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EMPIRICAL RESEARCH

Pathways to Youth Activism Orientation in STEM: the Role of STEM Classroom Inclusivity and Motivational Beliefs

Emine Ozturk[1] · Jacqueline Cerda-Smith[2] · Angelina Joy[3] · Channing J. Mathews[4] · Kelly Lynn Mulvey[2]

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Abstract

Activism around science, technology, engineering, and mathematics (STEM) is a critical task to promote social justice and to develop sustainable and effective solutions to global problems (e.g., climate change) in contemporary society. The present study examines relationships between adolescents' perceptions of gender and ethnic classroom inclusivity, outcome expectancies, utility values, and activism orientation in STEM, grounded in the situated expectancy-value theory. Participants were 699 adolescents (50.2% boys, 47.8% White; $M_{T1age} = 15.11$ years, $SD = 0.84$) in the southeastern United States. A structural equation model with FIML estimation, multiple imputation with Bayesian analysis, and multigroup SEM analyses were utilized to test the hypothesized associations using two time points, controlling for sociodemographics and STEM grades. The findings revealed that adolescents' perceptions of STEM classroom inclusivity appeared to play an important role in shaping STEM expectancies and perceived value of STEM. Multigroup SEM analysis showed that ethnicity significantly moderates the effect of perceived STEM classroom inclusivity on STEM expectancies, suggesting the effect of inclusivity on expectancies is stronger for racially/ethnically majoritized adolescents as compared to racially/ethnically minoritized adolescents. Associations from STEM motivational beliefs to activism orientation revealed that adolescents with higher STEM utility values are more likely to have a higher orientation toward STEM activism. Adolescents' perceptions of STEM classroom inclusivity had an indirect positive effect on STEM activism orientation through STEM utility values. These findings provide support for the conceptual premise that classroom inclusivity can foster motivational beliefs, and activism orientation in STEM.

Keywords Inclusivity · Motivation · Activism · Achievement · STEM

Introduction

Investigating and meaningfully addressing real-world problems (i.e., climate change, soil pollution, chemicals in food) in today's world often requires advanced science, technology, engineering, and mathematics (STEM) knowledge. Preparing students to tackle local and global STEM challenges by fostering inclusive classroom culture (e.g., Schwarz, 2023), and developing efficacy around activism can help to address these real-world problems and promote social justice (Hope et al., 2019). The term STEM activism refers to "one's efficacy around being able to take steps to solve or address a STEM-related problem in one's community" (Mulvey et al., 2022, p. 1451) and requires students' understanding of social and political issues from a social justice perspective. STEM activism plays a critical role in building equitable environments and developing effective policies to make a significant impact in society. However, much of the activism debate focuses on how to promote activism among youth leaders in social and political contexts (Wegemer, 2023) and relatively little research has been carried out on civic engagement outcomes in STEM (Flanagan et al., 2022; Gallay et al., 2021; Knight et al., 2011; Xie, 2014). Prior research documented that adolescents' perceptions of classrooms (Godfrey & Grayman, 2014; Torney-Purta, 2002), civic expectancies, and utility values (Wegemer, 2023) might help to promote

✉ Emine Ozturk
eozturk2@asu.edu

1 T. Denny Sanford School of Social and Family Dynamics, Arizona State University, Tempe, AZ, USA

2 Department of Psychology, North Carolina State University, Raleigh, NC, USA

3 Department of Human Development and Family Science, Purdue University, West Lafayette, IN, USA

4 Department of Psychology, University of Virginia, Charlottesville, VA, USA

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student civic engagement and activism. However, less is known about if and how adolescents' STEM motivational beliefs may drive orientation toward STEM activism. Thus, the current study sought to test the links between adolescents' perceptions of STEM classroom inclusivity (how welcoming STEM classrooms are for different genders and ethnic/racial groups), STEM motivational beliefs (outcome expectancies and utility values), and activism orientation in STEM. Specifically, this study examines classroom inclusivity as a key classroom factor that may drive STEM activism orientation.

Situated Expectancy-Value Theory

Situated expectancy-value theory (SEVT; Eccles & Wigfield, 2020) provides a useful account of socio-cultural and situational factors that shape individuals' expectancies and subjective task values. According to SEVT, adolescents' outcome expectancies and utility values predict adolescent achievement-related choices and academic performance (Eccles & Wigfield, 2020, 2023). Expectancy refers to individuals' expectations of success in a particular domain (Eccles et al., 1983; Eccles & Wigfield, 2002). Utility value is conceptualized as individuals' perceptions of the usefulness of a specific task that is aligned with individuals' future plans (Eccles & Wigfield, 2020).

Inclusive classroom climate involves specific perceptions of classroom experiences (Margas, 2023) and is assessed in multiple ways in the literature including the quality of relations between students, peers, and teachers (Margas, 2023; Quin, 2017; Roubinov et al., 2020), students' justice (or injustice) beliefs in the classroom (Berti et al., 2010; Dorman, 2001), perceptions of belonging to classrooms (Bossaert et al., 2013), and perceived classroom experiences in the context of diversity (e.g., gender-inclusive classrooms; Fabes et al., 2018). Students' perceptions of their classroom shape their motivational beliefs (Wigfield & Eccles, 2002). Research has shown that inclusive classroom climate is significantly associated with students' in and out-of-school outcomes, such as civic outcomes (Berkowitz, 2015), academic achievement (e.g., Erdem & Kaya, 2023), school engagement (Berti et al., 2010), and achievement motivation (Erentaitė et al., 2022). However, associations between perceived inclusivity and STEM motivational beliefs in informal STEM youth programs demonstrated differential effects of inclusivity on STEM motivational beliefs. For instance, in a longitudinal study, Ozturk et al. (2024) examined the effects of adolescents' perceptions of informal STEM youth programs' inclusivity on math expectancies and math utility values. They documented significant positive associations between perceived site inclusivity and math utility values and nonsignificant associations between perceived site inclusivity and math expectancies.

Students' interpretations of achievement-related experiences, their perceptions of socializers' (e.g., teachers, peers) beliefs, and attitudes influence perceived abilities, task values, and expectancies of success (Eccles & Wigfield, 2023). Students who perceive unjust treatment in the classroom may report lower perceptions of their academic capabilities (Dorman, 2001). In the civic engagement literature, research has shown that civic motivational beliefs (conceptualized as expectancies and values) predicted activism (Wegemer, 2023). However, context matters in activism goals (Bryant et al., 2012). For example, college students in engineering fields are less likely to develop a commitment to social activism due to increased materialistic orientation and decreases in societal concerns (Sax, 2004). Collectively, these studies outline the critical role of classroom environment, expectancies, and values on students' academic, social, and civic outcomes. Yet, little is known about STEM activism orientation, and it is not clear how adolescents' perceptions of classroom inclusivity and motivational beliefs are associated with activism orientation in STEM context. The current study sought to assess whether relations between perceived STEM classroom inclusivity and STEM activism orientation work through improved expectancies and utility values of STEM.

Expectancy Beliefs, Utility Values, and Activism Orientation

Adolescents' beliefs about their own capabilities may be especially important for ensuring that young people can provide effective and sustainable solutions for global problems through civic education (Liem & Chua, 2013). However, the role of expectancies and task values on students' civic outcomes is still poorly understood (Liem & Chua, 2013) and even less has been done on STEM activism. The expectancy-value model might help to explain adolescents' motivation toward civic participation (Levy & Akiva, 2019). The existing literature highlights the distinctive features of expectancies and utility values in shaping youth civic behavioral intentions and engagement (Liem & Chua, 2013; Liem & McInerney, 2011; Wegemer, 2023). Results suggest significant associations between political efficacy (Kahne & Westheimer, 2006), utility values (Omoto et al., 2010), interest (Voight & Torney-Purta, 2013), and political participation (Levy & Akiva, 2019). For instance, Liem and Chua (2013) carried out an extensive study on the mediating role of expectancies and task values on the relationship between socio-academic factors (e.g., gender, ethnicity, prior achievement) and adolescents' civic outcomes (e.g., future goal orientation, civic capital). Their findings revealed that both expectancy beliefs and utility values mediate the relationship between socio-academic background factors and civic outcomes; however, utility value was a more dominant predictor than expectancies. Similarly, a longitudinal study revealed that college students' civic values and behaviors were significantly associated with their social activism orientation in a longitudinal framework (Bryant et al., 2012). Recently, Wegemer (2023) examined the role of civic motivation (expectancies and task values) on behavioral outcomes of service and activism. He established a link between civic expectancies, values, and activism in a sample of Latino/a/e/x and low-income high school students and highlighted the differential effects of expectancies and task values. Aligned with SEVT, these findings suggest that adolescents' STEM expectancies and utility values may be associated with STEM activism orientation. Together, these findings also indicate that the association between adolescents' utility values and activism orientation may be stronger than the relationship between outcome expectancies and activism orientation in STEM.

Classroom Inclusivity and Activism Orientation

Inclusivity is a broad term that captures teaching and learning approaches that are welcoming to all students and make all students feel that they are valued (Ainscow & César, 2006; Li & Singh, 2022). Inclusivity has a key role in moral and civic aspects of education to build an inclusive society (Curcic et al., 2011; Dassonneville et al., 2012), and has direct relevance to achievement motivation (Kumar et al., 2018), in particular utility value (Priniski & Thoman, 2020), effective school-based interventions (e.g., Kaufman & Killen, 2022), and engagement to serve the community (Casey et al., 2023).

An inclusive classroom environment plays a major role in promoting students' sense of consciousness regarding sociopolitical concerns (Kumar et al., 2018). Understanding adolescents' perceptions of social inequalities (e.g., those faced by racial-ethnic minoritized students) in STEM classrooms is crucial to improve students' positive attitudes toward STEM (McLure et al., 2022) and to create positive and inclusive learning environments (Kaufman & Killen, 2022). Research on inclusivity in STEM settings has relied primarily on academic STEM outcomes including academic achievement (Dalbert & Stoeber, 2006), belonging (Zhao et al., 2023), engagement (Mulvey et al., 2022), and motivation (Ozturk et al., 2024) and relatively little is known about how inclusive STEM learning environments are associated with civic outcomes in STEM.

Despite calls for action to achieve equity and diversity by promoting inclusive STEM classrooms and teaching practices, change has been slow (Handelsman et al., 2022). Additionally, women and individuals from ethnic/racial minoritized backgrounds are still underrepresented in many STEM degree programs and careers (Fry et al., 2021; National Center for Science and Engineering Statistics (NCSES), 2023). Further, remarkably few studies have been designed to examine associations between classroom inclusivity and STEM activism, which is efficacy around using STEM knowledge and skills to address local STEM problems (Mulvey et al., 2022). Thus, more research is needed on STEM inclusivity research including diverse gender and ethnic groups (e.g., BrckaLorenz et al., 2021; Milanovic et al., 2023; Schmader, 2023). This study aims to explore the associations between adolescents' perceptions of ethnic and gender inclusivity in STEM classrooms and activism around STEM.

Current Study

The current study aimed to address the following research questions: (1) Are adolescents' perceptions of STEM classroom inclusivity related to their STEM motivational beliefs (expectancies and utility values) and STEM activism orientation? (2) Are adolescents' STEM motivational beliefs (expectancies and utility values) related to STEM activism orientation? (3) Are there any indirect effects of adolescents' perceptions of STEM classroom inclusivity on STEM activism orientation via adolescents' STEM motivational beliefs (expectancies and utility values)? Guided by SEVT, it was hypothesized that adolescents' perceptions of more inclusive STEM classrooms (in terms of gender and ethnic/racial groups), would be related to greater orientation toward STEM activism. It was also hypothesized that STEM expectancies and utility values would be related to higher STEM activism orientation. It was expected that perceived STEM classroom inclusivity would be indirectly related to a higher STEM activism orientation through adolescents' STEM expectancies and utility values (see the hypothesized SEM model, Fig. 1).

Methods

Participants

The sample for this study was taken from a larger ongoing longitudinal study on adolescents' experiences in STEM classrooms. All 9–10th graders (Year 1) and 10th - 11th graders (Year 2) in participating schools were invited to participate in the study. The sample at Time 1 (T1) consisted of 699 high school students ($M_{ageT1} = 15.11$ years, $SD = 0.84$) recruited from five public schools in the southeastern United States (the U.S.), in primarily rural communities and serving low to middle-income students. The sample at T1 included 348 (49.8%) girls, and 351 (50.2%) boys and was racially diverse, with 334 (47.8%) White/European American, 190 (27.2%) Black/ African

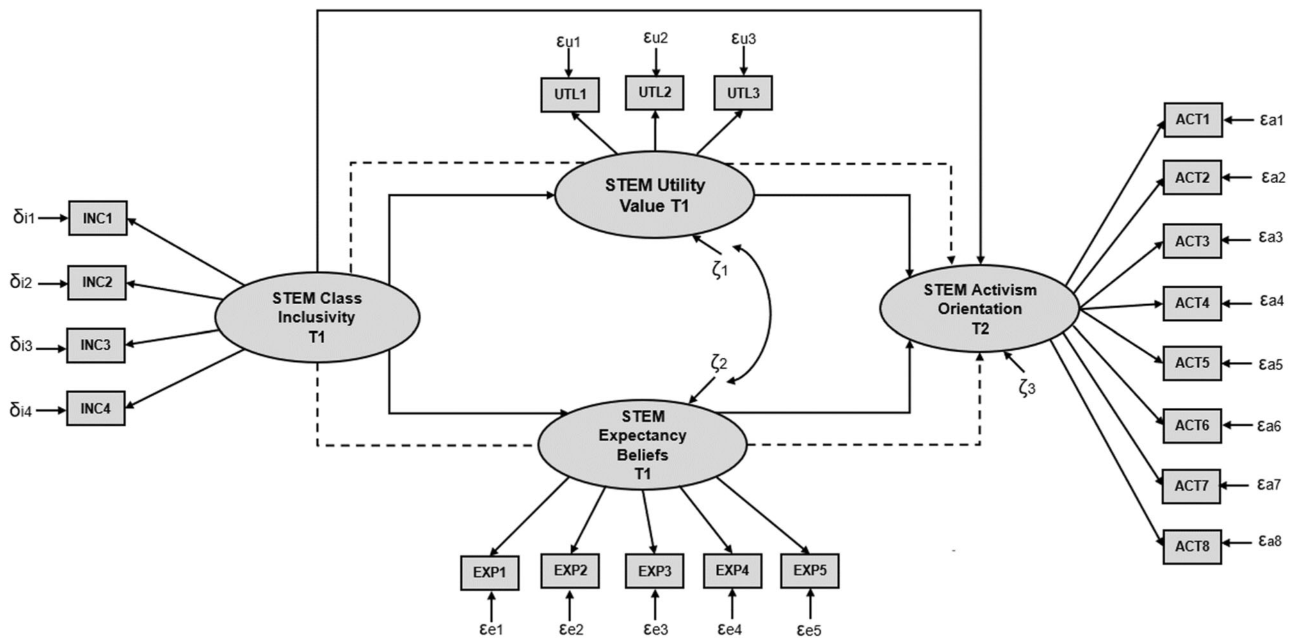

Fig. 1 The hypothesized structural equation model. *Note*. Correlated residuals and covariates (gender, age, ethnicity, STEM grades T1, and STEM activism orientation T1) were not shown for clarity. The dotted lines represent the indirect effects of perceived STEM classroom inclusivity on STEM activism orientation via STEM expectancies and STEM utility values. INC inclusivity; EXP expectancy beliefs; UTL utility value; ACT activism orientation; STEM science, technology, engineering, and mathematics; T1 Time 1; T2 Time 2.

American, 106 (15.2%) Latino/a/e/x, and 69 (9.87%) biracial/other (American Indian/ Native Hawaiian Asian/ Pacific Islander/Arab American) participants. Students who responded that they did not identify as male or female or chose to not report their gender (2% of the total participants) were excluded from the data analysis due to a low response rate, high missingness at individual items, and non-responders in the main study variables. A priori power analysis was conducted using Soper (2023)'s sample size calculator for SEM models to estimate the required sample size for the proposed SEM model. The analysis showed that a total of 209 respondents were required to detect small-medium ($d = 0.25$) effects with a power of 0.80, and an alpha of 0.05.

Procedure

This study was approved by the Institutional Review Board at North Carolina State University (Ethics approval number: 20526). Opt-out informed consent forms were sent to 9th and 10th grade high school students' families. Parents/guardians were informed about the study aims, data collection, voluntary participation, and confidentiality. Then, potential participants whose parents/guardians did not opt them out of the study completed an assent form and a survey via Qualtrics software between January-April 2022 (T1), and again in November 2022-April 2023 (T2). At the beginning of the survey, the following definition of STEM was given to all assented participants: "We will use the term STEM. This refers to Science, Technology, Mathematics, and Engineering". Students were thanked for their time and effort for their participation in the study. Students who participated in the study received a small ($10) electronic gift card at each time point. The sample attrition was quite high for T2, and this is likely due to student burnout with online school-based activities following the pandemic. Thus, multiple imputation with Bayesian analysis was used to handle nonnormality and missing data (See additional details below).

Measures

Perceived STEM Classroom Inclusivity

Adolescents' perceptions of STEM classroom inclusivity was assessed at T1 using a 4-item 6-point Likert scale ranging from 1 (*not at all welcoming)* to 6 (*very welcoming*), with higher scores indicating higher levels of perceived inclusivity in STEM classrooms (Mulvey et al., 2022). Items include: (a) "How welcoming are your STEM classes for girls?"; (b) "How welcoming are your STEM classes for boys?"; (c) "How welcoming or not welcoming are your STEM classes for racial-ethnic majority (White/European American) students?"; (d) "How welcoming or not welcoming are your STEM classes for racial-ethnic minority (non-White) students?" The inclusivity measure was well-validated in previous research (e.g., Ozturk et al.,

Table 1 Descriptive Statistics and Zero-Order Correlations among Study Variables ($n = 699$)

Variable	1	2	3	4	5	6	7	8	9
1. Age	1								
2. Gender	-0.083^{*}	1							
3. Ethnicity	−0.003	-0.088^{*}	1						
4. STEM grades T1	−0.017	0.046	0.148^{***}	1					
5. STEM classroom inclusivity	0.032	−0.051	0.110^{**}	0.156^{***}	1				
6. STEM expectancy beliefs	−0.053	−0.017	0.041	0.513^{***}	0.353^{***}	1			
7. STEM utility value	−0.020	0.050	0.108^{**}	0.323^{***}	0.289^{***}	0.641^{***}	1		
8. STEM activism orientation T1	0.035	0.075	0.011	0.103^{***}	0.634^{*}	0.298^{***}	0.248^{***}	1	
9. STEM activism orientation T2	−0.019	0.167^{*}	−0.027	0.155^{*}	0.166^{*}	0.161^{***}	0.246^{**}	0.412^{***}	1
M	15.11	-	-	4.20	5	5.02	4.88	2.97	3.11
SD	0.843	-	-	0.855	0.896	1.08	1.23	0.968	0.960
Skewness	0.405	-	-	−0.952	−1.133	−0.750	−0.664	−0.049	−0.254
Kurtosis	0.141	-	-	0.728	1.784	0.881	0.517	−0.261	0.092
Min	13	0	0	1	1	1	1	1	1
Max	19	1	1	5	6	6	6	5	5
Range	6	1	1	4	5	5	5	4	4
Cronbach's α	-	-	-	-	0.88	0.90	0.82	0.92	0.93
McDonalds' ω	-	-	-	-	0.88	0.90	0.83	0.92	0.92

STEM Science, Technology, Engineering and Mathematics. *T1* Time 1, *T2* Time 2. *M* Mean, *SD* Standard deviation

$^{*}p < 0.05$. $^{**}p < 0.01$. $^{***}p < 0.001$

2024). Aligned with the previous studies, gender, and ethnic inclusivity was used as a latent variable in the present study (e.g., Mulvey et al., 2022). The Cronbach's alpha (α) and McDonald's omega (ω) for this variable were 0.88 (See Table 1).

STEM Activism Orientation

Adolescents' STEM Activism orientation was assessed at T1 and T2 using the 8-item STEM Activism Orientation Scale (Mulvey et al., 2022). This scale was developed to assess perceived preparation to solve and address STEM problems in the community, based on Flanagan et al. (2007)' s qualitative work. First, the following prompt was provided to the students: "If you found out about a problem in your community or school that you wanted to do something about, how well do you think your STEM experiences in school have prepared you to do each of the following to solve the problem?" The sample items include: "Write a letter to a local newspaper to inform the public about the problem"; "Contact a scientist you have never met to get their help with the problem"; "Contact an elected official about the problem"; "Organize a petition to address a STEM problem". Students rated to what extent they feel capable of addressing a problem in a STEM context in their community using each approach on a 5-point Likert scale ranging from 1 (*I definitely can't*) to 5 (*I definitely can*), with higher scores indicating higher levels of orientation toward STEM activism. The Cronbach's α for this measure were 0.92 at T1, and 0.93 at T2. McDonald's ω for this measure were 0.92 at T1 and T2 (see Table 1). This measure has been validated in previous studies on high school students in the U.S. (e.g., Mulvey et al., 2022).

STEM Expectancy Beliefs

Adolescents' STEM expectancy beliefs were measured at T1 using a 5-item expectancy measure adapted from Eccles and Wang (2016). Items include: (a) "How good are you at STEM?"; (b) "If you were to list all the students from best to worst in STEM, where are you?"; (c) Compared to other subjects, how good are you at STEM?; (d) "How well do you expect to do in STEM next year?; (e) "How good would you be at learning something new in STEM? Participants rated their expectancy beliefs in STEM on a 7-point Likert scale ranging from 1 (*not at all good*) to 7 (*very good*), with a higher score indicating a higher level of expectancy in STEM. The Cronbach's α and McDonald's ω for this measure were 0.90.

STEM Utility Value

Adolescents' STEM utility values were assessed using a 3-item measure (Eccles & Wang, 2016) at T1: (a) "How useful is what you learn in STEM?" (1 = *not at all useful*; 7 = *very useful*); (b) "For me, being good at STEM is… (1=*not at all important*; 7=*very important*); (c) "Compared to other activities, how important is it to be good at STEM?

(1 = *not at all important*; 7 = *very important*). A higher score corresponded to higher levels of utility value in STEM. The Cronbach's α and McDonald's ω for this measure were 0.82 and 0.83, respectively, indicating adequate internal consistency.

Controls

Previous research established that adolescents' STEM grades (e.g., Petersen & Hyde, 2017), and sociodemographic variables (e.g., gender, ethnicity) were correlated with STEM variables (Guo et al., 2015); thus, they were controlled in the SEM model. Additionally, STEM activism orientation at T1 was controlled for STEM activism orientation at T2. As the data were collected at two-time points (T1 and T2), age was controlled to examine its potential influence on main study outcomes. Adolescents' self-reported STEM grades were assessed at T1 using the following item: "In general, what grades do you get in STEM classes?" Participants' responses were reverse coded on a 5-point Likert scale ranging from 1 (*Fs*) to 5 (*As*), with higher scores indicating higher STEM grades ($M_{STEM\ Grade} = 4.20$, $SD = 0.855$). Adolescents' gender (0 = *male*, 1= *female*), age (in years), and ethnicity were measured with self-reported items. The ethnicity variable was dummy-coded as 0 (*racially/ethnically minoritized group*; Black/African American, Latino/a/e/x, and Biracial/Others) and 1 (*racially/ethnically majoritized group*, White/European-American).

Data Analysis

The current study utilized structural equation modeling (SEM) with full information maximum likelihood (FIML) estimation (Wang & Wang, 2020). See Fig. 1 for the hypothesized SEM model. First, diagnostic tests (e.g., skewness and kurtosis) were used to test the normality at the univariate level, and variance inflation factor (VIF) was used to test the multicollinearity among study variables. Skewness values (from −1.523 to 0.405) and kurtosis values (from −0.979 to 2.608) were within the acceptable range (e.g., skewness < 3; kurtosis < 7) indicating normality at the univariate level. VIF values lower than 10 are acceptable (Kline, 2016). VIF values fell between the acceptable ranges (from 1.07 to 1.86) indicating no presence of multicollinearity among the variables in this study. IBM SPSS Statistics V. 29 (IBM Corp., Released 2022) was used to calculate zero-order correlations. All SEM analyses were conducted in *Mplus* V.8.11 (Muthén & Muthén, 2017).

Missing Data Procedures and Multiple Imputation Analyses

The percentages and patterns of missing data were analyzed using the IBM SPSS Statistics V. 29 missing values module (IBM Corp., Released 2022). Item level missingness ranged from 0.3% to 12.2% at T1, and from 74.8% to 75.1% at T2. Construct level missingness ranged from 3.3% to 75.5% and individual level missingness ranged from 3.1% to 62.5% at T1 and T2 (see Table S1 in the supplementary material). Gender and ethnicity variables did not have any missing values. To explore the missingness mechanism, a two-step approach was utilized. First, all study variables were dummy-coded as 0 (*missing*) and 1 (*not missing*). Second, *t-tests* and *chi-square* tests were conducted to examine if missingness was related to any study variables. As shown in Table S3, a *t*-test was conducted to explore if missingness at T2 is dependent on the T1 variables. Chi-square tests were run to examine the relationships between missingness at T1, T2, and sociodemographics (e.g., gender, ethnicity). The results were reported in the supplementary material (see Tables S2–S3). Chi-square test results showed that missingness at T1 and T2 was not associated with gender and ethnicity. Although t-tests documented that missingness at T2 was not associated with missingness at T1, the level of missingness in T2 is not ignorable, therefore multiple imputation (MI) analysis was utilized.

MI is a more effective strategy to deal with large proportions (e.g., from 40% to 80%) of missing data (Lee & Huber, 2021; Mishra & Khare, 2014) than listwise or pairwise deletion (Mueller & Hancock, 2019). As a recommended practice, participants with no responses and/or high missing data (e.g., who responded only to demographic survey questions, and had more than 75% missingness on main study variables) were not included in the data analysis. After descriptive statistics were computed, MI with Bayesian analysis (Muthén & Muthén, 2017) for 10 imputed datasets were used (Enders, 2010).

Model Estimation and Validation

Drawing on SEVT and previous findings (e.g., Degol et al., 2018; Mulvey et al., 2023; Ozturk et al., 2024), a SEM model was developed to examine the direct and indirect associations between adolescents' perceptions of STEM classroom inclusivity at T1, and STEM activism orientation at T2 through students' STEM expectancies and utility values at T1. As shown in Fig. 1, the observed variables *INC1- INC4* were used as indicators of the latent variable of STEM classroom inclusivity, *EXP1-EXP5* were used as indicators of the latent variable of STEM expectancies, *UTL1-UTL3* were used as indicators of the latent variable of STEM utility value, and *ACT1-ACT8* were the indicators of latent variable of STEM activism orientation. Previous research demonstrates that gender (e.g., Bowman et al., 2022; Milanovic et al., 2023), ethnic minority status (MacPhee et al., 2013; Sharkness et al., 2010), and academic achievement are critical factors that shape inclusive STEM learning environments

(Vivian et al., 2020); thus, these variables were included as covariates to the hypothesized SEM model. The MODEL INDIRECT statement in Mplus V.8.11 was used to examine the indirect effects of adolescents' perceptions of STEM classroom inclusivity on STEM activism orientation via STEM expectancy beliefs and STEM utility values. Two steps of SEM were utilized to first compute: 1) the measurement model, and 2) the SEM model. Residual covariances of the observed factor indicators for STEM classroom inclusivity (*INC1-INC2* and *INC3-INC4*) and STEM activism orientation (*ACT6- ACT7* and *ACT7- ACT8*) at T1 and T2 were added to the SEM model using WITH statements in Mplus V.8.11. All SEM models were evaluated using the following model-fit statistics: The chi-square statistic (χ^2), the comparative fit index ($CFI \leq 0.90$), the Tucker-Lewis ($TLI \leq 0.90$) index (Wang & Wang, 2020), the root-mean-square error of approximation ($RMSEA \leq 0.08$) with 90% CI (MacCallum et al., 1996), and the standardized root-mean-square residual ($SRMR \leq 0.08$, Hu & Bentler, 1999). Additionally, multigroup factorial measurement invariance analyses were utilized (see Tables S5–S6 in the supplementary material) to ensure that observed indicators under the study assess the same theoretical construct across racially/ethnically minoritized and majoritized and gender groups (Wang & Wang, 2020). Next, additional models were utilized to test the invariance of structural path coefficients across gender groups (see Tables S7 and S8) and racially/ethnically minoritized and majoritized groups (see Tables 4 and 5). The following model fit indices were used to evaluate the invariance across configural, metric, scalar, and partial measurement invariance models: $\Delta CFI \geq 0.010$, $\Delta RMSEA \geq 0.015$ indicates non-invariance (Chen, 2007). Given that inclusivity and motivational beliefs were measured at the same time point, additional sensitivity analyses were conducted to assess if STEM motivational beliefs predict perceived STEM classroom inclusivity (see Table S4 in the supplementary material). The direct effect of STEM expectancies on perceived STEM classroom inclusivity was positive and statistically significant ($\beta = 0.337$, $SE = 0.075$, $p < 0.001$); however, the direct effect of STEM utility value on perceived STEM classroom inclusivity was not statistically significant ($\beta = 0.117$, $SE = 0.065$, $p = 0.073$) in this model. These findings suggest that the relationship between STEM expectancies and perceived STEM classroom inclusivity may be bi-directional, but confirm that, while inclusion predicted utility value, utility value did not predict perceived inclusion in STEM classrooms. This is well aligned with the primary findings, see below.

Results

Table 1 illustrates descriptive statistics and zero-order correlations for all study variables. As expected, self-reported STEM grades at T1 were positively correlated with adolescents' perceptions of STEM classroom inclusivity T1 ($r = 0.156$), STEM expectancies at T1 ($r = 0.513$), STEM utility values at T1 ($r = 0.323$), and STEM activism orientation (T1: $r = 0.103$; T2: $r = 0.155$). STEM activism orientation was positively correlated with perceived STEM classroom inclusivity (T1: $r = 0.634$; T2: $r = 0.166$), STEM expectancies (T1: $r = 0.298$; T2: $r = 0.161$), and STEM utility values (T1: $r = 0.248$; T2: $r = 0.246$). There was a positive moderate correlation between STEM activism at T1 and T2 ($r = 0.412$). The measurement model fits the data well: $\chi2$ (359) = 728.89, $p < 0.001$, RMSEA = 0.038, 90% CI [0.034–0042], SRMR = 0.08, CFI = 0.915, TLI = 0.904. The hypothesized SEM model across 10 imputed datasets fit the data well: $\chi2$ (433) = 777.56, $p < 0.001$, RMSEA = 0.034, 90% CI [0.030–0.038], SRMR = 0.08, CFI = 0.925, TLI = 0.915 (see Fig. 2). The percentage of explained variation (R^2) for latent variables ranged from 0.045 to 0.409 and for observed variables 0.344 to 0.809. Unstandardized and standardized coefficients for the SEM model were reported in Tables 2 and 3, respectively.

The Role of STEM Classroom Inclusivity

The first research question examined the direct effects of adolescents' perceptions of STEM classroom inclusivity on STEM motivational beliefs (expectancies and utility values) and STEM activism orientation. As hypothesized, adolescents' perceptions of STEM classroom inclusivity had significant positive effects on STEM expectancies ($\beta = 0.305$, $SE = 0.036$, $p < 0.001$) and STEM utility values ($\beta = 0.295$, $SE = 0.040$, $p < 0.001$), controlling for age, gender, ethnicity, and self-reported STEM grades at T1. The results, as shown in Table 2, indicated that adolescents with higher perceptions of inclusivity in their STEM classrooms also tended to have higher STEM expectancies and utility values. The direct path from STEM classroom inclusivity to STEM activism orientation T2 was not statistically significant ($\beta = 0.147$, $SE = 0.132$, $p = 0.268$), controlling for covariates.

The Role of STEM Expectancies and Utility Values

The second research question was whether adolescents' STEM motivational beliefs (expectancies and utility values) shape STEM activism orientation. The data revealed that the direct effect of adolescents' STEM expectancy beliefs on STEM activism orientation was not statistically significant ($\beta = -0.020$, $SE = 0.168$, $p = 0.906$), but the direct effect of adolescents' utility values was positive and statistically significant ($\beta = 0.257$, $SE = 0.088$, $p = 0.003$), controlling for covariates. These results suggested that adolescents with higher utility value in STEM were likely to show greater STEM activism orientation (See Fig. 2).

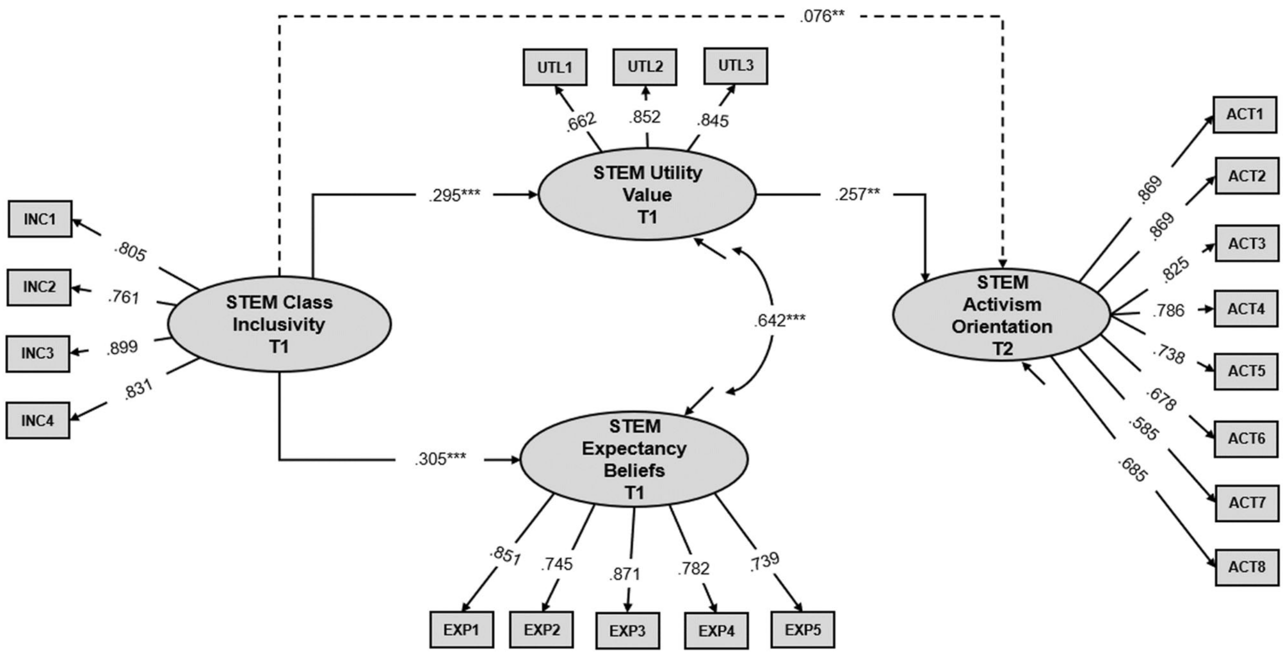

Fig. 2 Structure of associations between perceived classroom inclusivity, motivational beliefs, and activism orientation in STEM for adolescents ($n = 699$). *Note*. Covariates (gender, age, ethnicity, STEM grades T1, and STEM activism orientation T1), correlated residuals, and nonsignificant relations were not shown for clarity. INC = inclusivity; EXP = expectancy beliefs; UTL = utility values; ACT = activism orientation; STEM = science, technology, engineering, and mathematics; T1= Time 1; T2 = Time 2. The dotted line represents a significant indirect effect of perceived STEM classroom inclusivity on STEM activism orientation through STEM utility values. CFI, comparative fit index; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual; TLI, Tucker–Lewis Index. Model fit: $\chi 2\ (433) = 777.59$, $p < 0.001$, RMSEA = 0.034, 90% CI [0.030 –0.038], SRMR = 0.08, CFI = 0.925, TLI = 0.915. Standardized path coefficients are presented. $^{*}p < 0.05$. $^{**}p < 0.01$. $^{***}p < 0.001$

Table 2 Estimates of Path Coefficients of the SEM model: Direct and Indirect Effects (n = 699)

Effect	Path	Unstandardized estimate (SE)	Standardized Estimate	95% CI	
				LL	UL
Direct effect on STEM Expectancy Beliefs	Inclusivity → Expectancy	0.393 (0.047)***	0.305***	0.235	0.375
Direct effect on STEM Utility Values	Inclusivity → Utility	0.316 (0.047)***	0.295***	0.217	0.372
Direct Effects on STEM Activism Orientation	Inclusivity → Activism	0.184 (0.172)	0.147	−0.113	0.406
	Expectancy → Activism	−0.018 (0.159)	−0.020	−0.348	0.309
	Utility → Activism	0.294 (0.100)**	0.257**	0.085	0.429
Indirect Effects					
	Inclusivity → Expectancy → Activism	−0.007 (0.063)	−0.005	−0.130	0.116
	Inclusivity → Utility → Activism	0.093 (0.034)**	0.076**	0.025	0.160
Covariance/ Correlation	Expectancy ←→ Utility	0.449 (0.044)***	0.642***	0.580	0.703
	ActivismT1 ←→ STEM_GradesT1	0.194 (0.038)***	0.224***	0.144	0.304

STEM Science, Technology, Engineering and Mathematics, *CI* confidence interval, *LL* lower limit, *UL* upper limit. Unstandardized CIs were reported

$^{**}p < 0.01$. $^{***}p < 0.001$

Table 3 Covariates (n = 699)

Variable	Effect	Unstandardized estimate (SE)	Standardized Estimate	95% CI	
				LL	UL
STEM Class Inclusivity					
	Age	0.053 (0.041)	0.052	−0.028	0.134
	Gender	−0.067 (0.069)	−0.039	−0.202	0.067
	Ethnicity	0.143 (0.071)*	0.083*	0.004	0.282
	STEM_Grades_T1	0.180 (0.043)***	0.179***	0.095	0.265
STEM Expectancy					
	Age	−0.074 (0.042)	−0.056	−0.156	0.009
	Gender	−0.063 (0.071)	−0.028	−0.202	0.076
	Ethnicity	−0.156 (0.073)*	−0.071*	−0.299	−0.014
	STEM_Grades_T1	0.657 (0.047)***	0.507***	0.566	0.749
STEM Utility Value					
	Age	−0.011 (0.042)	−0.010	−0.093	0.071
	Gender	0.083 (0.070)	0.045	−0.054	0.220
	Ethnicity	−0.119 (0.071)	−0.065	−0.257	0.020
	STEM_Grades_T1	0.309 (0.045)***	0.286***	0.220	0.397
STEM Activism Orientation					
	Age	−0.003 (0.102)	−0.001	−0.204	0.197
	Gender	0.409 (0.181)*	0.195*	0.054	0.765
	Ethnicity	0.117 (0.150)	0.057	−0.176	0.410
	STEM_Grades_T1	0.021 (0.123)	0.016	−0.219	0.261
	STEM_Activism_T1	0.308 (0.065)***	0.296***	0.180	0.436

STEM Science, Technology, Engineering and Mathematics, *CI* confidence interval, *LL* lower limit, *UL* upper limit. Unstandardized Cis were reported. Dummy coding: Gender: 0 = male, 1= female; Ethnicity: 0 = racially/ethnically minoritized (non-White) student group, 1= racially/ethnically majoritized (White) student group

$^{*}p < 0.05$. $^{***}p < 0.001$

The Links Between Classroom Inclusivity and Activism Orientation via Motivational Beliefs in STEM

The third research question was whether STEM classroom inclusivity had indirect effects on STEM activism orientation via STEM motivational beliefs. As shown in Fig. 2, adolescents' perceptions of STEM classroom inclusivity had a positive indirect effect on STEM activism orientation via adolescents' STEM utility values ($\beta = 0.076$, $SE = 0.028$, $p = 0.007$), controlling for covariates. This result revealed that the association between adolescents' perceptions of STEM classroom inclusivity and STEM activism orientation was attributed to higher utility values for STEM. The indirect effect of perceived STEM classroom inclusivity on STEM activism orientation via STEM expectancies was not statistically significant ($\beta = -0.005$, $SE = 0.05$, $p = 0.916$).

Demographic Variables

As shown in Table 3, the effect of ethnicity on perceived STEM classroom inclusivity was positive and statistically significant ($\beta = 0.083$, $SE = 0.041$, $p = 0.042$), suggesting that racially/ethnically majoritized students had more positive perceptions of STEM classroom inclusivity than racially/ethnically minoritized students. On the contrary, racially/ethnically majoritized students had lower STEM expectancies than their racially/ethnically minoritized counterparts ($\beta = -0.071$, $SE = 0.033$, $p = 0.030$). Adolescents with higher self-reported STEM grades are more likely to have positive perceptions of inclusivity in STEM classrooms ($\beta = 0.179$, $SE = 0.040$, $p < 0.001$), higher levels of STEM expectancies ($\beta = 0.507$, $SE = 0.030$, $p < 0.001$) and perceived utility value of STEM ($\beta = 0.286$, $SE = 0.038$, $p < 0.001$). Although the girls and boys showed similar patterns in the hypothesized model, girls were more likely to report higher STEM activism orientation than their male counterparts ($\beta = 0.195$, $SE = 0.085$, $p = 0.021$). See supplementary material for multigroup SEM analyses across gender groups.

Multigroup Analyses by Race

Supplemental sensitivity analyses, multigroup SEM, were conducted to test the equality of variance of structural path

Table 4 The Results of the Baseline SEM Model for Racially/Ethnically Minoritized (non-White) Group ($n = 365$)

Effect	Path	Unstandardized estimate (SE)	Standardized Estimate	95% CI	
				LL	UL
Direct effect on STEM Expectancies	Inclusivity → Expectancy	0.308 (0.074)***	0.237***	0.163	0.454
Direct effect on STEM Utility Values	Inclusivity → Utility	0.242 (0.073)***	0.234***	0.099	0.385
Direct Effects on STEM Activism Orientation	Inclusivity → Activism	0.220 (0.162)	0.181	−0.097	0.538
	Expectancy → Activism	−0.089 (0.173)	−0.093	−0.427	0.250
	Utility → Activism	0.446 (0.175)**	0.378**	0.104	0.788
Indirect Effects	Inclusivity → Expectancy → Activism	−0.025 (0.051)	−0.021	−0.125	0.076
	Inclusivity → Utility → Activism	0.105 (0.045)*	0.087*	0.017	0.193
Covariance/ Correlation	Expectancy ←→ Utility	0.440 (0.062)***	0.656***	0.318	0.562
	Activism_T1 ←→ STEM_Grades_T1	0.164 (0.054)***	0.184***	0.058	0.269

Note. *STEM* Science, Technology, Engineering and Mathematics. *CI* confidence interval; *LL* lower limit, *UL* upper limit. Unstandardized CIs were reported. Model fit: $\chi2$ (408) = 518.171, $p < 0.001$, RMSEA = 0.027, 90% CI [0.019 –0.034], SRMR = 0.07, CFI = 0.959, TLI = 0.954
*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$

coefficients across racially/ethnically minoritized and majoritized adolescents, controlling for covariates (See supplementary material). Multigroup SEM consists of testing invariance procedures to compare certain parameters in a SEM model across different groups (Lee & Whittaker, 2021). First, the baseline models were tested for each group separately. The Racially/Ethnically Minoritized model fits the data very well: $\chi2$ (408) = 518.171, $p < 0.001$, RMSEA = 0.027, 90% CI [0.019 –0.034], SRMR = 0.07, CFI = 0.959, TLI = 0.954 (see Table 4). Perceived STEM classroom inclusivity had significant positive effects on STEM expectancies ($\beta = 0.237$, $SE =$ 0.049, $p < 0.001$) and utility values ($\beta = 0.234$, $SE =$ 0.062, $p < 0.001$). As shown in Table 4, STEM utility values had a significant positive effect on STEM activism orientation ($\beta = 0.378$, $SE = 0.143$, $p = 0.008$); however, STEM expectancies and classroom inclusivity showed no significant direct effects on STEM activism orientation. In this model, perceived STEM classroom inclusivity had an indirect positive effect on STEM activism orientation through STEM utility values ($\beta = 0.087$, $SE = 0.037$, $p = 0.018$). For covariates, STEM activism orientation T1 had a significant positive effect on STEM activism orientation T2 ($\beta = 0.225$, $SE = 0.087$, $p = 0.009$). Self-reported STEM grades had positive effects on perceived STEM classroom inclusivity ($\beta = 0.184$, $SE = 0.058$, $p < 0.001$), STEM expectancies ($\beta = 0.553$, $SE = 0.041$, $p < 0.001$), and STEM utility values ($\beta = 0.282$, $SE =$ 0.055, $p < 0.001$). Gender had a significant positive effect on STEM activism orientation ($\beta = 0.196$, $SE = 0.094$, $p = 0.037$).

The model for the racially/ethnically majoritized group also fits the data well: $\chi2$ (408) = 563.711, $p < 0.001$, RMSEA = 0.034, 90% CI [0.027 –0.040], SRMR = 0.09, CFI = 0.952, TLI = 0.946. As in the Racially/Ethnically Minoritized model, perceived STEM classroom inclusivity had significant positive effects on STEM expectancies ($\beta = 0.383$, $SE = 0.047$, $p < 0.001$) and utility values ($\beta = 0.363$, $SE = 0.052$, $p < 0.001$). As shown in Table 5, perceived STEM classroom inclusivity ($\beta = 0.204$, $SE = 0.109$, $p = 0.061$) and STEM expectancies ($\beta = -0.013$, $SE = 0.185$, $p = 0.944$) had no significant effects on STEM activism orientation. Distinct from the overall model and the model for the minoritized participants, the results of the racially/ethnically majoritized model show that utility values also showed no significant effect on STEM activism orientation ($\beta = 0.238$, $SE = 0.135$, $p = 0.078$) and the indirect effect of perceived STEM classroom inclusivity on STEM activism orientation via utility values was not statistically significant ($\beta = 0.087$, $SE = 0.051$, $p = 0.091$). As in the Racially/ethnically Minoritized model, STEM activism orientation at T1 had a significant positive effect on STEM activism orientation at T2 ($\beta = 0.296$, $SE = 0.128$, $p = 0.021$), self-reported STEM grades had positive effects on perceived STEM classroom inclusivity ($\beta = 0.185$, $SE = 0.057$, $p < 0.001$), STEM expectancies ($\beta = 0.436$, $SE = 0.044$, $p < 0.001$), and STEM utility values ($\beta = 0.286$, $SE = 0.052$, $p < 0.001$). Gender had a significant positive effect on STEM activism orientation ($\beta = 0.183$, $SE = 0.074$, $p = 0.013$).

Both the racially/ethnically minoritized and majoritized baseline SEM models fit the data well, but there were differences in the corresponding parameters (e.g., the estimated path coefficients from utility value to activism

Table 5 The Results of the Baseline SEM model for Racially/Ethnically Majoritized (White) Group ($n = 334$)

Effect	Path	Unstandardized estimate (SE)	Standardized Estimate	95% CI	
				LL	UL
Direct effect on STEM Expectancies	Inclusivity → Expectancy	0.468 (0.066)***	0.383***	0.339	0.598
Direct effect on STEM Utility Values	Inclusivity → Utility	0.389 (0.066)***	0.363***	0.260	0.519
Direct Effects on STEM Activism Orientation	Inclusivity → Activism	0.242 (0.136)	0.204	−0.024	0.509
	Expectancy → Activism	−0.011 (0.176)	−0.013	−0.355	0.333
	Utility → Activism	0.262 (0.149)	0.238	−0.030	0.554
Indirect Effects	Inclusivity → Expectancy → Activism	−0.005 (0.083)	−0.005	−0.168	0.158
	Inclusivity → Utility → Activism	0.102 (0.061)	0.087	−0.017	0.221
Covariance/ Correlation	Expectancy ←→ Utility	0.437 (0.060)***	0.616***	0.319	0.556
	Activism_T1 ←→ STEM_Grades_T1	0.230 (0.051)***	0.284***	0.130	0.331

STEM Science, Technology, Engineering and Mathematics. *CI* confidence interval; *LL* lower limit, *UL* upper limit. Unstandardized CIs were reported. Model fit: $\chi2$ (408) = 563.711, $p < 0.001$, RMSEA = 0.034, 90% CI [0.027 –0.040], SRMR = 0.09, CFI = 0.952, TLI = 0.946

***$p < 0.001$

orientation). Thus, the equality of the structural path coefficients across ethnic groups were tested for the following effects in the hypothesized model: (1) the direct effect of perceived STEM classroom inclusivity on STEM expectancies, (2) the direct effect of perceived STEM classroom inclusivity on STEM utility value, (3) the direct effect of perceived STEM classroom inclusivity on STEM activism orientation, (4) the direct effect of STEM expectancies on STEM activism orientation, (5) the direct effect of STEM utility value on STEM activism orientation, (6) the indirect effect of perceived STEM classroom inclusivity on STEM activism orientation via STEM expectancies, and (7) the indirect effect of perceived STEM classroom inclusivity on STEM activism orientation via STEM utility value. To test the structural path coefficient invariance, configural SEM models (a less restrictive model) were estimated for the racially/ethnically minoritized and majoritized samples simultaneously. To test the equality of the corresponding parameters, the MODEL TEST function was used in *Mplus V. 8.11* (Muthén & Muthén, 2017). A Wald test was used to test the invariance of specific structural path coefficients. The Wald test parameter constraints were as follows: (1) $\chi^2 = 4.787$, $df = 1$, $p = 0.028$; (2) $\chi^2 = 2.991$, and $df = 1$, $p = 0.0837$; (3) $\chi^2 = 0.006$, $df = 1$, $p = 0.937$; (4) $\chi^2 = 0.187$, $df = 1$, $p = 0.665$; (5) $\chi^2 = 0.712$, $df = 1$, $p = 0.398$; (6) $\chi^2 = 0.071$, $df = 1$, $p = 0.789$; (7) $\chi^2 = 2.260$, $df = 1$, $p = 0.133$. Findings suggest that the effect of perceived STEM classroom inclusivity on expectancies is noninvariant among racially/ethnically minoritized and majoritized adolescents, thus ethnicity significantly moderates the effect of perceived STEM classroom inclusivity on STEM expectancies (the effect is stronger for majoritized as compared to minoritized youth, see Tables 4 and 5). On the contrary, all other tested effects remained invariant among racially/ethnically minoritized and majoritized adolescents. Additional sensitivity analyses (multigroup SEM) were utilized across boys and girls, demonstrating that effects were the same for both boys and girls (see Tables S7 and S8 in the supplementary material).

Discussion

Drawing on situated expectancy-value theory (Eccles & Wigfield, 2020), this study focused on the associations between adolescents' perceptions of STEM classroom inclusivity, STEM motivational beliefs, and orientation toward STEM activism. First, the findings clearly indicate that adolescents' perceptions of STEM classroom inclusivity play an important role in shaping their STEM motivational beliefs controlling for covariates. In particular, the direct effects of perceived STEM classroom inclusivity on STEM expectancies and utility values were positive and statistically significant. Perceived STEM classroom inclusivity had a stronger effect on STEM expectancies than utility values. Second, the direct effect of STEM utility values on STEM activism orientation was positive and statistically significant, but the pathway from STEM expectancies to STEM activism orientation was not. Third, adolescents' perceptions of STEM classroom inclusivity had an indirect positive effect on STEM activism orientation through STEM utility values. Further, adolescents' perceptions of STEM classroom inclusivity and STEM expectancies differed by ethnicity, such that, racially/ethnically majoritized students reported higher inclusivity in their STEM classrooms but lower STEM expectancies than their racially/ethnically minoritized counterparts (See Table 3). Adolescents' self-reported STEM grades were significantly associated with their perceptions of classroom inclusivity, expectancies, and utility values in STEM. Further, girls were likely to report a higher orientation toward STEM activism than boys. Thus, these results confirm the important ways in which perceptions of inclusivity work through motivational factors to shape STEM activism orientation.

Pathways from STEM Classroom Inclusivity to Motivational Beliefs

This study found that higher perceived STEM classroom inclusivity was associated with higher STEM expectancies and utility values. This finding is consistent with the SEVT (Eccles & Wigfield, 2020), and empirical work from of Li and Singh (2022) who reported positive associations between college students' perceptions of the inclusiveness of the learning environment and motivational beliefs in physics and partially reflected those of Ozturk et al. (2024) who also found significant positive associations between adolescents' perceptions of STEM youth program inclusivity and changes in their math utility values. The results also align with previous findings, which showed the critical role of inclusive learning environments and teaching practices in promoting student confidence (French et al., 2023) and personal relevance in effective utility value interventions (e.g., Priniski & Thoman, 2020). The multigroup SEM analyses showed that the effect of perceived STEM classroom inclusivity on STEM utility values remained invariant across racially/ethnically minoritized and majoritized groups, suggesting that ethnicity did not significantly moderate the effect of classroom inclusivity on utility values. However, the findings of this study revealed that ethnicity significantly moderates the effect of classroom inclusivity on expectancies, suggesting that perceived STEM classroom inclusivity more strongly relates to STEM expectancies for racially/ethnically majoritized as compared to minoritized youth. These results suggest that one important way to ensure that students feel that they can succeed in STEM (expectancies) and that they see concrete ways in which STEM has value for them and their lives (utility value) is to first ensure that classroom environments are welcoming and supportive of all students. Thus, these results draw attention to the importance of considering the inclusiveness of STEM learning environments to promote motivational beliefs.

Pathways from STEM Motivational Beliefs to STEM Activism Orientation

Associations from STEM motivational beliefs to STEM activism orientation revealed one significant direct pathway. Utility values were positively associated with activism orientation, such that adolescents who see higher utility values in STEM had a higher STEM activist orientation. These results corroborate and expand upon the findings of previous work that indicate utility values in political activities are a key indicator of activism and civic engagement (Liem & Chua, 2013; Martín & Van Deth, 2007). Contrary to our expectations and previous studies which have reported that both civic expectancies and utility values predicted adolescent activism behavior (Wegemer, 2023), this study did not find any significant association between STEM expectancies and activism orientation. However, it is important to bear in mind that the prior work focused on general activism, not specific to STEM. Students with higher STEM expectancies might have a higher materialistic orientation (e.g., Sax, 2004) and less interested in STEM-related concerns that affect larger society. It may be that perceptions of the utility of STEM are particularly important to feel efficacious to engage in STEM civic action. Importantly, STEM activism orientation does not reflect adolescents' actual civic activism behavior; instead, it measures adolescents' perceptions of their capabilities to solve STEM-related problems. In other words, there might be discrepancies between adolescents' perceptions of their own abilities to solve civic problems and their actual STEM-related civic activism behaviors. The finding of multigroup SEM analyses revealed that the effects of perceived STEM classroom inclusivity, expectancies, and utility values on STEM activism orientation remain invariant across racially/ethnically minoritized and majoritized adolescents, suggesting that ethnicity did not significantly moderate the effects of classroom inclusivity, expectancies, and utility values on activism orientation.

The Indirect Effects on STEM Activism Orientation

Analyses revealed some support for the indirect effects of perceived STEM classroom inclusivity on STEM activism orientation via STEM motivational beliefs. In particular, perceived STEM classroom inclusivity had an indirect positive effect on STEM activism orientation via STEM utility values, aligned with previous research linking classroom inclusivity and STEM activism orientation via STEM outcomes including student belonging (Mulvey et al., 2022), and STEM activism such as youth entrepreneurship, questioning school authorities (Calabrese Barton et al., 2020). It may be that feeling included and supported in one's STEM classes builds values to address real-world

STEM problems and a desire to engage in this work. Expectancies did not account for the relationships between perceived classroom inclusivity and activism orientation in STEM. Students with higher STEM expectancies may have a higher orientation toward individual and materialistic concerns than STEM-related global problems (e.g., Sax, 2004). Additionally, STEM utility values are strongly associated with activism (Eide & Kunelius, 2021); thus, adolescents who see utility value in STEM are then more likely to be oriented towards solving STEM problems in their community. Recent research on civic science suggests that engagement with locally relevant STEM problems can help to diversify STEM fields (Flanagan et al., 2022); thus, one way to foster this engagement (by building STEM activism orientation) is to ensure that classrooms feel inclusive, which will promote perceptions of the utility of STEM and a sense of efficacy in solving local STEM problems.

The findings of multigroup SEM revealed that the indirect effects of perceived STEM classroom inclusivity on STEM activism orientation via STEM expectancies and STEM utility values were invariant among racially/ethnically minoritized and majoritized adolescents. However, the multigroup SEM analysis revealed that ethnicity significantly moderates the effects of adolescents' perceptions of STEM classroom inclusivity on STEM expectancies. This study documented that adolescents' self-reported STEM grades were positively associated with their perceptions of STEM classroom inclusivity, expectancies, utility values, and activism orientation. This finding broadly supports the work of other studies linking achievement and motivational beliefs (Guo et al., 2015; Prast et al., 2018).

Limitations and Educational Implications

Several limitations to this study need to be acknowledged. Given that missing data is a common challenge in cross-sectional and longitudinal research designs (Enders, 2011; Woods et al., 2024), a key strength of the present study was the implementation of robust imputation approaches to handle this missing data (Asendorpf et al., 2014), to account for the potential student burnout with online tasks following COVID which may have contributed to the high missingness at T2. The scope of this study was limited in terms of gender and ethnic/racial STEM classroom inclusivity. However, inclusivity in a classroom may be assessed in various ways (Barnard-Brak et al., 2014), including adolescents' perceptions of group norms and peers' fair and unfair treatment of others (Kaufman & Killen, 2022). Future research might take a qualitative approach to understanding more carefully how utility values shape activism in culturally relevant STEM learning settings such as in contexts where one might encounter racial microaggressions and structural racism (McGee, 2020). Further, in the current analyses, racially/ethnically majoritized and minorized groups were assessed, but future research should aim to also explore differences within minoritized populations. For example, Asian adolescents may exhibit different patterns than Black or Latino/a/e/x adolescents, given positive stereotypes for Asians in STEM (McGee et al., 2017). A greater focus on adolescents' lived experiences in online or in-person inclusive STEM learning environments using student artifacts, in-depth focus group interviews, and classroom observations could be usefully explored in further research (e.g., Casey et al., 2023). Additionally, exploring racially/ethnically minoritized students' personal relevance of STEM and their lived experiences toward social justice in and out of classrooms (e.g., Kokka, 2018) will contribute to a deeper understanding of STEM activism. Further research on inclusivity exploring intersectionality in the expectancy-value framework might also be beneficial (French et al., 2023).

The measures for this study were obtained from an ongoing longitudinal study that is limited to two time points. Moreover, STEM classroom inclusivity and STEM motivational beliefs were measured at the same time point, which makes understanding the directionality of effects more challenging. Thus, an issue that was not addressed in this study was the reciprocal causal effects between class inclusivity, motivational beliefs, and STEM outcomes. The findings of this study suggest a role for STEM utility value in promoting activism orientation. Further investigations are needed in STEM subdisciplines (e.g., engineering, technology) and other school subjects (e.g., English) to provide greater insights into the effects of expectancies and values on civic outcomes (e.g., Liem & Chua, 2013). The supplemental multi-group SEM analysis revealed that there were gender and ethnic group differences in STEM to activism orientation; thus, there is abundant room for further progress in determining distinct patterns in expectancies and values to support activism orientation using person-centered analysis across different gender/ethnic groups (Wegemer, 2023). For example, activism orientation in nonbinary youth would be a fruitful area for further work. Moreover, STEM-related concerns have become more prominent in recent decades; therefore, a greater focus on intergenerational effects on STEM activism orientation could produce interesting findings that account for changes in attitudes, beliefs, and behaviors toward activism over time.

Conclusion

Activism around STEM is critical for designing and advocating for sustainable solutions for STEM-related problems (e.g., climate change, air pollution, equity in access to

STEM resources) in a social-justice framework. SEVT provides foundational knowledge and theoretical insights regarding the key roles of contextual factors and motivational beliefs (expectancies and values) in youth civic engagement and activism. However, a limited number of studies have addressed how contextual factors, in particular adolescents' perceptions of STEM classroom inclusivity and STEM motivational beliefs shape STEM activism orientation. By providing a conceptual model embedded in SEVT, the findings contribute to the understanding of the critical role of perceived STEM classroom inclusivity on STEM activism orientation through STEM outcome expectancies and utility values. This study has shown that adolescents with higher perceptions of classroom inclusivity are more likely to have higher utility values of STEM which, in turn, is associated with a higher orientation toward STEM activism. An important implication is that educational interventions aimed at supporting STEM activism should consider promoting classroom inclusivity and differential effects of STEM motivation components across all groups simultaneously.

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Authors' Contributions E.O. conceived of the study, designed the conceptual model, performed the statistical analyses, interpreted the results, and drafted the manuscript. J.C.S. conceived of the study, provided interpretation of the results, and revised the manuscript; A.J. conceived of the study, provided interpretation of the results, and revised the manuscript; C.J.M. conceived of the study, provided interpretation of the results, and revised the manuscript; K.L.M. conceived of the study, participated in designing the study, secured the data, oversaw the process of data analyses, provided interpretation of the results, and revised the manuscript. Each author read and approved the final manusript.

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Data Sharing and Declaration The data are not publicly available due to privacy or ethical restrictions. The data that support the findings of this study are available on request from the principal investigator of the study.

Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

Ethical Approval This study was approved by the Institutional Review Board (IRB) at North Carolina State University (IRB approval number: #20526).

Informed Consent Opt-out consent forms were sent to potential participants' homes. Opt-out parental consent was obtained from all individual participants included in the study. Students with parental consent assented to participate in this study.

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Emine Ozturk is a postdoctoral research scholar in the PEAC Lab in the Sanford School at Arizona State University. Her research interests include educational inequality, gender dynamics, resilience and persistence in STEM education, immigrant students, and longitudinal research designs.

Jacqueline Cerda-Smith earned her doctorate in the Lifespan Developmental Psychology program at North Carolina State University. Her research broadly examines factors that support equity and adolescent well-being in schools. She is a former high school and middle school social studies teacher, earning her National Board Certification in 2018.

Angelina Joy earned her doctorate at North Carolina State University and is now a postdoctoral scholar at Purdue University. Her research focuses on children's and adolescents' beliefs in gender and racial/ethnic stereotypes and the factors that promote their motivation in STEM.

Channing J. Mathews is an Assistant Professor at the University of Virginia. Her major research interests include examining the intersections of ethnic-racial identity and social inequity within STEM contexts.

Kelly Lynn Mulvey is an Associate Professor at North Carolina State University. Her major research interests include broadening participation in STEM, inclusion, belonging, and bullying.