"I Felt Like I Completely Belonged in That Class": Gender and the Development of Sense of Belonging in K-12 STEM Education

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Abstract

Sense of belonging is an important motivational belief that represents individuals' sense of fit within an environment. However, many women report feeling a lower sense of belonging than men in STEM fields, which may perpetuate gender inequities. This lack of belonging may develop early in a student's educational trajectory and disproportionately affect girls. This paper offers two key contributions to improve our understanding of gender differences in STEM belonging in K-12 education. First, this paper reports a systematic review examining 50 samples from 46 quantitative studies looking at the development of children and adolescents' sense of belonging in K-12 STEM classes and fields. These studies offered valuable knowledge about factors supporting belonging and consequences of belonging, with limited or inconclusive evidence about gender differences and development. Second, we also conducted a mega-analysis of $N = 6{,}111$ children and adolescents across five studies to provide the most well-powered and rigorous analysis to date on this issue. Intersectional findings on gender gaps in belonging in four STEM fields showed that gender gaps in belonging were strongest for Hispanic/Latine students in middle school, and in middle/high school computer science and engineering. The discussion highlights experimental studies demonstrating causal influences on girls' STEM belonging, indicating the potential for future interventions to support belonging. It is critically important for future research to extend these findings in ways that promote girls' belonging and participation in STEM fields, especially the fields in which they are most underrepresented.

Keywords

Belonging, gender, STEM, childhood, adolescence, K-12 education

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Feeling that we belong is an essential social aspect of human life. Feelings of being accepted and respected as an individual and as a group member must be satisfied to support psychological health and well-being. In the words of Phoebe Stone (2011, p. 83), "Not belonging is a terrible feeling. It feels awkward and it hurts, as if you were wearing someone else's shoes." Belonging can be described as a critically important motivational belief that represents individuals' sense of fit within an environment, including family, friends, school, workplace, and community (Fiske, 2018; Maslow, 1954). However, an absence of belonging is associated with negative effects, both physically and psychologically (K. A. Allen et al., 2021; Choenarom et al., 2005). Literature on belonging is broad and researchers have addressed belonging from many diverse perspectives. Belonging may include both social (*"people here are similar to me"*) and academic (*"people like me can succeed here"*) components (Browman, 2025). Past research has largely focused on the study of the general need to belong, emphasizing that the desire to form social connections is a fundamental human motivation (Baumeister & Leary, 1995; Pickett et al., 2004; Walton & Cohen, 2007). However, academic belonging has attracted growing attention from researchers and practitioners in recent years due to its contribution to a variety of educational and developmental outcomes (K. A. Allen & Bowles, 2012; Fong et al., 2024; Korpershoek et al., 2020).

In this review, we examine a specific type of academic belonging–sense of belonging in science, technology, engineering, and math (STEM)–and its development for students in K-12 education based on gender. We define belonging and discuss why it is important to understand gender gaps in STEM belonging using an intersectional approach. We then provide two comprehensive and complementary analyses of the existing research in this area. First, we describe the results of a systematic review of STEM belonging among K-12 students, which resulted in 50 empirical quantitative studies published in 46 articles. We focused on quantitative

research in order to systematically examine belonging at different ages and for different STEM fields. This review allows us to summarize the current state of the field, share the most common measures of STEM belonging in elementary and secondary school, consolidate evidence of gender differences or lack thereof, and highlight gaps where more research is needed. Second, we report findings from a mega-analysis combining five large datasets with students in Grades 1-12 to examine the STEM fields, grade levels, and racial/ethnic groups that show significant gender gaps in belonging. This mega-analysis provides the most well-powered and rigorous examination of gender gaps among this age range, which allows us to determine the STEM fields and specific groups where support for belonging is most critical. The discussion points to important directions for future research and intervention, highlighting experimental studies demonstrating the malleability of STEM belonging. Our goal is to summarize existing quantitative findings on gender gaps in K-12 STEM belonging to guide further research in this area.

Definitions

Belonging represents students' beliefs about how much they fit in with others and have positive relationships with the people or environment around them (Master et al., 2021). Researchers have defined belonging as feeling like a "valued, accepted, and legitimate member" of an academic domain or environment (Banchefsky et al., 2019; Lewis et al., 2016). Other definitions emphasize perceptions of the quality of relationships or feelings of membership in addition to acceptance (C. Good et al., 2012; Walton & Brady, 2021). Belonging has also been argued to represent a "fundamental human motivation" to "form and maintain strong, stable, interpersonal relationships," with motivation defined as something that directs affect, behavior, and cognition (Baumeister & Leary, 1995, p. 497). In the current review, we operationalize belonging as a motivational belief (representing a sense or feeling) that drives motivated thoughts, feelings, and behaviors. In this way, belonging can be viewed as (a) a predictor of other important motivational variables, (b) a mediator between environmental cues and other motivational variables, and/or (c) an important outcome in its own right. Studies show that

students who have a strong sense of belonging in school are highly motivated to be academically successful (Gillen-O'Neel, 2021; Pedler et al., 2022). When students feel that they belong, they are motivated to participate and persist in academic pursuits.

Belonging in STEM has primarily been measured in terms of social belonging but is also strongly related to students' perceptions that they have the same intellectual abilities and capacities as their peers (Banchefsky et al., 2019). Belonging can apply at multiple levels of analysis, including broad school-level belonging (K. Allen et al., 2018; Bostwick et al., 2022), domain/academic field belonging (e.g., math, physics; Lewis et al., 2016), or belonging within a specific course (e.g., pre-algebra; Barbieri & Miller-Cotto, 2021). STEM fields vary in the extent to which brilliance is believed to be required for success, and this variation is meaningfully linked to belonging, making domain-level belonging an important outcome to examine (Bauer et al., 2025). In this review, we focus particularly on belonging in STEM domains and STEM courses. Both levels of belonging are linked to important motivational measures like engagement, although belonging in specific courses may be more strongly linked to effort and participation in that course than belonging to a domain or field (Wilson et al., 2015).

Several concepts are theoretically closely related to belonging in meaningful ways, including belonging uncertainty, mattering, and the need for belonging. First, belonging uncertainty occurs when members of marginalized or stereotyped groups are uncertain of the quality of their relationships and more sensitive to issues of belonging (Walton & Cohen, 2007). This uncertainty itself can have negative motivational consequences (Walton & Brady, 2021). Although belonging uncertainty is distinct from belonging itself, these are slightly negatively correlated: the more that students feel they belong, the less likely they are to be uncertain about their belonging (Goyer et al., 2019). Second, mattering is the feeling that your contributions are valued and recognized by others (Lombard & Cheryan, 2023). Mattering is strongly related to belonging, and some definitions of belonging include the perception of feeling valued (Banchefsky et al., 2019; Lewis et al., 2016). Empirically, sense of belonging and interpersonal

mattering appear to be related but distinct concepts (Dueñas & Gloria, 2017; Lombard & Cheryan, 2023). Finally, the need for belonging represents how much students have the desire to belong (Leary et al., 2013), which may be a potential moderator of the consequences of sense of belonging in STEM (McPherson et al., 2018), although research relevant to youths' STEM beliefs is limited.

Though belonging is important generally in education and at the institutional level, sense of belonging in STEM is a particularly important issue given the historical lack of representation of women and racially/ethnically minoritized students in these fields (Master & Meltzoff, 2020). Students from underrepresented groups are less likely to report feeling that they belong in STEM majors (Rainey et al., 2018). Additionally, sense of belonging can influence staying in or leaving STEM majors for women and students of color (Rainey et al., 2018). Therefore, it is necessary to understand how to better attract and retain a greater diversity of students to STEM fields by increasing feelings of belonging and inclusion among students.

Despite showing strong growth in STEM fields, women have remained underrepresented in these fields for decades (Veldman et al., 2021). Approximately 70% of all post-secondary degrees in STEM are awarded to men (National Center for Education Statistics, 2020). However, encouraging women in STEM is important for both reducing gender disparities and promoting better societal innovations and solutions. For example, voice recognition technology designed to help doctors with dictations can be less accurate for women's voices, a problem which could have been avoided with more women in technology (American Roentgen Ray Society, 2007). In addition, men overwhelmingly dominate some STEM fields; for instance, computer science has one of the lowest percentages (18%) of women among STEM degrees (National Center for Science and Engineering Statistics [NCSES], 2023). Women's perceptions of their sense of belonging may act as a barrier to participation and persistence in STEM fields. When adolescent girls feel that they do not belong in STEM classes, they are less interested than boys in enrolling in these classes, which in turn can influence their STEM entrance, persistence, or career

aspirations in the future (Cheryan et al., 2015; Master et al., 2016).

Race/Ethnicity, Intersectionality, and Belonging in STEM

In the next section, we discuss relevant research on racially/ethnically minoritized students in STEM, including a critical discussion of how the intersection of gender and race/ethnicity can affect youths' sense of belonging in STEM. We first note that gender refers to youths' understanding of themselves in the social categories including girls and boys, rather than their biological sex at birth. Gender can be consistent with biological sex (cisgender) or different (transgender). In addition, children and adolescents may identify as nonbinary or gender-fluid (Hyde et al., 2019). It is important to understand belonging in respect to students' gender, race/ethnicity, and the intersections of those identities to gain insights into the experiences of students from marginalized groups. For girls of color, their racial and ethnic background may prove to be an additional hurdle to their experiences of belonging in STEM (Matthews et al., 2024). Thinking only along the single axis of gender may limit our understanding of who experiences privilege and subordination in STEM environments (Cho et al., 2013). Intersectionality is not just about categories of identity, but also about structures of inequality. Students with multiple marginalized identities (e.g., Black and Hispanic/Latina girls and nonbinary students) experience interlocking systems of oppression and bias that can differ from the experiences of White girls or Black or Hispanic/Latino boys (Burnett et al., 2023; Fong & Irizarry, 2025; N. Lopez et al., 2018). For example, many Hispanic/Latina girls come from backgrounds that instill the cultural value of *marianismo*. This sets a norm for women as passive and family oriented rather than achievement oriented, creating tension between STEM career choices and traditional gender roles (S. L. Rodriguez & Blaney, 2021).

The graduation rates in STEM for students who are racially/ethnically underrepresented are significantly lower than the rates of their majority peers (Ireland et al., 2018; Morton et al., 2019). Out of all women ages 15-44 in the U.S., 14% are Black women and 21.5% are Hispanic/Latina women (U.S. Census Bureau, 2021). However, Black and Hispanic/Latina

women are highly underrepresented in engineering, computer science, and physics. For example, compared to all bachelor's degree awardees in engineering, only 1% are Black women, and out of all bachelor's degrees in computer science, only 2% are Hispanic/Latina women. In addition, only 14% of Hispanic/Latina students and 10% of Black women students earned STEM degrees/certificates from post-secondary institutions, compared to 56% of White women students in 2018-2019 (National Center for Education Statistics [NCES], 2020).

There is also an uneven demographic composition in the STEM workforce in the United States. For example, Black, Hispanic/Latine, and Native American individuals together make up only 23% of the STEM workforce (NCSES, 2023), despite being 32% of the total workforce (U.S. Bureau of Labor Statistics, 2023). Even though Latinas are the fastest-growing population of minority women in the U.S., their presence in STEM professions is declining, particularly in computer science, mathematics, physics, and engineering (NCSES, 2023). STEM jobs also have a higher median income and lower rates of unemployment compared to non-STEM jobs (NCSES, 2023). The lack of representation of women of color in STEM fields may mean a persistent wage gap and disparity in access to opportunities and resources. There are also large costs attached with the lack of diverse perspectives and decision making in STEM, as seen in race-based facial recognition software to identify crime suspects (Criado Perez, 2019).

STEM-specific belonging has been an important topic of research for underrepresented college students. Low belonging negatively impacts their academic performance, retention, and persistence (Hausmann et al., 2007; O'Keeffe, 2013). Importantly, there is evidence that when underrepresented STEM students receive social support from institutional interventions, they persist despite obstacles and attain their learning goals (Williams et al., 2017). Many of these intersectional issues are evident even before college. Addressing these issues earlier in the developmental trajectory becomes important because many students decide by middle school whether they are interested in pursuing STEM-related courses in high school and college (Maltese & Tai, 2011). There are also large racial/ethnic gaps in the representation and training

received by Black and Hispanic/Latine high school students in their computer science classes (Margolis et al., 2017). One of the reasons for this gap is the interaction between school structures (e.g., lack of course offerings) and youths' own lack of belief in their abilities. In a survey conducted across 1,821 girls across the U.S., Black girls reported the lowest levels of self-perceptions in science and belonging in STEM-related careers compared to girls who identified as Asian American, Hispanic/Latine, White, and multiracial (Kang et al., 2019). Many students of color in the United States who perform well in science classes at school do not opt to pursue a career in STEM (Kang et al., 2019). One reason for this may be a lack of sense of belonging and feeling unable to identify themselves with other members in the field. Additional research is needed to investigate the development of racially and ethnically diverse adolescents' sense of belonging in STEM and how this may operate differently for girls and boys.

Importance of a Developmental Approach

The present article fills a critical gap in the literature, as it provides a review of the development of girls' sense of belonging in K-12 STEM education, with the ultimate goal of helping researchers, practitioners, and administrators support girls' belonging. When and why might gender impact children's belonging in STEM? Gender stereotypes and gender roles begin to affect girls' attitudes and behavior in early childhood (M. L. Halim & Ruble, 2010; M. L. D. Halim et al., 2017, 2023; Leaper, 2015b). Children who identify with their gender group are motivated to show gender-typical attributes from a young age (Leaper, 2022; Tobin et al., 2010). The gender stereotypes of parents, teachers, and peers can affect how much they encourage and include girls in STEM opportunities (Chaffee & Plante, 2022; Lazarides & Watt, 2015, 2017; R. Robnett, 2013; R. D. Robnett et al., 2018; Shirefley & Leaper, 2022; Simpkins et al., 2015). These gendered experiences can influence girls' perceptions of whether they belong in STEM (Leaper, 2015a). As they get older, children's social cognitive skills develop in ways that enable more sophisticated reasoning about their gender identity and self-concepts (Master, 2021). Around middle school, early adolescents develop more complex representations of themselves

and others. This implies gender gaps in belonging may become larger as children progress through secondary school if girls receive negative cues about their gender group in STEM that become integrated into their self-concepts.

Since girls spend a significant amount of their formative years at school, it is crucial that learning environments foster their sense of belonging. Examining how belonging in STEM develops among children and adolescents is particularly important, as their motivational trajectory sets the stage for their academic and career choices (Maltese & Tai, 2010). Research shows that such motivational processes begin at early stages in their education (Dörnyei, 2000; Weinburgh, 1995). Students' interest in pursuing science careers is most likely to emerge around Grade 8 (Tai et al., 2006). However, students may form their motivational trajectories even earlier. One study found that most scientists and graduate students in science developed their initial science interest and engagement in the time period before middle school (Maltese & Tai, 2010). Additionally, courses that students take in high school can be prerequisites for STEM majors and help students develop their career interests (Wang & Degol, 2017). Therefore, efforts to promote the development of sense of belonging in STEM should aim to engage children as early as possible to prevent students from leaving or dropping out of science courses and future careers in STEM.

Belonging to STEM groups is meaningful throughout development. For children, perceiving oneself as part of a group positively impacts children's motivation and performance on math and spatial reasoning tasks as early as preschool (Master et al., 2017). With age, sense of belonging in STEM continues to predict STEM motivation and engagement among middle school and high school students (Dasgupta et al., 2022; Master, Alexander, et al., 2025; Mulvey, Cerda-Smith, et al., 2023). Middle school students who feel like they belong in their math classes participate more in class and have more positive math-self concepts (Dasgupta et al., 2022). One study examined how motivational beliefs, including whether students felt they would fit in at a career, influenced high school students' preferences for certain STEM careers (Rosenzweig &

Chen, 2023). Fitting in was among the highest-rated reasons why high school students selected their most-preferred STEM careers; lack of fitting in was also the highest-rated reason why students selected their least-preferred STEM careers. In addition, a sense of belonging in computer science and engineering predicts high schoolers' interest in pursuing postsecondary education in those fields (Tellhed et al., 2017). However, not all students reap the benefits of feeling that they belong to the same extent. Though prior research has not found gender differences in elementary students' sense of belonging in computer science (Master et al., 2023) or middle school students' sense of belonging in STEM in general (Meadows & Robinson, 2023), gender differences in STEM sense of belonging are well documented among high school students. For example, by high school, girls report a lower sense of belonging than boys do in computer science, engineering, math, and physical sciences (Ito & McPherson, 2018; Master et al., 2016, 2023; Master, Meltzoff, et al., 2025; Tellhed et al., 2017).

Current Study

In the present study, we examine students' sense of belonging in K-12 education in greater detail through a systematic review and mega-analysis. Though the importance of sense of belonging has been identified, the patterns by which children and adolescents' perceptions of belonging develop in K-12 STEM education remain unclear. This systematic review and mega-analysis aim to bridge this gap by improving our understanding of belonging and how it develops among school-age students. First, in the systematic review, we aimed to systematically locate and synthesize the empirical quantitative findings on sense of belonging in K-12 STEM classes. In the section below, we report methods and results from the systematic review, including the comprehensive search strategy and selection criteria for studies. In addition, the results section summarizes and synthesizes the findings of the located research studies including sample characteristics and measurement information. We also describe research questions and findings across studies, including examination of gender differences. Therefore, this systematic review provides the latest and most complete information on young students' feelings of STEM

belonging, particularly in relation to gender differences. Second, the mega-analysis provides a more extensive and robust synthesis of evidence of gender gaps in STEM fields. The pooled statistical evidence across five large quantitative studies provides comprehensive details for when intersectional gender gaps in belonging emerge and for which fields these gaps remain significant. In combination, the systematic review and mega-analysis highlight the significance of examining girls' belonging in K-12 STEM classes and establish the foundations for educational policy and practice to reduce gender gaps in STEM education.

Systematic Review

Methods

This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). See Figure 1 for the PRISMA flow diagram.

Search Strategy

We conducted a systematic search in April 2024. The search strategy was designed in consultation with an experienced librarian to identify studies that measured sense of belonging in STEM from Grades K-12. We used the EBSCO platform to search PsycINFO, H.W. Wilson full text, Psychology and Behavioral Sciences Collection, and ERIC simultaneously. The same search strategy was used to search title and abstract fields in the Dissertations and Theses Global database in ProQuest to identify more studies. We filtered search results to include articles written in English. We did not impose any other limits, such as restrictions on the study time frame or the study location. Together, these searches resulted in 2,527 hits. The full search strategy can be found in the supplemental materials (see Table S1).

We used two ancillary search strategies at the end of our data collection efforts to make sure all relevant studies were included. First, as recommended by a reviewer, we searched the reference list of a recent systematic review on youths' STEM identity (Simpson & Bouhafa,

2020) but did not find any relevant studies. Second, we included two additional studies that we had originally found during the first round of submission of this review.

Title and Abstract Screening

Documents identified in our database search were exported to EndNote, a citation management software. Duplicate records were removed automatically by EndNote (n = 46) and by a human using EndNote (n = 542). After removing duplicates, the second author exported the remaining 1,939 documents to abstrackr (Wallace et al., 2012), a study screening software used for the title and abstract screening process. The second author developed a screening guide to identify relevant studies based on titles and abstracts (see inclusion and exclusion criteria below) and all four authors met and finalized the screening guide together. The second author trained the screeners together to use the screening guide and software by screening two abstracts as examples. The third and fourth authors served as independent screeners who then screened another three abstracts each as part of the training. All four authors were present during the training and questions regarding the inclusion and exclusion criteria were resolved through discussion. Each potentially relevant document was then independently screened by the third and fourth author. They first screened the same set of 100 documents after which all four authors met again to resolve any disagreements. Documents that appeared to be ineligible for the review were marked for exclusion. The agreement rate was 89% for the first 100 documents screened.

The two screeners independently screened the remaining documents across four sessions and all four authors met after each session to resolve disagreements by identifying common areas of misunderstanding. Documents that were not clearly ineligible based on information in their titles and abstracts were included for full text screening. After identifying an additional 30 duplicates at this stage and nine articles that could not be accessed, 101 studies were retained for full text screening. The overall agreement rate for all the titles and abstracts screened using

abstrackr was 94%. An additional two articles identified via the ancillary search were manually screened independently by the first and second authors, resulting in a total of 103 studies for full-text screening.

Inclusion and Exclusion Criteria

A study was *included* if: a) it was an empirical study using quantitative methodology; b) it had a child, adolescent or youth sample in a K-12 setting; and c) the authors measured sense of belonging or sense of fit in STEM or a related construct like relatedness, mattering, or connectedness. If the sample was over 18 years of age, they were still included as long as they were in a K-12 setting (for example, high school students who may be over the age of 18). A study was *excluded* if: a) it was a qualitative study, review paper, or book chapter; b) it had a preschool, undergraduate, adult, or non-human sample; and c) the authors measured only STEM identity, school belonging, or institutional belonging.

Full Text Screening

All four authors participated in full-text screening and two reviewers screened each article independently. Coding teams met to reconcile disagreements. Coders noted down reasons when excluding an article. Out of 103 documents screened, there were eight instances of conflict where one reviewer decided to include an article and the other decided to exclude it. Discussions among all four authors were held to discuss any disagreements that could not be resolved by the coding teams.

Data Extraction and Synthesis

All 103 documents identified as nearly eligible based on their titles and abstracts were screened for potential relevance. Data extraction was done using Microsoft Excel. We developed a data extraction form for full-text screening (see supplemental materials). The second author trained the team on how to use the data extraction form and reconcile studies. Instructions were

included in the category titles and descriptions indicating the type of information required. The extracted data included information such as the study authors and publication year, report type, and reasons for making a study ineligible. This was followed by capturing different sample characteristics like age, grade level, location, data collection modality, sample size, gender, race/ethnicity, and socioeconomic status (SES) levels. Lastly, information regarding the study design and how sense of belonging was measured in the studies was documented. Across our coded data extraction fields, our percentage agreement rate was 97%.

Results

Study Characteristics

A total of 50 studies published in 46 articles were included in this review; see Table 1. Seven studies independently measuring sense of belonging were published in three multi-study papers (Brock, 2017; Master et al., 2016, 2021). Some articles appeared to use partially overlapping datasets (e.g., Graham & Morales-Chicas, 2015; Harris, 2022; Morales-Chicas & Graham, 2021). All the studies were published between 2011 and 2023. On a descriptive level, the number of articles published increased each year with a maximum of 10 articles published in 2022. From the 46 articles, 76% of the studies were published as journal articles reported in academic journals (n = 35), 22% were dissertation studies (n = 10), and 2% were conference proceedings (n = 1). Seventy six percent of the studies (38 out of 50) were conducted in the U.S., 18% were conducted in Europe (Germany = 5; Belgium = 1; Sweden = 1, Turkey = 1; U.K. = 1), and 6% (3 out of 50) were multi-site studies conducted in the U.K. and U.S.

Eighty four percent of the studies (42 out of 50) used the term “sense of belonging,” and other studies used terms like “social belonging” (n = 3), “belonging” (n = 2), “sense of fit” (n = 1), “sense of acceptance” (n = 1), and “connectedness” (n = 1). All 50 studies measured other constructs along with sense of belonging (see Table S2 in supplemental materials for a full list of

other constructs). In terms of STEM fields, sense of belonging was measured in math (24%; 12 out of 50 studies), STEM (18%; *n* = 9), computer science (16%; *n* = 8), science (8%; *n* = 4), science, math, and engineering (6%; *n* = 3), science and math (4%; *n* = 2), physics (4%; *n* = 2), engineering and computer science (24%; *n* = 12), and chemistry (2%; *n* = 1).

All 50 studies adapted a correlational study design. Only 12 studies included longitudinal designs, ranging from one week to one year (with four additional studies including same-day pre-test and post-test designs; see Table S3). Although 39 studies included multiple ages/grade levels, only 16 studies included age or grade level in analyses (see Table S3). Out of the studies, 58% were conducted in-person (29 out of 50) either in classrooms (*n* = 23) or in other settings like labs or museums (*n* = 6), 38% were conducted remotely (*n* = 19), and one study used a combination of in-person and online data collection. Only one study did not provide details about its data collection modality.

Sample Characteristics

The current review includes 50 samples in K-12 schooling. Sample sizes ranged from 6 – 2,939, with a mean of 708 and median of 290. On an average, study authors reported that their samples were 44% girls, with the samples reporting 4% – 100% girl participants. Only one study explicitly reported that its sample consisted of gender non-conforming youth, which is also the study representing 4% of its sample as girls. Nine studies had a sample of 100% girls. Two studies did not provide any information about the sample's gender distribution (one of these studies was focused primarily on teachers and the other measured gender but did not report specific frequencies). The mean ages of the samples ranged from 11.60 – 15.56 years, with an average mean of about 13.99 years across studies. Twenty-three studies did not report a mean age for the sample and 30 studies did not report an age range for the sample. Eight studies included samples between ages 18 – 21, out of which two studies were conducted outside of the United

States. These studies were included in the review as the sample was enrolled in K-12 schools. Overall, the sample belonged to Grades 1 – 12. Thirteen studies included elementary school students, 28 studies included middle school students, and 29 studies included high school students. Six studies did not report grade levels of their sample and five of those six studies were conducted outside the United States. Out of 50 studies, 19 did not provide information on participants' race/ethnicity. Among the other studies, the percent of participants from racial/ethnic groups minoritized in STEM (including Black, Hispanic/Latine, Native American, and Pacific Islander) ranged from 3 – 100%, with an average of 37% minoritized participants. See Table S3 in the supplemental materials for more information on how study authors described their sample's race/ethnicity and SES levels.

Measure Characteristics

With respect to measurement, 84% of the studies (n = 42 out of 50) used a survey design to measure sense of belonging, 14% adapted an experimental study design (n = 7) using surveys, and one used a quasi-experimental design (n = 1 out of 50). As seen in Table S4 in the supplemental materials, 46 studies used one or more well-accepted measures of sense of belonging, with the most popular being C. Good et al.'s (2012) sense of belonging scale, which was used across 15 studies, followed by Mendoza-Denton et al.'s (2002) institutional belonging scale, which was used across six studies. For two studies, the authors developed their own scale and two other studies did not provide any information on whether the authors developed their own scale or adapted the items from an existing scale. Sixty four percent (n = 32) of the studies reported using a modified version of the original scale and 36% of the studies did not report any such information (n = 18). The number of items used to measure sense of belonging ranged from one to 30, with a median of six items. Another study measured stereotypes about whether girls belong in engineering, rather than girls' sense that they personally belonged (Burns & Rice,

2018). Three studies did not provide any information on the number of items or examples of items used in the study. A sample-based coefficient alpha was reported in 82% of the studies (*n* = 42). When this estimate was reported, it tended to be acceptable, ranging between .61 – .96 with 79% of the values ranging between .80 – .96.

Narrative Review of Study Findings and Characteristics

We also examined common research questions and findings of the systematic review studies. The most common research questions involved variables predicting belonging (70%, *n* = 35 out of 50), belonging predicting other variables (44%, *n* = 22 out of 50), or demographic characteristics and belonging, such as gender (78%, *n* = 39 out of 50), race/ethnicity (26%, *n* = 13 out of 50), or age/time (24%, *n* = 12 out of 50). The research questions of these studies were not mutually exclusive.

Factors Predicting Belonging. Overall, most studies (70%, *n* = 35) examined factors that predicted sense of belonging for students. The most commonly studied predictor (24% of all studies, *n* = 12) involved inclusive climates, including supportive teachers and peers (Cerda-Smith et al., 2023; Graham & Morales-Chicas, 2015; Hazell-O'Brien, 2023; Maloney & Matthews, 2020; Meadows, 2018; Meadows & Robinson, 2023; Mulvey et al., 2022; Sakiz, 2015; Sakiz et al., 2012; Steegh et al., 2021; Xavier Hall et al., 2022; Zhao et al., 2023). When students perceived that the STEM classroom social climate felt inclusive and that their peers and teachers cared about and supported them, they felt a greater sense of belonging in STEM. The second most studied predictor (18%, *n* = 9 studies within six articles) involved gender stereotypes. When girls themselves believed in gender stereotypes favoring boys (Ladewig et al., 2020; Master et al., 2016, 2021, 2023) or perceived that their social group believed in these stereotypes (Barth et al., 2022), they reported lower sense of belonging. One study also found that cues of stereotypes increased elementary school boys' belonging but did not affect girls (Wille et al., 2018). A third common predictor of belonging (12%, *n* = 6) involved gender representation, including the availability of role models and mentors (e.g., Kuchynka et al., 2022; Merritt, 2021;

O'Brien et al., 2017; Pietri et al., 2019). When girls or racially minoritized students were in STEM environments with students who shared their identity, they felt a greater sense of belonging (Brock, 2017; Graham & Morales-Chicas, 2015). A similarly common predictor of belonging (10%, *n* = 5) involved direct experiences with STEM, including after-school programs, hands-on STEM activities, summer camps, and elective courses (Burns & Rice, 2018; Fox, 2021; J. A. Good, 2018; Kuchynka et al., 2022; Milton et al., 2023). A few studies (6%, *n* = 3) examined how networks and opportunities for social connections supported belonging (Belanger et al., 2020; Dasgupta et al., 2022; Faircloth & Hamm, 2011). Other studies looked at how identity (Meadows, 2018; Meadows & Robinson, 2023), social skills (Hoffman et al., 2021), implicit attitudes (Reichardt et al., 2023), or intentions to pursue STEM (Xavier Hall et al., 2022) predicted belonging.

Belonging Predicting Other Factors. A second common research question of the studies involved examining how belonging predicted other important factors (44%, *n* = 22). This was most commonly examined (28% of all studies, *n* = 14) in the context of belonging as a predictor of motivation, including higher STEM self-efficacy/self-concepts as well as higher value/interest/relevance (Dasgupta et al., 2022; Hoffman et al., 2021; Ladewig et al., 2020, 2023; Maloney & Matthews, 2020; Master et al., 2016, 2021; Mulvey, McGuire, et al., 2023; Sakiz et al., 2012; Steegh et al., 2021; Tellhed et al., 2017; Zdawczyk & Varma, 2023). Several studies (6%, *n* = 3) also examined how higher sense of belonging predicted higher classroom engagement (Mulvey, Cerda-Smith, et al., 2023; Mulvey et al., 2022; Penuel et al., 2024), while others (6%, *n* = 3) found that it predicted higher learning and achievement (Barbieri & Miller-Cotto, 2021; Dasgupta et al., 2022; Harris, 2022). Other studies looked at how belonging predicted identity (Bonds, 2022), future intentions/persistence (Ito & McPherson, 2018), feelings of career preparation (Zhao et al., 2023), and activism orientation (Mulvey et al., 2022). In addition, some studies (16%, *n* = 8) looked at how belonging acted as a mediator between other variables (Beck, 2020; Dasgupta et al., 2022; Hoffman et al., 2021; Maloney & Matthews, 2020;

Master et al., 2016; Sakiz et al., 2012; Zhao et al., 2023).

Demographic Characteristics and Belonging. The majority of studies (78%, *n* = 39) included gender as a relevant factor, either by examining gender differences or by focusing on the experiences of girls specifically (e.g., an all-girls summer camp; Milton et al., 2023). Some studies (30%, *n* = 15) found significant gender differences in belonging, while others (34%, *n* = 17) did not. It should be noted that some studies that found no gender differences used samples who had self-selected into STEM environments, with students who may have already been motivated to participate in STEM (e.g., AP Computer Science classes, J. A. Good, 2018; science museums, Mulvey, Cerda-Smith, et al., 2023; Mulvey et al., 2022). Some studies included race/ethnicity as a relevant factor (26%, or 13 out of 50). Only four explicitly discussed intersectionality between race/ethnicity and gender (Dasgupta et al., 2022; Milton et al., 2023; Penuel et al., 2024; Pietri et al., 2019), although others did quantitatively examine effects of both race/ethnicity and gender (e.g., Morales-Chicas & Graham, 2021). Finally, some studies included analyses that incorporated age/grade level (32%, *n* = 16; Brock, 2017; Burns & Rice, 2018; Cerda-Smith et al., 2022; Faircloth & Hamm, 2011; Hoffman et al., 2021; Kuchynka et al., 2022; Maloney & Matthews, 2020; Master et al., 2021, 2023; Mulvey, Mathews, et al., 2022; Mulvey, McGuire et al., 2023; Mulvey, Cerda-Smith, et al., 2023; Reichardt et al., 2023; Sakiz, 2015; Steegh et al., 2021; Xavier Hall et al., 2022) or longitudinal analyses that spanned a week to a school year although most did not examine or reported little change in belonging; see Table S3 (24%, *n* = 12; Barbieri & Miller-Cotto, 2021; Brock, 2017; Dasgupta et al., 2022; Faircloth & Hamm, 2011; Fox, 2021; J. A. Good, 2018; Kuchynka et al., 2022; Ladewig et al., 2023; Maloney & Matthews, 2020; Milton et al., 2023; Wille et al., 2018; Zhao et al., 2023). One study examined longitudinal changes at the midway point and end of a four-week geoscience program and found that social belonging increased over time (Kuchynka et al., 2022).

Gender Differences in Sense of Belonging

We coded the systematic review studies for whether they reported information on gender

differences in STEM belonging (see Table 1). However, when interpreting gender differences, it is important to keep in mind that such differences do not reflect inherent or innate differences that should position boys as the normative group in STEM (Matthews et al., 2024). Rather, such differences are likely to reflect meaningful systemic differences in the socialization experiences of girls and boys that have the potential to be changed by targeting the external social environment of students (Leaper, 2015b). (For further discussion of how to change social cues, see the discussion section below.)

We examined whether studies in the systematic review reported an effect size for gender differences between girls and boys in STEM belonging; see Figure 2a and Table 1. Out of 50 studies, only eight (16%) reported a statistical effect size. An additional 14 (28%) provided sufficient information for us to calculate an effect size, leaving 28 studies (56%) with no information about effect sizes (although seven of these did report whether the effect of gender was statistically significant). Thus, almost half of the reviewed studies did not provide information about the size of gender differences. The analyses of these effect sizes in this section are descriptive, rather than statistical. The provided and calculated effect sizes suggested that gender differences were smaller in elementary school (with general effect sizes $0.05 < d < 1.13$; $M = 0.33$) and middle school ($0.04 < d < 0.50$; $M = 0.20$) compared to larger gender gaps in high school ($0.05 < d < 0.77$; $M = 0.54$). Among middle and high school students, math and science also tended to show smaller effects of gender (unweighted average *d*s = 0.29 and 0.04, respectively) compared to computer science and engineering (unweighted average *d*s = 0.40 and 0.77, respectively). However, effect sizes were not available for science for elementary or high school (only one effect size was available, for Grades 6-8), or for engineering for elementary or middle school (only one effect size was available, for Grade 12). One dataset reported intersectional effects suggesting that gender gaps in math belonging were larger for White and Latine students than for Black and Asian students (Graham & Morales-Chicas, 2015). The limited number of studies indicates that more comprehensive studies are needed to improve our

understanding of how and when gender gaps in STEM develop, especially in terms of intersections with race/ethnicity. These findings support the need for a mega-analysis across existing datasets that could fill in many of the gaps left by the systematic review.

Development of Belonging in STEM: A Mega-Analysis Across Five Studies

In this section, we report research from our lab on the development of belonging in STEM in K-12 education, including when gender gaps in belonging emerge and for which fields. To more precisely identify when gender gaps in STEM sense of belonging emerge, as well as potential between-field differences, we conducted a mega-analysis of five large quantitative studies from our research lab, including data from a total of 6,111 U.S. public school students in Grades 1-12 (50% White, 16% Black, 10% Multiracial, 7% Asian/Asian American, 2% other/missing, and 1% Native American; in addition, 38% were Hispanic/Latine); see Figure 2b and Table 2. Mega-analysis involves pooling raw data from multiple studies into a larger, single sample (Eisenhauer, 2021). Benefits of such analyses include increased statistical power to provide more generalizable, consistent findings and reduced likelihood of false positive results from small samples. Mega-analyses also offer advantages over meta-analyses because data processing can be done in a more homogenous way, removing a potential source of variance (Koile & Cristia, 2021). Datasets were selected for inclusion in the mega-analysis if they involved survey studies with measures of STEM belonging across more than one STEM field. One dataset overlapped with two studies included in the systematic review (Master et al., 2021, 2023). Although the specific items and scales used to measure belonging varied slightly across datasets, all variables reported here were on 6-point Likert scales, from 1 = *strongly disagree/really not [belong]* to 6 = *strongly agree/really [belong]*.

When and for Which STEM Fields are Gender Gaps in STEM Belonging Evident?

For each STEM field separately, we conducted t-tests to examine effects of gender overall, split by school level, and split by grade level; see Figure 2b for effect sizes and Figure 3 for distributions (see Table S5 for details). We also created a measure of overall STEM belonging

averaging across math, science, and computer science belonging for all elementary school students, and averaging across math, science, computer science, and engineering belonging for all middle and high school students. Across STEM fields overall, there was not a gender gap in elementary school (d = -0.003, p = .97, 95% CI [-0.16, 0.16]), but there were small gender gaps in both middle school (d = 0.32, p < .001, 95% CI [0.24, 0.39]) and high school (d = 0.35, p < .001, 95% CI [0.27, 0.42]) STEM belonging. Averaging across grade levels, gender gaps were small in computer science (d = 0.35, p < .001, 95% CI [0.30, 0.40]) and small to medium in engineering (d = 0.41, p < .001, 95% CI [0.35, 0.47]), with small but significant gaps for math (d = 0.14, p < .001, 95% CI [0.04, 0.19]) and science (d = 0.07, p = .01, 95% CI [0.02, 0.13]). However, gender gaps differed by both grade level and STEM field. Beginning in Grade 6 and in all subsequent grades, girls reported a lower sense of belonging than boys in computer science, ds = 0.24 to 0.46, ps ≤ .021, 95% CIs [0.04, 0.59], and engineering, ds = 0.28 to 0.67, ps < .001, 95% CIs [0.16, 0.95]. Findings for math and science, however, were less consistent. Boys reported a higher sense of belonging than girls in science only in Grades 6, 8, and 9, ds = 0.17 to 0.26, ps ≤ .028, 95% CIs [0.02, 0.41], and reported a higher sense of belonging than girls in math only in Grades 6, 7, 9, and 10, ds = 0.14 to 0.24, ps ≤ .029, 95% CIs [0.02, 0.37]. Girls reported a higher sense of belonging than boys in math in Grade 2, d = -0.37, p = .047, 95% CI [-0.74, -0.006]. In all other grades, girls' and boys' sense of belonging in math and science did not differ significantly, ds = -0.16 to 0.26, ps > .10, 95% CIs [-0.50, 0.64], suggesting that middle school may be a particularly sensitive time for math and science belonging. These findings suggest that computer science and engineering show robust gender differences in sense of belonging starting in middle school, but this pattern does not necessarily generalize to other STEM domains.

Intersectionality in STEM Belonging

The large sample size of the mega-analysis afforded follow-up analyses examining intersectionality. We included participants who identified as girls or boys, and who were Hispanic/Latine (n = 2,245), White (n = 1,890), Black (n = 898), or Asian (n = 461), to represent

the four largest racial/ethnic groups in the U.S. For each STEM field separately, we conducted an ANOVA with gender, race/ethnicity, and school level (elementary or Grades 1-5, middle or Grades 6-8, and high school or Grades 9-12) as fixed factors (see Tables 3 and S6-S8 for details). We used school level rather than grade level to compare developmental trends with adequate cell sizes. The interactions between gender and race/ethnicity were not significant for any STEM field, ps > .48, n_p^2s ≤ 0.001, nor were the three-way interactions between gender, race/ethnicity, and school level significant, ps > .21, n_p^2s ≤ 0.001 (Table 3).

We next looked at main effects as well as simple effects of gender by race/ethnicity and school level (Table S7). We report main effects of race/ethnicity for completeness, but we again urge caution in interpreting differences between groups, because such differences do not reflect inherent or innate differences that should position Asian or White students as the normative groups in STEM (Matthews et al., 2024). For *math*, boys reported higher belonging than girls on average, p = .002, 95% CI [0.06, 0.28]; Asian students reported higher belonging than other racial/ethnic groups on average, ps ≤ .04, 95% CIs [0.004, 0.49]; and high school students reported lower belonging than other school levels, ps ≤ .001, 95% CIs [-0.42, -0.12]. Looking at simple effects of gender (Table S8), the gender gap in math belonging was only significant for Hispanic/Latine students in middle school, d = 0.22, p < .001, 95% CI [0.09, 0.34], and high school, d = 0.18, p = .004, 95% CI [0.06, 0.31]. For *science*, high school students reported lower belonging than middle school students, p < .001, 95% CI [0.00, 0.26]. Looking at simple effects, the gender gap in science belonging was only significant for Hispanic/Latine students in middle school, d = 0.20, p = .006, 95% CI [0.06, 0.34]. For *computer science*, boys reported higher belonging than girls on average, p < .001, 95% CI [0.25, 0.49]; Asian students reported higher belonging than other racial/ethnic groups on average, ps < .022, 95% CIs [0.03, 0.65]; White students reported higher belonging than Black and Hispanic/Latine students, ps < .01, 95% CIs [0.04, 0.40]; and elementary school students reported higher belonging than middle school students, p < .001, 95% CI [0.75, 1.08], who in turn reported higher belonging than high school

students, $p < .001$, 95% CI [0.08, 0.27]. Looking at simple effects, the gender gap in computer science belonging was significant for Black (*d*s = 0.27 to 0.50), Hispanic/Latine (*d*s= 0.35 to 0.36), and White (*d*s= 0.38 to 0.44) students in middle and high school, *p*s < .005, 95% CIs [0.06, 0.72], as well as Asian students in high school, $p = .01$, $d = 0.36$, 95% CI [0.09, 0.63]. For *engineering*, boys reported higher belonging than girls on average, $p < .001$, 95% CI [0.43, 0.67]; Asian and White students reported higher belonging than Black and Hispanic/Latine students, *p*s < .001, 95% CIs [0.19, 0.64]; and middle school students reported higher belonging than high school students, $p = .009$, 95% CI [0.04, 0.27] (no data was available for elementary school). Looking at simple effects, the gender gap in engineering belonging was significant for Hispanic/Latine (*d*s = 0.35 - 0.47, 95% CIs [0.21, 0.61]) and White (*d*s = 0.40 - 0.54, 95% CIs [0.24, 0.72]) students in middle and high school, *p*s < .001, as well as Black ($d = 0.61$, $p < .001$, 95% CI [0.38, 0.85]) and Asian ($d = 0.54$, $p = .004$, 95% CI [0.20, 0.88]) students in high school, *p*s < .005.

These analyses did not show meaningful overall differences in gender gaps in STEM belonging between racial/ethnic groups. However, these findings also suggest that girls with some intersectional identities may be particularly vulnerable to lower belonging in STEM. In particular, Hispanic/Latina girls in middle school reported lower belonging than Hispanic/Latino boys across all four STEM fields (as well as high school for all fields except science). Black, Asian, and White girls in secondary school also reported lower belonging than boys in computer science and engineering.

Discussion

Belonging matters for STEM motivation and persistence, yet many girls report lower feelings of belonging than many boys in STEM. As shown by our systematic review and mega-analysis, these differences are especially pronounced when students reach middle and high school and in STEM fields like computer science and engineering. In this discussion, we summarize developmental findings and their implications for educators and parents. We then highlight

important directions for future research, including conceptual and methodological improvements, further attention to intersectionality, and promising approaches for interventions to support belonging.

The take-home message from this integrative review is that gender disparities represent a significant concern in the development of sense of belonging, which also varies according to age and specific STEM fields. Although there are notable differences between STEM fields (Master, Meltzoff, et al., 2025; Miller et al., 2024), only six studies (12%) from our systematic review directly compared different STEM fields (Burns & Rice, 2018; Hazell-O'Brien, 2023; Master et al., 2021; Seigworth, 2017; Veldman et al., 2021; Xavier Hall et al., 2022). More work is required directly comparing girls' sense of belonging in different STEM fields. In addition, feeling a lack of belonging can disproportionately affect those with marginalized identities based on gender and race/ethnicity (e.g., Hispanic/Latina girls). However, only 13 studies (26%) in the current systematic review included race/ethnicity, with only four that explicitly discussed the intersections of gender and race, and only one study that explicitly looked at gender-nonconforming students. Research on general school belonging with minoritized students is similarly lacking (e.g., Hispanic/Latine students; F. López et al., 2025). Future research should look at sense of belonging with attention to gender, race/ethnicity, and further intersectionality issues (e.g., generational immigration status or heritage language for Hispanic/Latine students; nonbinary or transgender students; S. Rodriguez et al., 2025). Similarly, more research with international samples outside the U.S. is also needed, as only 16% of studies in the systematic review surveyed students outside the U.S. and the U.K. General school belonging varies extensively across countries (Organisation for Economic Co-operation and Development [OECD], 2023), and more research is needed to examine variations in STEM belonging between and within countries as well. The systematic review also revealed strong links between sense of belonging and other motivational variables. For example, if students feel a high sense of belonging, they are likely to feel more competent, interested, and attach a greater value to STEM

subjects and fields. Underlying all that, an inclusive classroom climate and strong support from teachers and peers directly predict students' sense of belonging. Thus, sense of belonging is embedded within many meaningful internal (e.g., motivation) and external (e.g., classroom environment) elements. Researchers can leverage these relations to further explore this topic.

The systematic review and mega-analysis both indicated that belonging is a dynamic feeling that differs by age and context (e.g., including specific STEM domains and classes). Deeper knowledge can ultimately help investigators and practitioners develop more effective interventions for increasing perceptions of belonging. First, in terms of age, the mega-analysis showed that high school students on average reported lower belonging compared to younger students across math, science, computer science, and engineering, with similar findings from the systematic review. However, there were few longitudinal studies in the sample, with most spanning a short period of time and finding little change in belonging. More long-term longitudinal studies are needed to examine how belonging changes within individuals over time and why, and whether such patterns match the cross-sectional findings of the systematic review and mega-analysis. While cross-sectional data can provide initial insights into how belonging might change across development, these analyses are based on individual differences that could vary by cohort. In contrast, longitudinal studies would provide evidence of intraindividual change. Another useful design for future studies could be cohort-sequential (or accelerated longitudinal) studies, which capture a wider range of grade levels in a shorter time period than traditional longitudinal designs (Estrada & Ferrer, 2019). The "cohorts" of grade levels can then be combined into a single sample to model a common developmental trajectory.

Second, in terms of context, developmental declines in STEM belonging were not identical across fields. Looking at the distributions of belonging (Figure 3), declines in girls' sense of belonging were sharpest in computer science (and could have been for engineering, although less data was available). Even though girls' belonging in math and science declined through high school, their average belonging remained on the positive side of the scale,

suggesting a slight positive sense of belonging. In contrast, girls' average belonging in computer science and engineering ranged from neutral to slightly negative by high school, indicating uncertainty or a slight sense that they did not belong in these fields.

Also in terms of age, the mega-analysis indicated that middle school (around Grades 6-9) was the school level in which gender gaps in most fields first became significant (although there was no data for elementary school engineering). However, there was a lack of consistency across the systematic review and mega-analysis in terms of the size of gender gaps during middle school. The systematic review found smaller gaps during middle school compared to elementary school, while the mega-analysis found larger gaps in middle school than elementary school. One explanation for this discrepancy may be the lack of available effect sizes involving engineering belonging in the systematic review. Data from the mega-analysis indicated that gender gaps are likely to be larger for engineering belonging than math or science during middle school.

What did the results indicate about STEM belonging for students in elementary school? First, more research is needed. Only 26% of studies (13) in the systematic review included elementary school students, and nine out of those studies included only students in Grades 4 or 5. Another discrepancy between the systematic review and the mega-analysis involved the magnitude of gender gaps in computer science in elementary school (i.e., Grades 3 and 4), with larger effect sizes found by the systematic review. This discrepancy may be due to the context in which belonging was measured in the systematic review studies, which varied across studies. Second, improving measures of belonging for children is also needed: some of the lowest reliabilities in the systematic review came from the studies that included elementary school students (including four studies with alpha < .70). What does it mean for a child to feel that they belong in a class or a field, compared to a school? Do children have a good enough understanding of STEM fields and professions to accurately respond? How do children interpret questions about belonging? While some qualitative researchers have begun to examine adolescents' STEM belonging through interviews (Adams-Wiggins et al., 2020; Burgin et al., 2015; Green et al.,

2016; Mroczkowski et al., 2022; Vossen et al., 2023), more work is needed with children. Finally, in terms of gender gaps in elementary school, the mega-analysis found only one significant gap across math, science, and computer science, which favored girls in Grade 2 in math. This suggests that elementary school may be a time when girls feel a positive sense of belonging in STEM, including in computer science.

What are the implications of these developmental trajectories in STEM belonging for educators and parents? Because high school students on average reported lower belonging compared to younger students, efforts are particularly needed among high school STEM educators in formal and informal settings to provide greater cues to belonging for all their students. Formal and informal high school educators, especially in computer science and engineering, need targeted efforts to build a positive sense of belonging for girls, so that they enter college with the sense that they would belong in computer science and engineering college courses and majors. In addition, high school girls' sense of belonging in computer science and engineering may be particularly low due to a lack of experience in these types of classes. This indicates the importance of policy changes to (a) increase access to foundational computer science and engineering courses, and (b) require mandatory STEM electives, which would ensure that gender representation is more balanced in these courses (Master, Alexander, et al., 2025). In addition, cross-cultural studies comparing STEM education policies and the development of STEM belonging could help provide insights into effective policies and systems (Hoffman et al., 2021; Mulvey, McGuire, et al., 2023). Creating an inclusive and welcoming classroom environment in engineering and computer science is crucial for attracting and retaining young women.

In addition, middle school may be the beginning of a vulnerable period for girls. One goal of middle school STEM educators should be to pay careful attention to the cues and messages that they send to students (particularly to girls and most especially to girls of color) about whether they are valued and fit in within STEM classes. Providing students with opportunities to

belong (also known as “belonging affordances”) may be particularly important for middle school educators (Kroeper et al., 2025). For example, conducting hands-on STEM projects and student-led exploration and investigation could be beneficial for middle school girls to engage with STEM, increase interest, and feel a greater sense of belonging (Milton et al., 2023). We discuss cues and messages that might improve belonging in more detail in the section below. Even before middle school, parents may be able to help girls build a positive sense of identity in STEM by capitalizing on elementary school children’s positive sense of belonging in STEM, encouraging them to enroll in STEM afterschool programs and summer camps every year with friends. Addressing gender disparities in STEM requires efforts to encourage girls to pursue STEM subjects from an early age.

In the next section, we discuss gaps in the current literature and important directions for future research.

Recommendations for Future Research

Theoretical and Empirical Clarity

First, although belonging is considered a fundamental human need, our field lacks sufficient attention to the theoretical clarity of the construct of belonging in STEM, particularly for children and adolescents. How is belonging theoretically and empirically related to and distinct from other concepts such as belongingness, belonging uncertainty, mattering, or identity in STEM (K. A. Allen et al., 2021; Meadows & Robinson, 2023)? For example, belonging and identity in STEM have often been used interchangeably in their definition or measurement (Voelkl, 1996). Disciplinary identity in STEM (e.g., “I am a STEM person”) has been argued to involve interest, competence/performance, and recognition in a STEM domain (Carlone, 2017; Carlone & Johnson, 2007). Some researchers have defined identity as also including belonging (Blunt & Pearson, 2021; Boyer et al., 2010), refer to belonging as a precursor to identity (Hazari et al., 2020; Liu et al., 2023), or argue that a strong identity can increase sense of belonging (Chen et al., 2021; Hughes et al., 2021; Wu et al., 2024). It is important for quantitative research to examine

precursors and consequences of both belonging and STEM identity and whether those differ by age (using cross-sectional and longitudinal studies) and demographic groups. There is a need for quantitative research to clarify both psychometric *coherence* (does belonging cohere with the other subcomponents of identity?) and predictive *validity* (does belonging in combination with other components of identity predict outcomes in different ways?). Adolescents may identify themselves with a STEM field based on their self-perceptions of academic competence (Pérez et al., 2014); however, they may not feel they socially fit in STEM fields or belong to the STEM community. One goal of this review is to help bring attention to the theoretical and empirical gaps in this literature.

Improved Measurement

Second, there is a strong need to develop more consistent and standardized measures to assess belonging in STEM, especially with elementary and middle school students. Several different instruments have been used to assess belonging in academic contexts, including STEM (see Table S4), where our systematic review found that instruments are often adapted from scales used to measure institutional belonging and/or created for college students (C. Good et al., 2012; Mendoza-Denton et al., 2002). Belonging to an institution may be related to the support and opportunities an individual experiences from others in the environment (Kroeper et al., 2025). However, academic belonging is not only connected to social acceptance, but also how successfully a student completes academic tasks. In addition, previous scales often show lower reliability among elementary or middle school students. Therefore, the scales measuring belonging in STEM should be precise and consistent with the context, and developmentally appropriate. Researchers interested in adapting previous belonging scales should carefully examine the measures listed in Table S4 to assess their suitability. In addition, researchers should consider other ways to examine belonging. Along with variable-centered studies, person-centered approaches can help researchers to better understand experiences of belonging in diverse populations within and across STEM fields.

Attention to Intersectionality

Third, more studies are needed that address the intersectionality of gender and race for sense of belonging in K-12 STEM contexts. Few studies have focused on the belonging of girls of color in STEM (for exceptions, see Milton et al., 2023; Pietri et al., 2019), but our mega-analysis suggests that specific groups like Hispanic/Latina girls may be particularly sensitive to issues of belonging, especially when they reach middle school. There is great need to further explore how racially/ethnically minoritized students experience belonging in STEM, especially for children and adolescents (Lewis et al., 2016). These experiences may also vary based on nationality and cultural context; for example, Black American and Black British students may have different experiences with belonging and inclusion (Mulvey, McGuire, et al., 2023). It is also important to expand our understanding of how gender identity (including nonbinary identity) intersects with other identities, especially for multiple stigmatized identities (e.g., girls who are Hispanic/Latina, Black, first-generation immigrants, on pathways to becoming first-generation college students, and/or LGBTQ). How can educators and researchers help create STEM learning environments that foster belonging, creativity, and innovation for girls and nonbinary students of color (L. C. Mims et al., 2022; L. Mims et al., 2024)? Initiatives like Black Girls Code aim to equip girls of color, specifically Black girls, with programming skills to increase their sense of belonging in computer science (Black Girls Code, 2023). Researcher-practitioner partnerships with such organizations could be valuable in understanding how best to leverage Hispanic/Latina and Black girls' assets, cultural capital, and creativity in STEM.

Experimental Studies and Interventions to Support Belonging

Fourth, more research with experimental methods to increase girls' sense of belonging in STEM is needed. Although gender gaps in STEM belonging may exist for adolescents, they are not set in stone. The systematic review demonstrated that research on K-12 students' sense of belonging in STEM is limited, with experimental studies particularly rare (only 7 of 50 studies, three of which were from our research lab). However, most of these studies showed that children

and adolescents' sense of belonging in STEM is sensitive to cues from the social environment. In this section, we describe these experimental studies, which suggest key mechanisms that educators can leverage to improve girls' sense of belonging in STEM, including environmental cues, gender stereotypes, and gender representation.

Environmental Cues. Many STEM contexts have "masculine defaults" that are evident through ideas, institutions, interactions, and individuals (Garr-Schultz et al., 2023). Messages and stereotypes about who belongs in a setting can be transmitted not just from people, but also from the environmental context. For example, two of the experimental studies from the systematic review examined effects of changing the decorations in a computer science from stereotypically "geeky" (with soda cans, Star Trek and Star Wars posters, and messy electronic equipment) to non-stereotypical (with water bottles, art and nature posters, and magazines; Master et al., 2016). High school girls felt a significantly greater sense of belonging in the computer science course in a non-stereotypical classroom compared to a stereotypical classroom or a baseline condition. Gender gaps at baseline or in stereotypical environments disappeared for the non-stereotypical classroom. Another experimental study from the systematic review looked at how different types of programming language environments affected belonging for upper elementary and middle school students (Zdawczyk & Varma, 2023). However, programming language did not impact girls' sense of belonging, which was lower than boys when they were shown either Python or no visual programming environment (both girls and boys reported a low sense of belonging when Scratch was shown).

Gender Stereotypes. Gender stereotypes may also impact girls' sense of belonging in STEM. If stereotypes of the typical person in a domain do not match students' identities, they may believe that they will not fit in or belong there. Such stereotypes associating engineering and computer sciences with masculine traits often discourage girls from pursuing these STEM fields. Therefore, beliefs that STEM is for boys can cause girls to have less involvement in STEM, which furthers the gender gap in STEM education and careers. Negative stereotypes are also

reinforced when parents, teachers, and peers are less supportive of girls pursuing STEM, and make it more difficult for girls to see themselves as belonging in STEM fields (Starr & Simpkins, 2021). One of the experimental studies from the systematic review examined elementary school students' sense of belonging for computer science activities linked to a gender stereotype ("boys are more interested in this activity than girls") or not (Master et al., 2021). Girls felt a significantly greater sense of belonging for a non-stereotyped activity compared to a stereotyped activity. Gender gaps for the stereotyped activity disappeared when the activity was not stereotyped. A similar study published after our systematic review was conducted found the same pattern for enrollment in computer science classes: gender stereotypes reduced belonging in the class for middle school girls but not boys (Master, Alexander, et al., 2025). Another study from the systematic review looked at how salient gender stereotypes in television shows affected elementary school children's sense of belonging (Wille et al., 2018). In that study, the stereotype boosted boys' sense of belonging but did not impact girls.

Gender representation. Another environmental cue that impacts belonging may be numeric representation and the availability of role models. One experimental study (published after our systematic review was conducted) examined middle school girls' sense of belonging in computer science classes in which girls were unequally represented at 20% or equally represented at 50% of students (Master, Alexander, et al., 2025). Unsurprisingly, girls felt significantly lower belonging in the unequal representation class compared to the equal representation class. The gender gap in belonging in the unequal class disappeared for the class with equal representation. To counter the effects of underrepresentation, it may be important to provide girls with similar role models in STEM (Thiem & Dasgupta, 2022). One experimental study from our systematic review found that writing about a favorite role model from a one-day workshop increased girls' sense of fit in science (O'Brien et al., 2017). However, the effectiveness of role models depends on many complex factors. Another experimental study from our systematic review found that framing the achievements of a Black woman scientist as the result of hard work or natural

brilliance had no effect on middle school girls' sense of belonging in science (Merritt, 2021). Providing positive mentorship and support networks in STEM may help girls to overcome identity threats and see themselves as able to succeed in STEM education and careers.

In this section, we reviewed experimental studies demonstrating that girls' sense of belonging in STEM can be sensitive to the environment around them. These are encouraging findings for STEM educators who are concerned about girls' sense of belonging in their programs. By paying attention to cues and messages about who is interested and valued in that environment, educators can create welcoming spaces. Individual differences and STEM contexts play central roles in shaping belonging; hence, interventions combining personal, social, and environmental cues might be helpful to enhance belonging among girls. However, more work is needed.

Conclusions

The research reviewed in this article highlights the supportive role that sense of belonging can play in motivating girls to enter STEM courses and careers. As shown by the systematic review, belonging is a key motivational belief that supports students' academic choices and outcomes. However, girls report feeling a lower sense of belonging than boys in some STEM fields (especially computer science and engineering), at certain ages (especially middle school and high school), and potentially in some specific intersectional groups (especially Hispanic/Latina girls). Importantly, sense of belonging is malleable. Many environmental cues and messages can send girls the message that they do belong and they can succeed in STEM. Teachers, parents, and other STEM stakeholders can work together to improve girls' sense of belonging. Our goal is to have more girls report a strong sense of belonging in their STEM courses, like the middle school girl who told us that when it came to her computer science class, "I felt like I completely belonged in that class. It was an amazing class and I felt perfectly included." However, more research is still needed to fully understand the development and role of belonging throughout childhood and adolescence. Efforts to improve girls' belonging can

improve their experiences and persistence in STEM.

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Table 1

Systematic Review Studies and Effect Sizes for Gender

Author(s) and year	Sample size	Percent girls	Grade level	STEM field	Effect size of gender
Barbieri & Miller-Cotto (2021)	206	50	Middle school Algebra I classrooms (mostly Grade 8)	Math	NA
Barth et al. (2022)	110	100	9-10	Science	NA
Beck (2020)	168	39	9	Computer science	NA
Belanger et al. (2020)	110	100	7-8	STEM (general)	NA
Bonds (2022)	34	100	8	Technology, engineering	NA
Brock (2017) - Pilot	60	57	5 & 7	Math	Not significant
Brock (2017)	461	53	4-12	Math	0.39
Brock (2017) subsample	181	55	5-8	Math	0.24
Burns & Rice (2018)	217	53	6-8	Engineering	NA
Cerda-Smith et al. (2023)	412	50	9-12	STEM (general)	NA
Dasgupta et al. (2022)	2,939	75	8	Math	0.15*
Faircloth & Hamm (2011)	468	58	6-7	Math	Not significant
Fox (2021)	6	50	8	Computer science	0.1*
J. A. Good (2018)	263	30	9-12	Computer science	0.45*
Graham & Morales-Chicas (2015)	2,265	55	9	Math	Black students: 0.05-0.24* Asian students: 0.02-0.08* Latine students: 0.24-0.26* White students: 0.30-0.40*
Harris (2022)	2,726	54	9	Math	Same dataset as Graham & Morales-Chicas (2015)
Hazell-O'Brien (2023)	73	100	7-8	Science, math	NA
Hoffman et al. (2021)	268	67	Adolescents	STEM (general)	Not significant
Ito & McPherson (2018)	127	42	High school	Physical science, technology, engineering, math	Social belonging: 0.41* Ability belonging: 0.59*
Kuchynka et al. (2022)	T1: 98, T2: 95, T3: 88	43	High school	Geoscience	NA
Ladewig et al. (2020)	282	30	NA	Physics	0.41
Ladewig et al. (2023)	298	28	NA	Physics	0.15*
Maloney & Matthews (2020)	321	NA	5-9	Math	NA
Master et al. (2016)	165	47	9-12	Computer science	0.68
Master et al. (2016)	104	46	9-12	Computer science	0.71
Master et al. (2021) Study 1	733	48	3-7	Computer science	0.09*
Master et al. (2021) Study 2	1544	47	1-12	Computer science	0.25*
Master et al. (2021)	125	49	3-4?	Computer science	Stereotypical

Study 4					condition: 1.13* Nonstereotypical condition: -0.32*
Master et al. (2023)	363	50	1-3	Computer coding classes and activities	Not significant
Meadows (2018)	337	57	7	STEM (general)	0.14*
Meadows & Robinson (2023)	763	53	7	STEM (general)	0.11*
Merritt (2021)	150	100	Middle school	Science	NA
Milton et al. (2023)	59	100	6-9	STEM (general)	NA
Morales-Chicas & Graham (2021)	2,938	54	9	Math	Significant
Mulvey et al. (2022)	523	49	9-12	STEM (general)	NA
Mulvey, McGuire, et al. (2023)	467	67	NA	STEM (general)	NA
Mulvey, Cerda- Smith, et al. (2023)	852	48	9-10	STEM (general)	NA
O'Brien et al. (2017)	175	100	5-8	Science	NA
Penuel et al. (2024)	9,725	52	Middle school	Science	0.04*
Pietri et al. (2019)	55	100	9-12	Science	NA
Reichardt et al. (2023)	517	63	5-12?	Math, STEM (general)	Math: 0.26 STEM: 0.45
Sakiz (2015)	138	49	4, 5	Science	Not significant
Sakiz et al. (2012)	317	60	7, 8	Math	NA
Seigworth (2017)	36	64	8-12	Math, science, engineering	Item 3: -0.25* Item 5: -0.13*
Steegh et al. (2021)	445	51	7-13	Chemistry	NA
Tellhed et al. (2017)	1,327	51	12	Engineering, computer programming	0.77
Veldman et al. (2021)	336	100	11	Biological sciences, math and natural sciences, technological, physical, and computer sciences	NA
Wille et al. (2018)	335	49	5	Math	0.05
Xavier Hall et al. (2022)	539	4	Pre-college (high school?)	Math, science	Math: significant Science: not significant
Zdawczyk & Varma (2023)	187	NA	5-8	Computer science	No visual: 0.50* Python: 0.51* Scratch: 0.08*
Zhao et al. (2023)	209	70	NA	STEM (general)	Not significant

Note. Grade levels with question marks are inferred from age ranges. For information about race/ethnicity of participants, see Table S3. Effect sizes for gender are provided in the context of each paper as relevant, including specific groups of participants (e.g., divided by race/ethnicity) and STEM field. *Effect size calculated from means and standard deviations.

Table 2
Mega-Analysis Datasets

Study Name	*Beliefs about STEM (Time 1)*	*Resist 2020*	*Resist Racism*	*Equity*	*Positive Beliefs*
Date Collected	1/2019-3/2019	10/2020	Fall 2021	Fall 2021	Fall 2021
Method	Online surveys in classrooms	Online surveys through CLRN	Online surveys through CLRN	Online surveys through CLRN	Online surveys through CLRN
N	1847	1487	1150	551	1495
***n* per Grade Level**	127 Grade 1 121 Grade 2 132 Grade 3 112 Grade 4 138 Grade 5 181 Grade 6 173 Grade 7 211 Grade 8 176 Grade 9 156 Grade 10 156 Grade 11 164 Grade 12	207 Grade 6 210 Grade 7 217 Grade 8 219 Grade 9 215 Grade 10 209 Grade 11 203 Grade 12	289 Grade 7 289 Grade 8 283 Grade 9 289 Grade 10	279 Grade 6 272 Grade 7	371 Grade 7 379 Grade 8 374 Grade 9 371 Grade 10
Gender	49% girls, 51% boys	52% girls, 48% boys	51% girls, 49% boys	46% girls, 54% boys	50% girls, 50% boys
Race/ Ethnicity	37% White, 24% Latine, 8% Black, 9% Asian, 22% Other/ Multiracial	33% White, 30% Latine, 15% Black, 6% Asian, 16% Other/ Multiracial	22% White, 43% Latine, 15% Black, 7% Asian, 13% Other/ Multiracial	8% White, 56% Latine, 17% Black, 7% Asian, 12% Other/ Multiracial	27% White, 37% Latine, 18% Black, 6% Asian, 12% Other/ Multiracial
Academic Fields Included	Math, science, computer	Math, science, coding, engineering, language arts	Math, science, coding, engineering	Math, science, coding, engineering	Math, coding, engineering, language arts
Geographic Location	Suburban, Rhode Island, U.S.	Urban/ suburban, Southeast U.S.	Urban/ suburban, Southeast U.S.	Urban/ suburban, Southeast U.S.	Urban/ suburban, Midwest and Southeast U.S.
SES	43% eligible for FRL	38% eligible for FRL	35% eligible for FRL	50% eligible for FRL	35% eligible for FRL
Belonging Measure	"I feel like I belong in my [math] class" "I feel comfortable in my [math class]" "People in my [math] class are a lot like me"	"How much do you feel like you belong when you do these classes and activities at school?" "How comfortable do you feel when	"How much do you feel like you belong when you do these classes and activities in school?" "How comfortable do you feel when	"How much do you feel like you belong when you do these classes and activities in school?" "How comfortable do you feel when	"How much do you feel like you belong when you do these classes and activities in school?" "How comfortable do you feel when

		you do these classes and activities at school?" "How much do you feel like people in these classes and activities are similar to you?"	you do these classes and activities in school?" "How much do you think people in these classes and activities in school are similar to you?"	you do these classes and activities in school?" "How much do you think people in these classes and activities in school are similar to you?"	you do these classes and activities in school?" "How much do you think people in these classes and activities in school are similar to you?"
Reliability of STEM Belonging	Math α = .75; science α = .74; computer α = .71	Math α = .80, science α = .79, coding α = .84, engineering α = .86	Math α = .84, science α = .80, coding α = .90, engineering α = .92	Math α = .82, science α = .79, coding α = .88, engineering α = .89	Math α = .85, coding α = .91, engineering α = .90
Previous Publications using Dataset	Master et al., 2021, 2023; Master, Meltzoff, et al., 2025; Sriutaisuk et al., 2025; Tang et al., 2024	Master, Meltzoff, et al., 2025; Sriutaisuk et al., 2025		Master, Roy, et al., 2025	

Note. SES = socioeconomic status. FRL = free/reduced-price lunch (based on district average for Beliefs about STEM dataset and based on specific sample for other datasets). CLRN = Character Lab Research Network. Students who did not identify as girls or boys were excluded. Students in the Resist 2020, Resist Racism, Equity, and most students in the Positive Beliefs dataset were from the same large school district.

Table 3

Mega-Analysis Intersectionality Analyses

Predictor	*df*	*F*	*p*	n_p^2
Math (*n* = 5,105)				
Gender	1	10.09	.002	.002
Race/Ethnicity	3	4.07	.007	.002
School Level	2	17.71	<.001	.007
Gender × Race/Ethnicity	3	0.68	.57	.000
Gender × School Level	2	0.01	.99	.000
Race/Ethnicity × School Level	6	1.42	.20	.002
Gender × Race/Ethnicity × School Level	6	0.37	.90	.000
Science (*n* = 4,043)				
Gender	1	0.35	.55	.000
Race/Ethnicity	3	1.53	.21	.001
School Level	2	7.99	<.001	.004
Gender × Race/Ethnicity	3	0.24	.87	.000
Gender × School Level	2	1.44	.24	.001
Race/Ethnicity × School Level	6	1.45	.19	.002
Gender × Race/Ethnicity × School Level	6	0.31	.93	.000
Computer Science (*n* = 5,023)				
Gender	1	35.73	<.001	.007
Race/Ethnicity	3	7.84	<.001	.005
School Level	2	80.19	<.001	.031
Gender × Race/Ethnicity	3	0.23	.88	.000
Gender × School Level	2	4.08	.02	.002
Race/Ethnicity × School Level	6	3.14	.005	.004
Gender × Race/Ethnicity × School Level	6	0.42	.87	.001
Engineering (*n* = 3,586)				
Gender	1	84.83	<.001	.023
Race/Ethnicity	3	15.34	<.001	.013
School Level	1	6.90	.009	.002
Gender × Race/Ethnicity	3	0.81	.49	.001
Gender × School Level	1	11.51	<.001	.003
Race/Ethnicity × School Level	3	1.00	.39	.001
Gender × Race/Ethnicity × School Level	3	1.49	.22	.001

Note. Gender included only students who identified as girls or boys. Race/ethnicity included only White, Hispanic/Latine, Black, and Asian participants. School level was coded as elementary, middle, or high school. For engineering analyses, school level included only middle and high school.

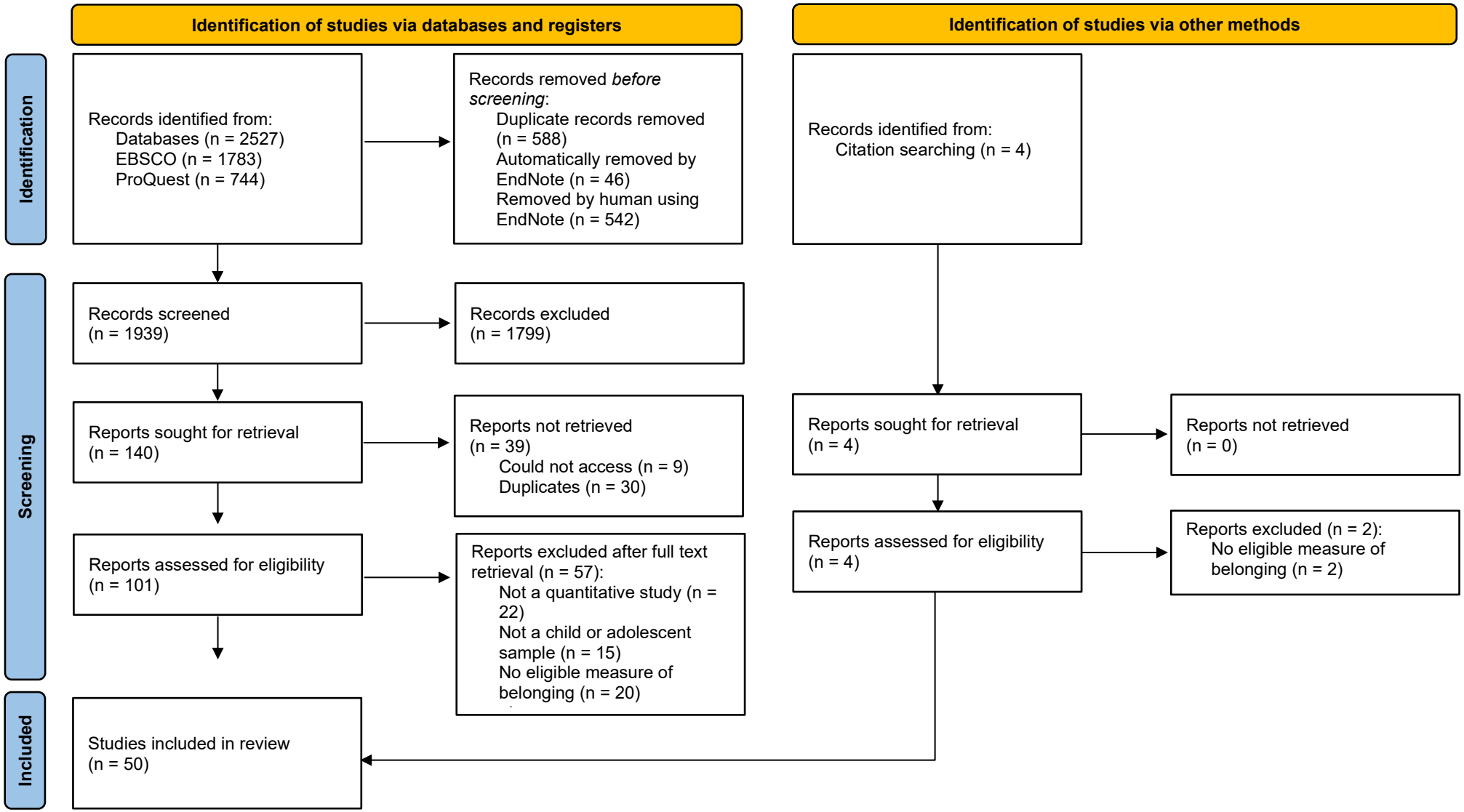
Table 4
Main Points

Key Take-Away	Supported by Systematic Review?	Supported by Mega-Analysis?
Belonging predicts motivation and learning.	Yes	Not examined
Social cues and experiences predict belonging.	Yes	Not examined
STEM belonging decreases as students get older.	Limited cross-sectional or longitudinal evidence	Yes
When do gender gaps begin?	Inconclusive	Middle School
When are gender gaps largest?	High School	Middle and High School
Computer science and engineering show the largest gender gaps.	Yes*	Yes
Intersectional identities matter: gender gaps are often larger for Hispanic/Latine and Black girls.	Inconclusive	Yes
More research is needed.	Yes	Yes

Note. *Few studies in the systematic review directly compared fields.

Figure 1

PRISMA 2020 Flow Diagram for Systematic Review

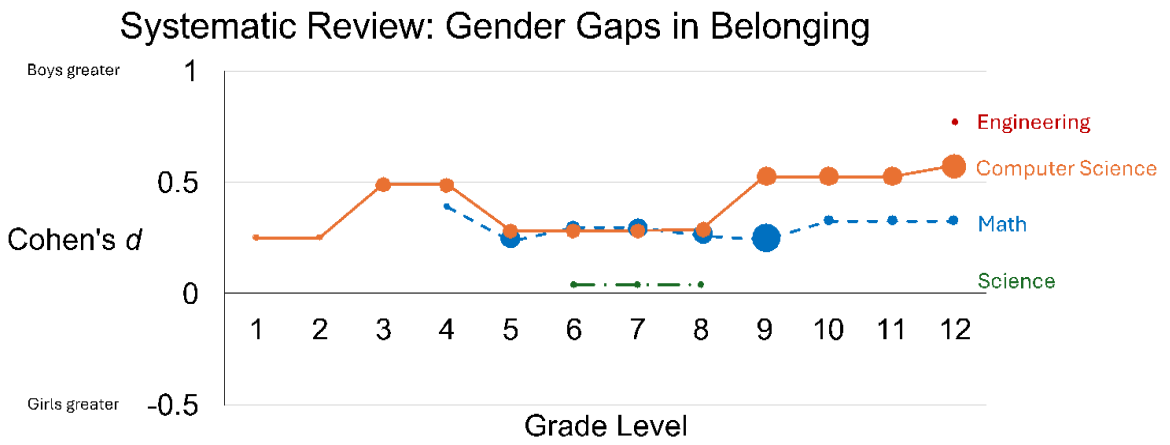


Note. A total of 50 independent studies published in 46 articles are included in this review, which included searches of databases, registers, and other sources.

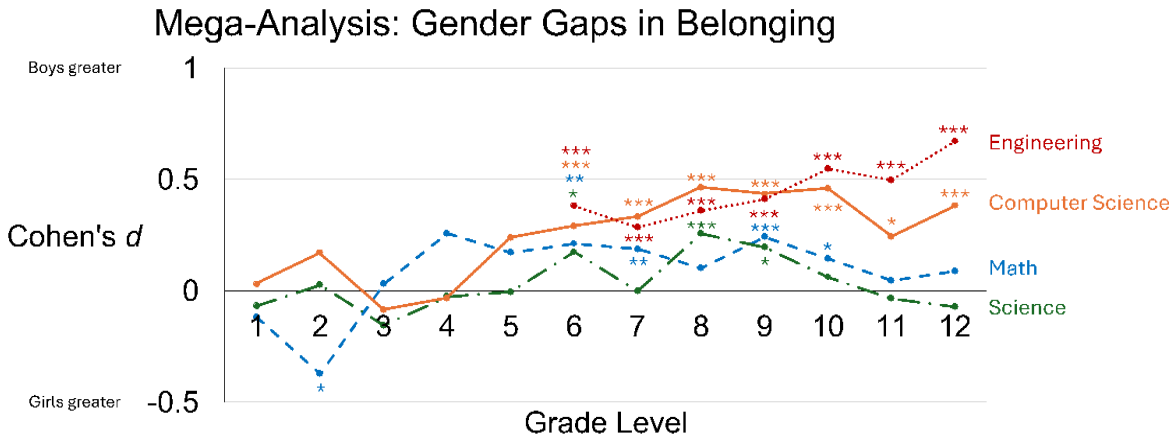
Figure 2

Gender Differences in Belonging by STEM Field and Grade Level

A



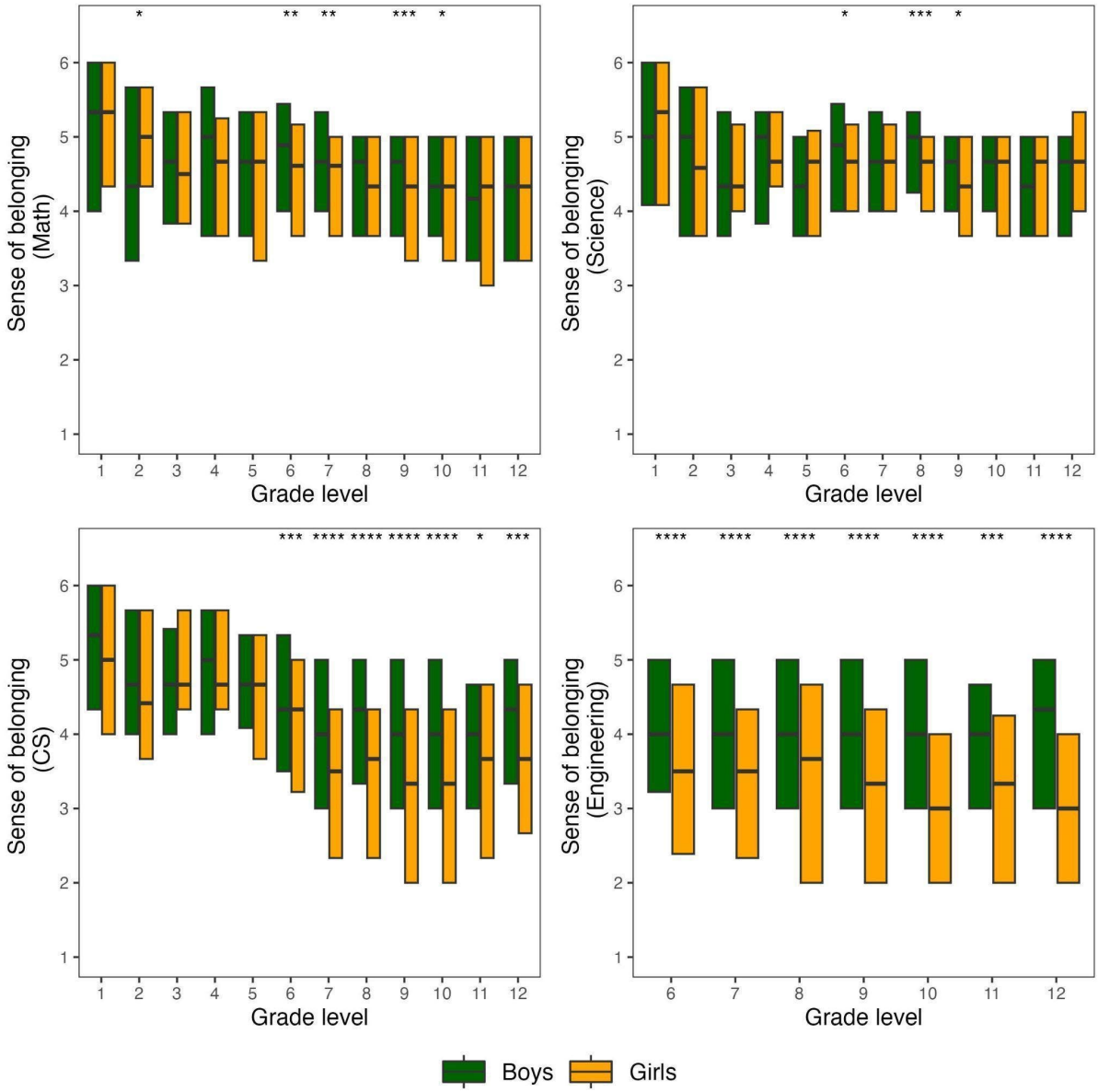
B



Note. Effect sizes of gender differences in belonging by grade level found in the systematic review (**A**) and mega-analysis (**B**). Engineering belonging is dotted red, computer science belonging is solid orange, math belonging is dashed blue, and science belonging is dash dot green. The size of the marker in **A** represents how many relevant effect sizes were found at each of those points. Some effect sizes shown in **A** are from unweighted averages across ranges of grade levels. Significant gender differences were also reported for math in Grades 9-12 without effect sizes. Non-significant gender differences were also reported for computer science in Grades 1-3, math in Grades 5-7, and science in Grades 4-5 and 9-12 without effect sizes. See Table S5 for details of the statistical tests for the mega-analysis. Significant gender gaps are shown in **B**: *$p < .05$, **$p < .01$, ***$p < .001$.

Figure 3

Sense of Belonging by Field, Grade Level, and Gender



Note. Gender differences in sense of belonging in four STEM fields across five past studies in the mega-analysis (N = 6,111). Boxes represent the 25th percentile through 75th percentile of the data. The bar through the middle of each box represents the median (50th percentile). Boys are shown in green and girls are shown in orange. CS = Computer science. See Table S5 for details of the statistical tests. Gender differences (shown at the top of each graph): *p < 0.05, **p < 0.01, ***p < 0.001, ****p < 0.0001.