social capital gained from fictive kindships. Future research might further explore this using phenomenological approaches, which are well suited to understand specific experiences that shape adolescent perceptions of equal status at school.

6.1.1 | Stereotyping

Although group means for STEM belonging, engagement, and needs satisfaction were higher for the AvgSRC and PosSRC groups compared to the AvgSt and PosSt groups, respectively, these differences were not significant. Instead, group means for STEM belonging, engagement, and needs satisfaction tended to be higher for participants who had more PosSRC perceptions, see Table 2. Given this trend, perceptions of stereotyping seemed to have little impact on group differences in STEM-related outcomes despite its importance in differentiating latent groups of SRC perceptions. Rather, perceptions of equal status, support for interracial interactions, frequent interactions, and quality interactions seemed to relate more to STEM-related constructs. Prior research suggests that discrimination, exclusion, and unwelcoming racial climates are pervasive in STEM classrooms (Chang et al., 2014; R. M. Simon et al., 2017) and negatively impact belonging for all students (Hurtado & Carter, 1997; Hurtado et al., 2007; Leaper et al., 2012). Exclusive climates contribute to women and racially minoritized individuals dropping out of STEM majors (Chang et al., 2014; Jones et al., 2000), leading to underrepresentation in STEM careers. Our findings highlight the importance of frequent and positive interracial contact in shaping SRC and influencing STEM-related outcomes in high school.

Most of the SRC stereotyping items included in this study involved perceptions of negative stereotypes relative to one's own racial or cultural group; however, one item asked about prejudice against “certain racial/ethnic groups” at school (Byrd, 2015). Thus, the SRC stereotype component somewhat represented overall perceptions of stereotyping in school. As their label suggests, the AvgSt and PosSt groups perceived the highest rates of stereotyping amongst the five latent groups. White students were overrepresented in both of these groups, making up approximately 60% of the PosSt group and approximately 25% of the AvgSt group. This finding suggests that even if they might not personally experience racial stereotyping at school, White students were still aware of stereotypes targeting other racial/ethnic groups. Thus, awareness of racial injustice at school likely informed individuals' perceptions of stereotyping and overall SRC, leading to more critical perceptions of interracial interactions and racial socialization regardless of individual racial/ethnic identity.

6.2 | SRC group membership

Results confirmed Hypotheses 2a and 2b regarding racial/ethnic group differences and age differences in group membership. Our findings suggest that racism and adolescent criticality might have played an important role in SRC perceptions and STEM-related disparities.

6.2.1 | Racial differences

Black and White participants perceived SRC quite differently such that Black participants were overrepresented and White participants were underrepresented in the CritSRC and AvgSRC groups whereas the opposite was true for the PosSt group. Furthermore, Black participants comprised the largest proportion of the two groups with the most critical perceptions of SRC (CritSRC and AvgSt) whereas White participants comprised the largest proportion of the three groups with the most positive perceptions of SRC (AvgSRC, PosSt, and PosSRC). This trend confirms our expectations (Hypothesis 2a) and aligns with prior research identifying a racialized within-school climate gap such that White students are more likely to report positive experiences in schools compared to Black and Hispanic students regardless of the school's racial composition (Voight, 2013), although we did not find differences for Latinx students in group membership in this sample. Voight et al. (2015) found that Black students' less favorable experiences with safety, connectedness, and relationships with adults contributed to the within-school race disparities in general school climate perceptions.

Racial differences in SRC perceptions may also be indicative of students' experiences with racism in school (i.e., discrimination, stereotyping, and microaggressions) as these experiences likely inform students perceptions of racial equity, stereotyping, and interracial interactions at school. The CCT framework suggests that racially under-represented and minoritized students' experiences with systemic and interpersonal racism constrains their social and cultural capital, contributing to disparities in STEM achievement and persistence (Bancroft, 2018). Lee et al. (2020) recent findings offers some support for our understanding of how experiences of racism and perceptions of racial climate might fit into the CCT framework. They found that racial microaggressions were ingrained in college campus culture including interactions with STEM instructors, advisors, and peers and that Black STEM majors were more likely to experience racial microaggressions than other racially minoritized undergraduates. Although research with adolescent samples demonstrates that racial microaggressions occur daily in K-12 schools and negatively impact students' academic and psychological well-being (Keels et al., 2017; Steketee et al., 2021), future research should explore directional relationships between microaggressions, perceptions of SRC, and STEM-related outcomes in high school.

Our finding that the latent groups in which Black students were overrepresented (CritSRC and AvgSt) reported lower STEM belonging, engagement, and needs satisfaction than the group in which White students were overrepresented (PosSt) could relate to stereotype vulnerability, or the expectation that people are negatively judged based on stereotypes associated with some aspect of their social identity (Aronson & Inzlicht, 2004). Stereotype vulnerability may contribute to perceptions of school climate, belonging vulnerability (Gray et al., 2020), and diminished academic performance for racially minoritized students (Steele & Aronson, 1995), corresponding to low engagement and needs satisfaction. Future research should consider how stereotype vulnerability relates to SRC perceptions and STEM-related outcomes.

6.2.2 | Age differences

Generally, we found that groups with more CritSRC perceptions tended to be older than groups with more positive perceptions. This trend confirms our expectations (Hypothesis 2a) and aligns with prior research which demonstrates that older adolescents are more likely to perceive negative school climates than younger adolescents (De Pedro et al., 2016). It is possible that as adolescents progress through high school, they become more aware of the racial inequities at school such as racialized academic tracking systems that often create opportunity gaps between racially majoritized and minoritized youth (Legette, 2020). Indeed, 11th and 12th graders tend to be more aware of systemic social inequities involving race and socioeconomic status than 10th and 9th graders (Bañales et al., 2019; Seider et al., 2019). Future research should explore how adolescents' critical consciousness and their awareness of inequitable school practices develop overtime and contribute to perceptions of SRC.

6.2.3 | Learning environment differences

Group memberships also differed by students' learning environment (i.e., virtual, hybrid, and in-person) at the time of data collection in the spring of 2021. Our findings indicate that students attending school online tended to have a more critical perception of SRC than hybrid students. Students attending in-person school only comprised 13% of our sample. Thus, we may have lacked the power to detect differences in group membership compared to virtual or hybrid students. To our knowledge, research has yet to explore how nontraditional learning environments may impact student perceptions of SRC. Longitudinal and qualitative methods would benefit this gap in the literature by exploring potential long-term effects of hybrid and virtual environments on students' SRC perceptions and a deeper understanding of the factors that inform students' SRC perceptions in nontraditional contexts.

6.3 | Latent group differences in STEM-Related outcomes

MANOVA results confirmed Hypothesis 3 such that students with more CritSRC perceptions reported less belonging, psychological needs satisfaction, and engagement in high school STEM courses compared to students with more positive perceptions of SRC. This is an important finding as prior research indicates that higher levels of these STEM-related constructs predict greater motivation and persistence in STEM (Moore et al., 2020; Rainey et al., 2018; Wang et al., 2016). We also found that students who held critical perceptions of SRC reported less interest in a STEM career than students with more PosSRC perceptions. Given that our analyses controlled for potential differences between demographic groups, our findings suggest that SRC has important connections to STEM-related outcomes for all high school students.

Our findings speak to the need for STEM educators to acknowledge students' criticality and demonstrate how STEM skills and careers can be a tool for social justice. In a recent interview study involving racially minoritized adolescents, none of the 34 participants perceived STEM as being able to give back to their community, help them enact their commitment to social justice, or ameliorate social inequality (Mayworm et al., 2021). Martin and Fisher-Ari's (2021) results indicate that science education should employ more culturally and community-centered pedagogy that provide opportunities for students to see STEM as a tool to support their activist orientations. In particular, Waight et al. (2022) proposed a new pedagogical framework for science educators known as equitable, socially-just criticality which centers on broadening participation, exposing the myth of science and technology as neutral, amplifying asset-based counter stories, centering a racially equitable fixes, and committing to transparency. Their framework extends general antiracist efforts in secondary schools that educate students about historical and current inequities (Upadhyay et al., 2021) and improve interracial interactions at school (Spyropoulou et al., 2020) to STEM education by emphasizing inclusive and culturally competent research/technical design and implementation (Waight et al., 2022). Our results, aligned with Martin and Fisher-Ari's (2021) qualitative findings, suggest that high school curricula should adopt equitable, socially-just criticality to support critically conscious adolescents' social and cultural capital in STEM, thereby reducing racial-disparities in STEM.

6.3.1 | Psychological needs satisfaction

Our findings contribute to the literature grounded in the SDT demonstrating that greater psychological needs satisfaction in STEM courses is positively related to perceptions of SRC. What remains unclear is the directionality of this relationship indicating that future research should examine this relationship using longitudinal measures. For example, Hilts et al. (2018) found that undergraduate science majors' sense of relatedness was derived from peer contact whereas their sense of competence was derived from contact with their STEM classmates. Our findings indicate that *interracial* contact between students, teachers, and administrators may be especially important in relating to students' psychological needs satisfaction. Thus, future research should explore relationships between specific SDT psychological needs (i.e., autonomy, competence, and relatedness) and components of SRC to elucidate more nuanced relationships to inform instructional practices that encourage psychological needs satisfaction and positive racial climates in STEM contexts.

Our study was somewhat limited by our decision to combine the three psychological needs of autonomy, competence, and relatedness into a single construct. Prior research involving undergraduate and high school samples took a more nuanced approach by examining psychological needs separately, finding that competence predicts STEM persistence and achievement (Hilts et al., 2018; Sahin et al., 2017) and autonomy support plays an important for high school girls' engagement in their physics, chemistry, and engineering courses. Additionally, our study only involved student perceptions of fictive kindships (i.e., peers, teachers, and administrators) at school via SRC but the CCT framework (Bancroft, 2018) and prior research (Cian et al., 2022; Mayworm et al., 2021; Morton & Parsons, 2018) suggest that family relationships (i.e., blood kindship) play an especially important role in contributing to underrepresented and racially minoritized individuals' interest in and persistence towards a STEM career. Future research should explore how blood kindships might buffer against critical perceptions of SRC to support individuals' interest in a STEM career during adolescence.

6.3.2 | STEM career interest

Our finding that adolescents' perceptions of SRC relate to their interest in a STEM career offers novel contributions to the literature. We found that students with critical perceptions of SRC (i.e., CritSRC) were less likely to be interested in a STEM career or to consider a STEM career compared to students with more positive perceptions of SRC (i.e., AvgSt, AvgSRC, and PosSRC groups) which confirms our expectations (Hypothesis 4). Prior research suggests that students experience different STEM classroom climates (Aschbacher et al., 2010). Experiencing a supportive, positive STEM climate is associated with more positive orientation towards STEM (Aschbacher et al., 2010). Furthermore, ethnically minoritized girls are less likely to enroll in advanced STEM courses in high school, translating to low enrollment in college STEM classes and majors (National Girls Collaborative Project, 2016). Perhaps adolescents extrapolate inequitable experiences in their STEM classes to their perceptions of school-wide racial climate and expect inequitable climates to persist in college and in the workplace, diminishing their interest in future STEM careers. Future research should explore the relationship between perceptions of SRC, broadly, and perceptions of inclusivity and discrimination in STEM classes, specifically. In addition, future research should aim to examine the directionality of this relationship by studying the development of STEM career interests and perceptions of SRC longitudinally in concert.

Our finding that high school males were more likely to report being interested in a STEM career compared to females aligns with prior research documenting similar gender disparities (Robnett & Leaper, 2013; Sadler et al., 2012; Tellhed et al., 2017; Young et al., 2016). In particular, Sadler et al. (2012) retrospective study involving undergraduates found that females' interest in a STEM career was lower than males' both at the beginning (15.7% and 39.5%, respectively) and at the end of high school (12.7% and 39.7% respectively). These statistics also show that males' interest in a STEM career remained stable whereas females' interest declined throughout high school. Furthermore, high school females were more interested in STEM careers involving health and medicine than males (Sadler et al., 2012) but recent research demonstrates that a larger proportion of females who enter college with medicine and health career intensions end up in careers outside of STEM compared to men (Witherspoon & Schunn, 2020). Our finding that the odds of *considering* a career in STEM did not differ between high school males and females, coupled with previous work finding that females' participation in out-of-school time science activities enhances their interest in STEM job more than males who participate in this programs (Dabney et al., 2012; Price et al., 2019) offers insight into potential avenues for intervention to reduce pre-college gender disparities in STEM job interest. Out-of-school time programs or in-school enrichment programs aimed at enhancing females' STEM career interest might be more effective if they target females who are initially unsure of their interest in a STEM career.

6.4 | Limitations and future directions

Our findings regarding latent SRC groups and differences in STEM-related outcomes are not without limitations. First, the PosSt group comprised a relatively small proportion (9%) of our overall sample which may limit the generalizability of this group in other school contexts. Despite the small size of this group, we opted to keep this group in our analyses because the five-group model demonstrated better fit indices compared to the four-group model (see Table 1) and we felt the group was theoretically sound. As previously discussed, White students were overrepresented in this group which perceived a mostly egalitarian racial climate despite their awareness of racial stereotyping of same or other racial/ethnic groups at school. Given our finding that group membership in the PosSt group did not differ by students' learning environment (i.e., virtual, hybrid, and in-person), we would expect the PosSt group to replicate in future research examining latent groups of adolescents' racial climate perceptions.

Our study was also limited by its cross-sectional and single-reporter design because we could not test the directionality of our theoretical model or explore heterogeneity within latent groups. Future research should examine long-term associations between perceptions of SRC and belonging, engagement, and needs satisfaction in STEM courses to better determine directionality of the relationship and should employ multilevel modeling to assess the extent to which STEM outcomes vary within latent groups. Additionally, self-reported engagement in STEM courses would benefit from additional data for triangulation such as teacher reports or classroom observations to ensure construct validity, which reflects how well the measure assesses what the researchers intended.

Our study was further limited by our decision to not include 6.6% of our sample in our gender analysis due to issues with cell sizes for the χ^2 test. These participants identified as nonbinary or questioning students. Future research should target nonbinary and questioning adolescents to understand how their perceptions of SRC might differ from students who identify as male or female.

Finally, our study did not include individual socioeconomic status, although our sample was recruited from a low-income school district where the vast majority of students are eligible for free and reduced meals. Prior research suggests that socioeconomic status plays a role in perceptions of school climate (Mayworm et al., 2021) and STEM achievement in secondary school (National Science Board, 2021). Future research should examine socioeconomic status differences in SRC latent group membership and STEM outcomes. Additionally, future research should compare perceptions of SRC and STEM-related outcomes between students at low-income schools, affluent schools, and schools with economically heterogeneous student bodies. Despite these limitations, our findings offer important implications for secondary schools aimed at promoting STEM belonging, engagement, and needs satisfaction for all students.

7 | CONCLUSION

Taken together, our findings highlight that, even before entrance into college, adolescents' perceptions of SRC are potential contributors to racial disparities in high school STEM contexts. Achieving STEM competency in secondary school prepares students to obtain postsecondary STEM degrees and jobs (National Science Board, 2021). However, racial inequities in standardized test performance in STEM are exacerbated by unequal access to resources and quality instruction via online learning environments caused by the COVID-19 pandemic (National Science Board, 2021). Now, more than ever, interventions are needed to ameliorate STEM racial inequities in secondary schools. Our findings indicate that future interventions aimed at supporting adolescent success in STEM courses should (1) consider taking a broad approach by fostering positive SRCs that reject stereotypes and promote frequent and quality interracial interactions and (2) support adolescent criticality by acknowledging racism in STEM and demonstrating how STEM skills and careers can be a tool for social justice (Waight et al., 2022).

ACKNOWLEDGMENTS

We thank the research assistants in the Social Developmental Lab at North Carolina State University for their work with this project. This project was funded by the National Science Foundation (DRL-1941992).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Cerda-Smith, J., Joy, A., Mathews, C., Knox, J., & Mulvey, K. L. (2023). STEM-related outcomes for adolescents with differing perceptions of school racial climate: A latent class analysis. *Science Education*, 107, 651–676. https://doi.org/10.1002/sce.21784