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FAIRNESS AND OPPORTUNITY IN STEM CONTEXTS

Gender, Stereotypes, and Moral Judgments

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There is growing attention to the need to diversify the science, technology, engineering, and mathematics (STEM) workforce (Langdon et al., 2011). Globally, there is a shortage of students entering STEM fields and becoming STEM professionals (ACT, 2011; Kramer et al., 2015; Peterson et al., 2015). As an example, in the U.S., the growth in STEM jobs has been three times faster than non-STEM jobs (Langdon et al., 2011). Increasingly, research documents that this shortage may also be a moral issue. Findings suggest that workforce challenges are related to unfair treatment of some groups and the "chilly climate" within STEM classes and organizations, which results in women and individuals from ethnic/racial minority backgrounds feeling that STEM is not welcoming or inclusive for them (Simon et al., 2017). Findings from assessments of girls' and boys' achievement on science and math assessments across over forty-five countries demonstrate that there are no global gender differences, although some differences are present within particular countries (Reilly et al., 2019). By college, both women and ethnic/racial minorities are lagging behind their White male peers in STEM course-taking (National Girls Collaborative Project, 2016).

Critically, research from the U.S. indicates that an important barrier to persistence in STEM fields for marginalized groups (e.g., women, individuals with disabilities, etc.) is a culture that is found in many STEM organizations (e.g., academic institutions) that fosters discrimination, harassment, and prejudicial treatment of those from underrepresented groups (Beasley & Fischer, 2012; McGee, 2016; Reuben et al., 2014; Robnett, 2015; Shapiro & Williams, 2012). One key way to shift this dynamic is to encourage individuals to recognize that equity, opportunity, and inclusion in STEM domains are moral issues involving the unfair treatment of others (Mulvey et al., in press). Specifically, opportunity and inclusion in STEM involve key issues related to psychological harm experienced by groups excluded from STEM contexts, discrimination in STEM domains, and lack of fair access to opportunities. Further, it is important to recognize that limiting the potential pool of STEM workers to help solve the global challenges that face society (for instance, illness, climate change, and environmental injustice) may stymie efforts to solve these problems. In this chapter, we argue that stereotypes, bias, and discrimination around who can and should have opportunities in STEM domains foster exclusion from STEM for women in STEM fields in a multitude of ways. Our perception of exclusion from STEM is consistent with the United Nations definition of social exclusion, which identifies exclusion as manifesting in rejection from group activities, denial of educational/occupational opportunities, restricted access to social supports (for instance, workforce development), inadequate access to infrastructure, and systematic inequality (United Nations, 2016).

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Our focus within this chapter is on gender. In particular, it is essential to recognize that individuals bring a multitude of social identities to their experiences in STEM contexts. Disparities in the representation of women and other underrepresented groups, such as low-income students and non-White individuals, in STEM fields are pervasive (National Science Board, 2018). For instance, only about 20% of men and women from ethnic minoritized backgrounds earn college degrees in science and engineering domains (National Center for Science and Engineering Statistics, 2017). Moreover, even though women represent about half of the college-educated workforce in the US (National Center for Science and Engineering Statistics, 2015), as of 2017, women held only 24% of STEM jobs (Noonan, 2017). Additionally, recent research has documented that individuals who identify as LGBT also report experiences of exclusion, bias, and discrimination in STEM contexts (Cech & Pham, 2017). While this chapter will focus on moral judgments related to gender-based stereotypes, bias, and exclusion in STEM contexts, as most current research centers on gender, we recognize the importance of considering intersectionality (Cho et al., 2013; Crenshaw, 1991) to address disparities in STEM opportunities based on other central dimensions of identity that may be relevant in concert with one's gender, such as race/ethnicity, when appropriate.

Limiting exclusion from STEM domains is a central moral issue not only because fostering inclusion will help to ensure equitable access to opportunities but also because there is a critical need in STEM workplaces for individuals who have the key STEM skills to innovate and to collaborate and work together to solve global problems. Denying some the opportunity to help solve these problems may lead to increased harm to others (for instance, loss of life as a result of increased likelihood of natural disasters caused by climate change). There is a clear need for a diverse, skilled, and culturally competent STEM workforce (Langdon et al., 2011). The problem of developing global competence and STEM skills is more important than ever as we face global challenges, such as climate change, pandemics, and growing populations, that require STEM competence to address. Further, the STEM workforce increasingly recognizes that solutions to these problems must be developed collaboratively on a global level through engagement in STEM.

Unfortunately, some young people often do not have the opportunity to be part of these global solutions because they face challenges that lead them to stop pursuing STEM opportunities and participating in STEM domains (Allen-Ramdial & Campbell, 2014). Women, ethnic minorities, people with disabilities, and children from low-income families, if given the right opportunities, have the potential to increase the rate of STEM innovation fourfold (Bell et al., 2018). Research suggests that a key barrier that prevents women and others from stigmatized groups from persisting in STEM domains is stereotype threat or group performance anxiety (Beasley & Fischer, 2012). In this chapter, we will outline key research that examines attitudes, stereotypes, moral judgments, and reasoning about opportunities in STEM domains. We will first outline the theoretical approach we take in this chapter as we consider the moral dimensions of these challenges in STEM domains. Then, we examine prior research across developmental periods from early childhood to adulthood. Finally, we close with recommendations for future research and policy related to ensuring fairness in STEM contexts.

Theoretical Framework: Social Reasoning Development Perspective

We frame our understanding of fairness in STEM contexts as a moral issue by drawing on the social reasoning development (SRD) perspective (Rutland & Killen, 2015; Rutland et al., 2010). As reviewed in Chapters 5, 7, and 13 of this volume the SRD perspective argues for the importance of considering both moral principles and the role of social identities and loyalty to one's group in understanding individuals' judgments and decisions in social contexts. Specifically, this perspective draws together social identity theory (Tajfel & Turner, 1976), which argues that individuals strive

to promote and enhance their in-group and that identities serve as a source of self-esteem, and social domain theory (Turiel, 1983), which argues that individuals weigh concerns from different social knowledge domains in making judgments. These domains include the moral domain, which involves understanding issues related to justice, fairness, rights, and others' welfare; the societal domain, which involves customs and traditions, conventions, group functioning, concerns with status, and stereotypes; and the psychological domain, which involves personal choice and autonomy (Turiel, 1983).

We argue that the SRD perspective can help to explain both inclusive and exclusive behavior in STEM contexts. If individuals prioritize moral concerns around issues of equity and fairness, they may seek out opportunities to be inclusive, create policies and practices that ensure equity in STEM contexts, and challenge those who rely on stereotypes around STEM or engage in exclusion of others. On the other hand, if one is part of a group historically represented in the STEM fields (such as White men), one may seek to protect and enhance their group's established role in STEM and, as a result, condone stereotypes or exclusion, implicitly and/or explicitly. Research from an SRD perspective documents that, depending on the context, individuals may differentially weigh moral, psychological, and group-based concerns about a social situation (Rutland & Killen, 2015; Rutland et al., 2010). We review research drawing on this theoretical approach and interpret the findings of research studies by considering this tension between the group and morality across development.

Early Childhood

STEM Stereotypes

Research indicates that stereotypes, which are cognitive categorizations about groups that are typically fixed and overgeneralizations, can emerge quite early in development (Mulvey et al., 2010). During early childhood, gender stereotypes emerge soon after children begin understanding the concept of gender, and children hold gender stereotypes about a range of activities, traits, and even occupations (Liben & Bigler, 2002). Even in early childhood, children hold stereotypes linking boys with science careers (Liben & Bigler, 2002), with boys and younger children more likely to hold these occupational stereotypes than girls and older children (Miller & Budd, 1999). Moreover, these stereotypes can change quickly during early childhood and shape choices of activities and interests. For example, 5-year-old children show a preference for indicating that their own gender is "brilliant," and by 6 years of age, a stereotype that boys are brilliant quickly emerges, with girls less likely than boys to indicate that their own gender group is "really, really smart" (Bian et al., 2017). Moreover, these stereotypes about brilliance shape behaviors early on: girls aged 6 and older express less interest in playing a game for children who are smart (Bian et al., 2017).

Some research findings with children in the U.S. and the UK suggest that children between 4–7 years of age show a gender in-group bias when asked who should be, can be, and usually is good in STEM domains (McGuire et al., 2020). Findings also demonstrate that boys are more likely to show a gender in-group bias than are girls in early childhood and that gender stereotypes associating boys with engineering are stronger in early childhood than in middle childhood or adolescence (McGuire et al., in review). Further, early cross-cultural research in the U.S., China, and Japan demonstrated that children (as early as first grade) and their mothers in all three countries were more likely to believe that boys are better at math and girls are better at reading (Lummis & Stevenson, 1990). More recent findings suggest that this pattern has not changed: children in the U.S. as young as 6 years of age are more likely to indicate that math is for boys than for girls (Cvencek et al., 2011). Finally, although perceptions of self-concept are not the same as stereotypes, these perceptions may also shape interests and achievement. Research suggests that, as early as first grade, boys may hold higher

perceptions of their math self-competence than do girls, although boys' self-concept about math abilities declines more rapidly with age than does girls' (Fredricks & Eccles, 2002).

Bias, Prejudice, and Exclusion from STEM Contexts

To date, only limited research has examined young children's judgments and reasoning about inclusion and exclusion from STEM contexts. A study with U.S. children aged 3–8 years examined judgments and reasoning about the acceptability of pursuing counter-stereotypic STEM careers (nurse or library scientist for boys and doctor and engineer for girls) and the acceptability of exclusion from these counter-stereotypic careers (Mulvey & Irvin, 2018). Participants were asked to evaluate European American and African American boys and girls who wanted to pursue counter-stereotypic STEM careers. Findings documented that younger children (aged 3–5 years) judged counter-stereotypic career choices as less acceptable than did older children (aged 6–8 years), although participants, in general, evaluated exclusion from counter-stereotypic STEM careers as morally wrong when asked to assess how okay or not okay exclusion would be. Further, findings indicated that more positive parental attitudes toward STEM predicted children's recognition of the harmful nature of exclusion from STEM contexts, documenting the important role that parents can play in shaping inclusive attitudes toward STEM. Finally, participants were randomly assigned to assess either Black or White targets but did not vary in their evaluations based on the ethnicity of the target, which may suggest that young children may not hold or use stereotypes about ethnicity and STEM when making moral judgments about exclusion from STEM fields. However, ethnic-minority participants did judge counter-stereotypic choices as less acceptable than did ethnic majority participants. Thus, future research may need to examine intersectionality more carefully, as gender roles (including those around STEM) may be socialized differently in different ethnic groups (Belgrave et al., 2016).

Additional research asked children (from early childhood through adolescence) who were visiting informal science learning sites, such as zoos and museums, in the U.S. and the UK to make decisions about if they would include a girl or a boy into a peer group to help solve a difficult science problem and to assess their perception of the abilities of a target girl and boy (how good he or she is at science) (McGuire et al., under review). Interestingly, there were no documented age-related differences: even in early childhood, female participants were more likely to seek help from the male character. Moreover, participants who generally showed more bias toward males (by indicating that boys were usually better at STEM, for instance), both in terms of general STEM stereotypes and their perception of how good the male and female target would be at science, were more likely to select the male character to help answer the science question (McGuire et al., under review).

One novel area of research examines how societal gender stereotypes—for instance, about colors and toy preferences—may shape preschoolers' engagement with STEM materials. Stereotypes associating boys with primary colors such as blue and girls with pastel colors such as pink are pervasive in early childhood (Chiu et al., 2006; Cunningham & Macrae, 2011; Picariello et al., 1990) and shape the decisions that children make about toys and choices for playing (Weisgram et al., 2014). As an example, research with children 3–8 years of age documented that while girls' performance on an engineering aptitude task did not depend on whether they were assigned STEM materials that were primary or pastel colors, younger boys (3–5 years) exhibited significantly lower engineering aptitude when assigned pastel-colored toys (counter-stereotypic) than when they were assigned primary-colored toys (stereotypic) (Mulvey et al., 2017).

Related research suggests that activation of STEM gender stereotypes can influence young children's STEM-related performance (Shenouda & Danovitch, 2014). Preschool girls in the U.S. experienced stereotype threat and exhibited reduced performance when gender stereotypes about STEM were activated when they were completing a spatial task with Lego blocks. Moreover, the more stereotypes children (4–10 years) held about Legos, the slower they were at completing a building

task with Legos (Shenouda & Danovitch, 2014). These findings suggest that explicitly affirming that all children can and should play with STEM toys may be an important way in which early childhood teachers and parents of young children can help to ensure equity in STEM contexts. Young children spontaneously engage in STEM play—for instance, by asking and answering questions, observing phenomena, making numerical comparisons, and measuring (Butler, 2020; Dale Tunnicliffe & Gkouskou, 2020). This spontaneous play can lay the foundation for equitable opportunities in STEM if all children's STEM play is supported and encouraged in inclusive ways. Recent research documents that preschool STEM curricula can be implemented effectively (MacDonald et al., 2020) in partnership with parents and that such curricula shape STEM knowledge but also positive feelings toward STEM and STEM dispositions (Ata-Aktürk & Demircan, 2021). Further, findings suggest the importance of attending to students' identity when designing STEM curricula. Early childhood STEM curricula, which aim to implement culturally relevant STEM practices, can be especially effective in promoting STEM interests for diverse boys and girls (Brenneman et al., 2019). Moreover, attention to specific curricular resources is important: gender-fair classroom materials (such as books) can help to combat the emergence of stereotypes in early childhood (Karniol & Gal-Disegni, 2009). Together, these findings suggest that, while stereotypes limiting opportunities around STEM emerge early in childhood, explicit practices by teachers and parents can counter these stereotypes, creating equitable climates and promoting fair inclusion practices for all in STEM domains.

Middle Childhood

STEM Stereotypes

During middle childhood, ideas about gender roles become more flexible (Liben & Bigler, 2002) as children begin to understand that societal roles can be fulfilled by both men and women. Despite this, "masculine" careers are still seen as having higher status than "feminine" careers at these ages (Liben et al., 2001). Explicit stereotypes about gender decline in middle childhood; however, implicit measures have documented that gender stereotypes persist beyond this point (Steffens & Jelenec, 2011; Wilbourn & Kee, 2010). Similarly, both explicit and implicit gender stereotypes about STEM have been documented in middle childhood. For example, Cvencek et al. (2011) measured gender stereotypes about math in children between 6 and 10 years old using both implicit and explicit measures to demonstrate that up to 10 years children associated math with boys more than girls. In particular, boys identified with math more strongly than girls. This finding is indicative of a range of studies demonstrating that both children and adults continue to identify math as a stereotypically male domain (Guiso et al., 2008; Lummis & Stevenson, 1990; Nosek et al., 2009).

Although both boys and girls in middle childhood report that boys have some innate math ability, other evidence suggests that an in-group preference may exist in this age range. For example, Kurtz-Costes et al. (2014) measured gender differences in math, science, and verbal ability stereotype awareness ("Who is usually good at STEM?") and endorsement ("Who should be good at STEM?") in fourth-, sixth-, and eighth-grade participants. Participants in fourth and sixth grade favored the abilities of their own gender group rather than endorsing traditional gender stereotypes and, with age, were more likely to report equitable beliefs about male and female STEM ability. This finding suggests that in middle childhood, an in-group preference begins to give way to more equitable beliefs about gendered ability in STEM.

Similarly, recent work from McGuire et al. (2020) documented STEM gender stereotypes in informal science learning sites in the U.S. and the UK. Across awareness, endorsement, and flexibility ("Who can be good at STEM?") measures, participants (from diverse ethnic groups) in middle childhood were a key developmental bridge between early childhood and adolescence. That is, youth in middle childhood, compared to those in early childhood, were more likely to say that both boys

and girls are usually good, should be good, and can be good at STEM. Crucially, male participants were more likely to report that their own gender in-group are usually good at STEM than they were to say that girls were usually good. In contrast, female participants were not more likely to say that girls were usually better than boys. Recent work has examined gender stereotypes within each STEM domain, revealing important domain-specific differences (McGuire et al., under review). When asked about the domains of math and science, male participants in middle childhood, as compared to female participants, were more likely to favor boys' ability in these domains. Girls in middle childhood expressed equitable beliefs about male and female ability in science and math. However, in both engineering and technology domains, all participants favored boys' ability. These findings reveal that in middle childhood, the move away from bias toward male ability in explicit measures occurs in certain STEM domains but not others. Crucially, boys in this age range express an in-group biased perspective of STEM ability, which may reinforce the status quo of male ability in this age range. In domains where children may have less personal experience (i.e., technology, engineering), ability estimates favor boys for both boys and girls in this age range.

Bias, Prejudice, and Exclusion From STEM Contexts

Outside of STEM and during middle childhood, children show a preference for members of their in-group, and accordingly, in-group norms come to play an important role in determining intergroup attitudes and behaviors. In the STEM context, in-group norms are often based on stereotypes, which can have important consequences for children's motivation and perception of their own abilities. For example, Steffens et al. (2010) measured implicit math-gender stereotypes among 9-year-old children in Germany. Girls in this age range already showed an implicit affinity toward languages as compared to math. Crucially, for girls (but not boys), this implicit math-gender stereotype was related to academic self-concept, academic achievement *and* future enrollment preferences above and beyond explicit stereotypes. This finding demonstrates that in middle childhood, gender stereotypes exert a powerful influence on girls' beliefs about their own abilities and their desire to participate in the spaces where crucial future STEM decisions are made.

Other research has also examined how those individuals who challenge stereotypical norms are evaluated by their peers. During middle childhood, individuals are aware that peers who challenge group norms can be excluded from groups (Mulvey et al., 2014). In the context of STEM, this is problematic, as stereotypes suggest that STEM domains are male domains; thus, when girls express STEM interests, they may be exposed to negative consequences for challenging norms. Therefore, girls who seek to pursue their interests in these domains may be seen as non-normative by their peer group members and a threat to the group's status and functioning. McGuire, Jefferys et al. (2020) examined how children in the UK aged between 8.5 years and 10.5 years evaluated peers who challenged STEM gender norms. Participants were inducted into simulated groups based on gender and told that their group held a norm to either take part in a technology or biology activity. They were then asked to evaluate a peer who challenged this norm by expressing interest in the opposite activity. Male participants most negatively evaluated a peer who wanted to take part in a biology activity when the rest of the group wanted to do a technology activity. Crucially, male participants also expected that members of their peer group would negatively evaluate this peer, and this belief about peer evaluation predicted participants' own individual evaluations. Female participants, in contrast, did not negatively evaluate a peer who challenged a STEM gender norm. These results suggest that where STEM norms based on stereotypes are endorsed, male peer groups in this age range are more likely to prioritize such norms and act as gatekeepers by negatively evaluating those who challenge them. However, girls did not expect that their group would negatively evaluate someone who wished to participate in a counter-stereotypical activity, nor did they themselves negatively evaluate this peer. The link between boys' own evaluations and their perceptions of their group's evaluation

makes clear the importance of understanding STEM inequality as a social-conventional issue where group membership and group decisions can serve to maintain the status quo and exclude those from minority groups.

In middle childhood, boys are more likely than girls to endorse male-biased stereotypes and to act as gatekeepers when members of their own group challenge peer group norms based on stereotypes. Although it is not currently clear whether boys act as gatekeepers of these activity groups when girls wish to join them, there may be instances when this occurs. Moreover, educators may also act as implicit gatekeepers when making decisions about how to structure groups and activities in classroom spaces. Educators interested in promoting STEM equity in middle childhood would be well placed to target boys in this age range in order to foster inclusive peer group norms. Promoting such norms and encouraging discussion to reduce pluralistic ignorance around individual and perceived group perspectives of peers who challenge such norms will be essential to challenging stereotyped views of male ability.

Research in early childhood has documented the consequences of stereotype threat for girls' STEM motivation. The activation of such stereotypes can further impact girls' perceptions of their abilities and their actual performance in middle childhood. For example, among 7- and 8-year-old French children, the activation of participant gender (through coloring in an image of a girl holding a doll) is related to girls' reduced performance on difficult math questions (Neuville & Croizet, 2007). Similarly, when 10-year-old participants were informed that exceptional math achievement is usually a male phenomenon (i.e., stereotype threat was activated), female participants in this age range believed their own math ability was poorer and performed worse on a math task (Muzzatti & Agnoli, 2007). These stereotypes create a damaging cycle where girls negatively rate their own abilities and perform worse when these stereotypes are activated. Actively challenging such stereotypes in middle childhood will serve to moderate the consequences of stereotype threat, challenge boys' views of male dominance in these domains, and promote more equitable norms in peer-group contexts.

Adolescence

STEM Stereotypes

With the advent of adolescence, new physical and contextual factors converge and lead to the likely increase in the awareness and endorsement of gender stereotypes among adolescents (Kurtz-Costes et al., 2014). Further, understanding the effects of STEM stereotypes is of particular importance during adolescence, as students during this time begin to decide whether to take advanced math and science courses, which can have later effects on the decision to pursue STEM majors in college. Interestingly, results regarding the endorsement of explicit and implicit gender stereotypes in STEM domains are relatively mixed among adolescent samples; sometimes they suggest that no gender differences can be observed between boys' and girls' STEM abilities, and other times they suggest that the in-group is more likely to excel in STEM domains compared to the out-group. This may be because of methodological differences and the measurement of explicit and implicit stereotypes. This inconsistency signals the importance of future work that examines developmental differences in the endorsement of explicit and implicit stereotypes but also possible moderators of STEM performance, such as socioeconomic status and ethnicity. However, findings suggest the powerful impact that stereotypes about gender can have: research from over thirty countries documents that national-level implicit stereotypes about math and science predict individual sex disparities in science and math academic achievement even more so than do individually held stereotypes (Nosek et al., 2009).

In a study with Croatian adolescents, both boys and girls endorsed the gender-stereotyped belief that STEM-related subjects are more suitable for boys than they are for girls. Boys were more likely than girls to endorse this belief (Blažev et al., 2017). Across two samples of German adolescents in

seventh and ninth grade, both boys and girls explicitly endorsed the notion that boys were better than girls at math, with a stronger endorsement of this stereotype among ninth graders in the second sample (Steffens et al., 2010). In the domain of computer science and technology, American high school girls were less likely than boys to report that they fit the stereotype of a computer scientist (Master et al., 2016). Girls who reported greater fit with computer science stereotypes were likely to report more interest in enrollment in computer science classes than girls who reported lower fit with computer science stereotypes. Finally, among French adolescents in high school, both boys and girls reported that men are more talented in math than women and that women are more talented in art (Chatard et al., 2007). Taken together, these studies provide converging evidence for the notion that both adolescent boys and girls endorse explicit stereotypic gender beliefs about ability in STEM domains.

However, there is also a growing body of evidence that paints a different picture as to what gender stereotypes adolescents endorse. Evidence from these studies employs more of a mixture of explicit and implicit measures of gender stereotypes and demonstrates that some adolescent samples do not explicitly endorse gender stereotypes but may still hold implicit gender biases. More specifically, the following studies suggest that adolescent boys and girls hold predominantly explicit egalitarian views about STEM abilities across gender groups. However, when considering implicit stereotypes, in-group biases persist, especially among girls. For example, when asked explicit stereotypes about ability in math by gender group, eighth-grade Italian girls reported no difference in math ability, and boys actually reported counter-stereotypical beliefs about math ability (Passolunghi et al., 2014). However, among implicit stereotypes that were also assessed in this study, results indicated that girls and boys did associate boys with math at greater levels compared to girls. Examining math ability stereotypes in American middle and high school adolescents, Vuletich and colleagues (2020) found no gender differences in explicit reports of math ability for girls or boys. This study also included a measurement of implicit math stereotypes. Results indicated that girls held implicit bias favoring girls in math in middle and high school but that boys did not hold an implicit bias favoring either gender. In a study with sixth- and eighth-grade American adolescents, girls held strong, explicit, non-traditional stereotypes about gender differences in science and math, whereas boys did not exhibit stereotypic gender beliefs about science or math (Kurtz-Costes et al., 2014). Among Canadian eighth-grade boys and girls, no implicit gender stereotyping was observed in the domain of math (Morrissey et al., 2019). Recent research, for instance, documents that, even into adolescence, individuals are more likely to show preferences for male peers in STEM-related tasks if they hold more male-biased stereotypes about STEM (McGuire et al., under review).

As outlined previously, the empirical evidence regarding STEM stereotypes and their endorsement across adolescence is unclear and in need of further investigation to better contextualize results and understand the endorsement of STEM stereotypes. Evidence points to the notion that some adolescents do endorse gender stereotypes about STEM in adolescence; however, they do not always endorse them explicitly. Finally, research is needed regarding the various domains of STEM, as a vast majority of studies examine math stereotypes (for an exception, see McGuire et al., under review).

Bias, Prejudice, Discrimination, and Exclusion From STEM Contexts

Adolescence represents a key developmental time period as adolescents begin to consider the possibilities of their identities and their future selves. During adolescence, many may make the decision as to whether or not they will pursue a career in STEM. Of course, experiences of gender bias, prejudice, discrimination, and exclusion, as well as fair and equal treatment, are all factors that would likely contribute to a decision to pursue further education and eventual career in STEM fields. Given the consistent underrepresentation of women in most STEM fields, understanding how these experiences of bias play out in adolescence is key as adolescents begin to consider their future.

Scholars have only just begun to investigate these instances of bias and discrimination and their implications for motivation and future interest in STEM domains and fields. Research documents that over 50% of adolescent American girls report academic sexism (sexism related to academic domains, including math, computers, and science), with this sexism coming from numerous sources, including parents, teachers, and peers (Leaper & Brown, 2008). Extending this work, in a study with Latina and European American adolescent girls, scholars found that girls' greater experiences of sexism in math and science were related to feelings of being less competent in math and science and reports of finding less value in math and science, compared to girls who experience fewer of sexism in math and science (Brown & Leaper, 2010). In another study with American high school girls, approximately 50% of the girls reported gender bias from male peers in the context of life sciences and math-intensive courses. For example, participants reported experiences such as peers making negative comments about women's science abilities, ignoring their comments or questions in STEM classes because of their gender, or excluding them from STEM study groups because of their gender. Results also revealed that the frequency of experiences of gender bias was associated with lower STEM self-concept, especially when girls had less peer support (Robnett, 2015). Finally, in a mixed-methods study, results indicated that girls were more likely than boys to report being a victim of micro-insults based on their gender and STEM. Further, both boys and girls recounted more gender role expectations for girls and women that were in opposition to STEM interest and motivation among ninth- and tenth-grade American adolescents (Grossman & Porche, 2014).

Importantly, discrimination can have lasting effects on adolescents' performance and motivation in STEM domains. Further, it is important to consider the role of discrimination that targets multiple dimensions of one's identity. For example, research with African American adolescents documents that perceptions of teacher discrimination were associated with reduced perceptions of the relevance of the math teaching they received, and this predicted math achievement, suggesting that discrimination can undermine student perceptions of the teachers' capabilities, which can lead to weaker performance (Diemer et al., 2016). Parents can play a key role in shaping the opportunities that adolescents have (Casad et al., 2015; Rouland et al., 2013): findings suggest that mothers' communication around math and science course-taking does shape the classes that adolescents take (Hyde et al., 2017), and parental stereotypes around STEM can limit opportunities, career choice, and achievement for adolescents (Bleeker & Jacobs, 2004). Peers, too, can shape adolescent course-taking (Crosnoe et al., 2008), with findings suggesting that having an all-female friendship group can help to counter-stereotypes suggesting that girls should not pursue STEM interests and motivate girls to persist in advanced STEM classes (Riegle-Crumb et al., 2006).

These studies provide preliminary evidence that adolescent girls are experiencing bias and discrimination on the basis of their gender. However, more research is needed to corroborate these results but also provide more nuance as to the kind and forms of bias and discrimination that girls are experiencing, as well as the experiences of girls in countries other than the U.S. Fortunately, scholars have already begun to consider how STEM motivation can be maintained or even enhanced in the face of gender bias in STEM domains during adolescence through interventions. For example, values affirmation represents one kind of intervention researchers have employed in an effort to enhance STEM motivation and close gender STEM achievement gaps, but these interventions have only resulted in varied success (Hoffman & Kurtz-Costes, 2019; Miyake et al., 2010; Serra-Garcia et al., 2020). A review of fifty-three STEM motivation interventions showed that results were highly variable, with some studies showing positive effects and others showing mixed or no effects (Rosenzweig & Wigfield, 2016). Of the fifty-three interventions, thirteen interventions assessed gender as a moderator and only six showed gender differences in intervention benefits, with some benefiting girls and some benefiting boys. Thus, gender does not consistently moderate the effectiveness of STEM interventions.

Adulthood

STEM Stereotypes

While much research has focused on STEM stereotypes in childhood and adolescence (McGuire et al., 2020), research suggests that STEM stereotypes may limit opportunities for certain groups in adulthood as well (Liben & Bigler, 2002). Research with a college student sample suggests that adults hold pro-male implicit STEM biases more so than anti-female STEM biases and that these biases are stronger when asked to complete an implicit association task for adults and STEM fields than for children and STEM fields (Fleming et al., 2020). Interestingly, findings with adults highlight the importance of approaching STEM stereotypes with an intersectional lens: findings with American college students suggest that European American women hold stronger implicit STEM gender stereotypes than do African American women and that a similar pattern also holds for men, although the magnitude of the difference for men was smaller (O'Brien et al., 2015). O'Brien et al. (2015) argue that this may be because stereotypes associated with STEM (such as being independent) are not considered as stereotypically masculine among African Americans. Concerning findings specific to math-gender stereotypes suggest that, although adolescents showed in-group favoritism in terms of their math stereotypes, adults showed clear stereotypes associating men with math on both implicit and explicit measures (Morrissey et al., 2019). The presence of these strong stereotypes in adults suggests that adults with whom youth interact (such as parents and teachers) may be implicitly or explicitly communicating these stereotypic ideas about who can and should engage in STEM domains. In fact, research suggests that adults' stereotypes can impact children and adolescents' feelings and behaviors as well (Ambady et al., 2001).

Adults do hold gender stereotypes about STEM. However, there is evidence that these stereotypes can be challenged with individuals overcoming the impact of stereotypes and explicit policies and interventions working to establish inclusive norms. For instance, there is correlational evidence that young adult college students can be influenced by counter-stereotypical exemplars. Findings suggest that at schools with a greater proportion of female STEM faculty, girls and women are more likely to enroll in and complete STEM degrees (Sonnert et al., 2007). Additional findings suggest that for women in coeducational schools, science and math academic environments automatically activated gender stereotypes for women, but only in classes that were not led by female faculty (Dasgupta & Asgari, 2004). Related research suggests that exposure to female STEM experts resulted in adults' positive implicit attitudes toward STEM and greater identification with STEM (Stout et al., 2011). Findings also suggest that reading about STEM role models who are diverse can shape a sense of belonging in STEM and STEM self-efficacy for college students (Shin et al., 2016).

Bias, Prejudice, and Exclusion From STEM Contexts

Adults' attitudes toward inclusion and exclusion in STEM contexts have also been assessed in academic and workplace environments. For example, research has examined young adults' evaluations of gender-based academic exclusion in physics and English classes, exploring attitudes toward exclusion and college students' expectations regarding if they would intervene if they observed a male peer excluded from an English class group activity and a female peer excluded from a physics class group activity (Gönültaş & Mulvey, 2021). Interestingly, participants responded in ways that indicated an awareness of the historical inequity: college students judged the exclusion of a female member as less acceptable than the exclusion of a male member. The participants expected that they would speak up if they observed this exclusion of either a male or female peer. However, participants with greater theory-of-mind competency and those who held more gender-equitable attitudes were more likely to condemn the exclusion and to express a desire to intervene than were other participants (Gönültaş & Mulvey, 2021).

These findings indicate that college students may seek to rectify the prior history of exclusion of females from STEM domains (National Science Board, 2018). Of concern, however, the results found that this may result in college students overlooking the exclusion of males. Results from the study indicated that participants judged counter-stereotypic academic pursuits by men (an English class activity) more harshly than counter-stereotypic academic pursuits by women (a physics class activity) (Gönültaş & Mulvey, 2021). An interesting question is if exclusion based on gender is viewed as more legitimate than exclusion based on other categories, such as nationality or race/ethnicity. Findings also suggest that researchers may need to examine context closely. Recent research in STEM classes documents gender bias in biology undergraduate classes, with male students underrating the performance of their female peers (Grunspan et al., 2016). However, another study found no instances of gender bias in mechanical engineering classes (Salehi et al., 2019). This suggests that contextual factors, such as classroom norms, teacher practice, and peer group dynamics, may be important in shaping whether classroom spaces are inclusive for all students or not.

In the workplace, findings suggest that women often experience explicit exclusion and bias, with findings suggesting that STEM contexts often reflect a masculine culture that is unwelcoming to women (Cheryan et al., 2017). Research suggests that this discrimination, in particular sexism, related to STEM fields begins by high school and can come from peers, teachers, or even mentors (Robnett, 2015). Findings also suggest that when women are aware of gender bias in STEM contexts, they are less willing to pursue those fields, potentially limiting opportunities for women to advance in STEM (Moss-Racusin et al., 2018). Moreover, research documents that bias and discrimination can contribute to so-called "leaky pipeline" issues (Griffith, 2010), where promising young women and ethnic minority individuals leave STEM pursuits, with reports noting that exclusive climates contribute to those historically underrepresented in STEM dropping out of STEM majors (Allen-Ramdial & Campbell, 2014; Chang et al., 2014; Jones et al., 2000). Further, discrimination and occupational segregation contribute to these individuals leaving the STEM workforce at high rates (Alonso-Villar et al., 2012; Reid, 2002). There have been numerous calls from the research community to address exclusive STEM contexts and identify ways to encourage success for those underrepresented in the STEM fields (Allen-Ramdial & Campbell, 2014; Chang et al., 2014; Salehi et al., 2019; Schneider et al., 2018; Simon et al., 2017), yet change in exclusion and bias in STEM contexts may need to begin long before women and others underrepresented in STEM are seeking employment. Findings suggest that childhood and adolescence are key periods to prevent the emergence and development of stereotypes and promote understanding of equity for all in STEM contexts (Olsson & Martiny, 2018). Moreover, approaches to change the climate of STEM workplaces may need attention to multiple factors. For instance, research suggests that women are less likely to even see STEM job ads, given biases in the way in which algorithms display job ads to potential applicants (Lambrecht & Tucker, 2019). Thus, creating inclusive STEM contexts for adults may need to begin in childhood and may require structural, institutional, and educational changes in addition to reductions in stereotypes.

Future Directions for Research and Intervention

While the research on gender bias in STEM contexts is growing quickly, there are new, important directions for research, policy, and practice related to understanding and reducing gender bias in STEM domains. Most centrally, scholars should work to frame the issue of STEM bias in the language of morality (specifically referencing others' welfare, fairness, and opportunity), recognizing that stereotyping, prejudice, and bias in STEM domains is causing psychological harm to those who are not included or given opportunities in STEM fields and damaging society by limiting who can contribute to innovation in STEM and global problem-solving around critical STEM issues, such as climate change. Framing this issue as a moral issue can help to shift the narrative from a focus on who is "good" at STEM or even who is "interested" in STEM toward recognizing the barriers that many individuals, including women and girls, have faced, which have made persisting with STEM

domains to be a particular challenge (Schneider et al., 2018). As an example, only scant research has explored how individuals cognitively understand exclusion from STEM domains, with findings suggesting that young children recognize exclusion from STEM as wrong and a moral issue (Mulvey & Irvin, 2018). Future research should aim to extend this work to explore reasoning around fairness in STEM contexts: What does fair treatment and opportunity look like? How do we ensure that all individuals have opportunities in STEM domains?

New work may also seek to identify what features of STEM spaces can foster inclusion as a way to inform social justice interventions to create welcoming STEM spaces. As an example, research demonstrates that relevance is key for maintaining students' interest and engagement (Priniski et al., 2018), and scholars might seek to explore how to ensure that STEM classes address topics relevant to the lives of all students. One way in which this might occur is to integrate social justice orientations into the teaching of STEM contents. Teachers could explore with students the ways in which STEM knowledge can be used to foster a more just world broadly, with STEM classes integrating discussions of issues around environmental justice and fostering opportunities for civic engagement in STEM domains. This approach is consistent with the global competence framework, which articulates that students need skills and preparation that will foster their abilities both to work with others who are different from them and to recognize and address issues of global concern—for instance, issues related to core concepts such as global sustainability (OECD, 2018). This work might draw upon scholarship around culturally relevant pedagogy (Ladson-Billings, 1995) as one way to make STEM welcoming for students who are historically underrepresented in STEM domains.

An additional important area for moral development research on gender bias in STEM is the movement away from a binary conception of gender. The majority of work to date focused on gender and STEM has taken a cisgender, binary lens, with almost no work considering the experiences of nonbinary and transgender individuals in STEM spaces. New research that moves beyond a gender binary is critically important, as is research that examines moral judgments and reasoning related to inclusion and exclusion of individuals with attention to intersectionality (Cho et al., 2013; Crenshaw, 1991) and the many identities one may bring to STEM spaces.

Future research should also expand our understanding of exclusion from STEM as a moral issue by more carefully exploring reasoning about and experiences in distinct STEM domains. Research demonstrates that while women are vastly underrepresented in some domains, such as computer science, there is more balanced representation in some STEM fields, such as biology (National Science Board, 2018). Further, research is documenting that children and adolescents do not hold the same stereotypes about STEM across domains (McGuire et al., under review), highlighting the importance of future research that attends to differences across domains. This work might also capitalize on connections between STEM domains and other fields of study, such as the arts, which rely on high levels of innovation and creativity.

In sum, the research to date provides an emerging picture of the role that gender stereotypes play in shaping inequitable and exclusive STEM spaces and highlights concerning patterns of gender bias, prejudice, and discrimination faced by girls and women historically underrepresented in STEM fields.

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