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GENDER MATTERS
Building on the Past, Recognizing the Present, and Looking Toward the Future

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Introduction: Building on the Past

In this chapter, as per the title, we build on the past, we recognize the present, and we look toward the future as we explore gender matters in science education research. Similarly to other chapters in this handbook, a departure point for this chapter is Kathryn Scantlebury's chapter with the same title, which was published in 2014 in the *Handbook of Research on Science Education*. We use Scantlebury's chapter as a departure point because until today it remains the most recent published work on gender and science education offering a rich and comprehensive historical overview on how research on gender and science education has evolved over the years.

In summarizing the findings of key review studies in school education as well as women scientists, Scantlebury argues that the findings of these review studies "suggest little has changed in the daily teaching of science in school education, and for many women, the sociocultural climate in science and science education remains chilly" (p. 189). Following on this, Scantlebury goes on to summarize the findings of two international studies (TIMSS and PISA) carried out in 2008 and 2009 and examined gender differences in students' science achievement and attitudes toward science. For most countries there were no gender differences on science achievement; however, more than three times the number of boys indicated interested in computing, engineering, or mathematics than girls, while more girls indicated a preference for a biology, agricultural, or health career. These differences have been examined through research studies that followed these two international studies and focused on students' attitudes toward science. The outcomes of these studies, as Scantlebury summarized, point to structural issues and gender essentialism as impacting students' participation within the sciences. Next, Scantlebury critically synthesizes the findings of several gender studies, ranging on purpose from an examination of learning science in different spaces and teachers' gendered perspectives. In discussing the findings of these studies, Scantlebury highlights the important role that teachers play in supporting girls to engage with science as well as the possible impact that spaces outside of a formal classroom might have on positively impacting attitudes toward science. Following on this section, Scantlebury summarizes studies focused on individuals' engagement with learning science and/or as a career pathway. In doing so, she draws upon feminist theory and reviews studies in the area of science identity and physics masculinity to argue that the culture of physics needs to change its practices and image if we want more students to identify with the subject.

The chapter ends with a set of recommendations for future directions based on identified gaps in existing knowledge base and questions that remained unanswered. Some of these include the

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following: (1) at a structural level, gender has been approached through a binary approach; (2) data on gender are rarely reported through an intersectional lens to include race, socioeconomic status, first language acquisition, and immigration status; (3) how gender or other social categories influence research, the context, or the theoretical framework remains unexplored; and (4) the knowledge base on the intersection of gender and subjects besides physics remains scarce. In responding to these questions, as Scantlebury argues, calls for the adoption of intersectionality, material feminism, and queer theory as theoretical frames for the purpose of expanding gender research and including other social categories as well. In this chapter, we critically synthesize studies on gender matters in science education from 2014 onwards. We have included studies where the authors use "gender" as a descriptor of their work. This means that the conceptualizations of gender in the included work vary considerably; from gender as a way to denote studies of women and men to studies utilizing, for example, poststructuralist or posthumanist theories of gender. As such, not all included studies have an explicitly stated theoretical approach to gender, but all studies make gender a relevant category of analysis. In addition, we have included studies concerning LGBT+/queer, even when such studies do not explicitly deal with gender. The included studies are published in international, peer-reviewed journals. It should be noted that we have only reviewed English-language articles, and while we have strived to include research from different national contexts, the limitation in terms of language skews the selection.

The chapter is organized in three main sections, where the first includes research focused on understanding gender gaps, the second includes research that utilizes identity-based approaches to gender, and the third brings emerging perspectives to the fore. Each main section is followed by a short summary and synthesis. The chapter is concluded by a discussion and recommendations for future research directions.

Part I: Understanding Gender Gaps

Gender gaps in science participation and performance have received considerable attention from researchers since at least the 1980s and continue to do so (Jacobs, 2005; Kanny et al., 2014). Research about "gender gaps" typically assumes a taken-for-granted view of gender as representing either social and/or biological sex, by, for example, dividing research participants into men and women, without further problematizing this. Consequently, studies within this line of research do not necessarily define or theorize gender. Instead, theoretical constructs such as self-efficacy or sense of belonging are used to explain gender differences in performance and participation.

Performances and Participation

Although female students overall outperform male students in school (Voyer & Voyer, 2014), gender gaps in performance favoring male students have been found in a variety of physics learning contexts (Day et al., 2016; Gok, 2014; Henderson et al., 2017). However, researchers have also stressed that findings concerning gender gaps in performance need to be treated with caution and examined in relation to contextual factors. For example, Day et al. (2016) found gender differences in performance among physics students on the Concise Data Processing Assessment (CDPA), but also observed compelling gender differences in how students divide their time in the lab. On a similar note, Traxler et al. (2018) found that when items on the Force Concept Inventory that appear to be substantially unfair to either women (six items) or men (two items) were removed, the gender gap in performance was halved. They analyzed three samples (N [pre-test] = 5391, N [post-test] = 5,769) and looked for gender asymmetries using classical test theory, item response theory, and differential item functioning. Andersson and Johansson (2016) analyzed a gender gap in course grades favoring male students during a six-year period for a university course in electromagnetism (N=1,139) and found that the grade difference between female and male students on the same program was in most cases not statistically significant. The gender gap for the student group as a whole was predominantly related to different achievements on different programs.

Women continue to be underrepresented in mathematics-intensive science fields (Schwab et al., 2017; Skibba, 2019). However, a numerical parity in a science field is not the same in that there are no gender disparities in participation. In a study of 23 large introductory university biology classes, Eddy et al. (2014) examined two measures of gender disparity in biology: academic achievement and participation in whole-class discussions. They found that even though women on average made up 60% of the students in the studied courses they only made up 40% of responses to instructor-posed questions in the classes. Females also consistently underperformed on exams, compared to males with similar college grade point averages. An interaction analysis of video data recorded in Swedish high schools demonstrates that boys still occupy more space in science classrooms, taking up more teacher–student interaction time in classroom discussions (Eliasson et al., 2016), although girls do seem to have extended the time they take up in science discussions. The researchers cautiously suggest that this may in part explain why Swedish girls today perform better than boys; however, boys still occupy the majority of interaction space in the classroom. The researchers suggest that an implication could be that teachers more often address their interactions to boys, which may negatively impact girls' attitudes in science. A follow-up study to this one (Eliasson et al., 2017) investigates the nature of those interactions and found that closed (lower cognitive demand) questioning tends to predominate classroom discussion, which limits interactions between students and teachers. Taken in light of the limited classroom interactions that girls already have with teachers, the researchers suggest that this may further disadvantage girls, who already have limited time to engage in productive science talk.

International and National Tests

One recurring theme in the research on gender gaps is gender differences in international and national tests. In a study of gender differences in science achievements on the 2011 Trends in Mathematics and Science Survey among 45 participating nations (N=261,738) Reilly et al. (2019) found small to medium differences, with varied directions, and no global gender differences overall. In a meta-analysis of data from the US National Assessment of Educational Progress, Reilly et al. (2015) found small, but stable mean gender differences in mathematics and science achievement and that at the higher levels of achievement boys outnumber girls by a ratio of 2:1. In order to extend studies of achievement gaps to the early school years, several researchers have utilized the US Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999 (ECLS-K), a nationally representative cohort of children who entered kindergarten in 1998. Quinn and Cooc (2015) examined gender (and race) achievement gaps in science in third grade in ECLS-K and found that boys score approximately one quarter of a standard deviation higher than the girls. Quinn and Cooc (2015) also extended their study to eighth grade and found that controlling for prior mathematics achievement explained the entire eighth-grade science gender gap. Curran and Kellogg (2016) analyzed the ECLS-K 2010–2011 and did not find a gender gap in science achievement in kindergarten and only a small gap by the end of first grade, indicating that the gender gap found by Quinn and Cooc (2015) develops during the first years of schooling.

Cognitive Abilities

In a review of studies of observed gender differences in cognitive and motivational factors that affect women's decisions to opt out of mathematics-intensive STEM fields, Wang and Degol (2017) distinguish between biological and sociocultural explanations for observed gender differences. Studies investigating cognitive ability as linked to women's and men's differential participation in science suggest that such gender differences are not a result of differences in absolute cognitive ability, but rather linked to differences in the breadth of cognitive ability (Valla & Ceci, 2014). Individuals with similar cognitive abilities in mathematics and verbal skills are more likely to pursue non-STEM careers and since ability patterns are divided by gender, with women typically having more evenly distributed cognitive abilities across different fields, Wang et al. (2013) argue that this could be an important explanatory factor for the lack of women in mathematics-intensive STEM fields. However, the findings of studies examining the link between biological factors (such as brain lateralization) and the different cognitive profiles of men and women are inconclusive (Miller & Halpern, 2014). Research on cognitive abilities have also focused on ability beliefs, bringing this forward as potentially contributing to the underrepresentation of women in mathematics-intensive STEM-fields. Studies show that individuals are more likely to rate male-dominated fields than female-dominated fields as requiring raw intellectual talent or brilliance (Leslie et al., 2015; Meyer et al., 2015). Meyer et al. (2015) suggest that adults' field-specific ability beliefs, together with the stereotype that females are less likely than males to be brilliant, could lead to differences in how adults encourage girls' and boys' interests and provide them with opportunities to develop skills in different fields.

Stereotypes and Bias

The impact of stereotypes and bias is another area of research seeking to understand gender gaps. In the Global North, children as young as six years old subscribe to the stereotype of mathematics and science as male domains (Miller et al., 2015). Carli et al. (2016) examined the stereotypes about men, women, and scientists and found greater similarity between stereotypes about men and stereotypes about scientists than between stereotypes about women and scientists. They also found that in fields with a higher proportion of women, the stereotypes about scientists in that field was closer to the stereotype about women. Similarly, Ramsey (2017) found that agentic traits, which are typically associated with men, are considered more important for success in science than communal traits, which are typically associated with women. There is substantial evidence suggesting that stereotype threat can impact both the retention and performance of women in science (Smith et al., 2015) as well as women's career choices (Deemer et al., 2014). This has been conceptualized in the phenomenon *stereotype threat*. In this phenomenon, stereotypes held about a particular group (women; women of color) create psychologically threatening scenarios wherein individuals fear that they may be judged based on their membership in that group. This, in turn, inhibits their learning and can impact their performance (most often assessed on tests or exams). Smith et al. (2015) found that female students perceived less stereotype threat in female-dominated biology courses. Similarly, Taasoobshirazi et al. (2019) found that stereotype threat did not impact students' performances in biology and concluded that the negative effects of stereotype threat are found predominantly in physics, engineering, and mathematics fields. There is also evidence that agreeing with a gender stereotype correlates negatively with the performance of female students in physics (Maries et al., 2018). In addition, Makarova et al. (2019) found that women who held a strongly masculine image of mathematics and science were less likely to choose a science major at university. The extent to which the stereotype that science is a masculine profession is endorsed also varies between different national contexts, and in nations with a higher proportion of women employed in science such stereotypes are less likely to be explicitly endorsed (Miller et al., 2015).

There is also research indicating that stereotypes and biases lead to discriminatory practices. For example, Reuben et al. (2014) found that when female and male applicants who performed equally on a mathematical task applied for a hypothetical job, male candidates were twice as likely to be recommended for the position as females. Research has demonstrated that gender bias exists in hiring practices (Eaton et al., 2020), granting (Fox & Paine, 2019; Witteman et al., 2019), grading (Hofer, 2015), and in students' evaluations of teachers and professors (Graves et al., 2017). Regarding the latter, research has shown that male students underrate female high school teachers in biology and chemistry, while all students underrate female teachers of physics (Potvin et al., 2009). Following up on this work, Potvin and Hazari (2016) found that students who report a strong physics identity show a larger bias in favor of male teachers than those who report less strong physics identities. These results suggest a mechanism by which the physics community upholds the gender status quo, as younger members of the community move through inbound trajectories into physics membership. This is not a phenomenon that is isolated to physics. A recent social network analysis demonstrated that students in university biology classrooms over-nominate their male peers as knowledgeable about course content (Grunspan et al., 2016). This was predominantly due to male students over-nominating their male peers where female students nominated knowledgeable others based on student performance rather than gender. The researchers suggest that the favoring of male students by their peers can result in over-confidence, thus contributing to their persistence in biology.

Imposter Syndrome

The imposter phenomenon was first described in the late 1970s (Clance & Imes, 1978) to understand why highly successful women had difficulty recognizing their own achievements, and described feeling as imposters in their career fields. Since then, science education researchers have investigated the impact of the imposter phenomenon on gendered participation in the sciences. Generally, imposter syndrome is defined by attributing one's success in a field to luck or being in the right place at the right time. Imposter syndrome can also attribute success to hard work rather than natural ability. Ivie et al. (2016) suggest that women in astrophysics are more likely to have imposter syndrome than men, and that women who felt like imposters were more likely to take a path that led out of the field.

Self-efficacy, Self-determination, Interest, and Sense of Belonging

A set of studies have shown that male and female students have different interests toward science studies and careers and that those differences are attributed to various factors ranging from cognitive to sociocognitive ones, such as self-efficacy, self-determination, and sense of belonging in science. In a study with Finnish students, Kang et al. (2019) examined to what extent relationships between factors of students' science interest and career perspectives differ between male and female. With the use of a sample of 13-year-old students (N=401), the researchers found that there were strong gender differences regarding interest and preferences of science subjects as well as their relationship toward future careers. With regard to future careers, female students' science interest was positively correlated with time- and motivation-oriented career perspectives, while male students' science interest was positively correlated with outcome-oriented career expectations. Biology was preferred by females and physics and chemistry were preferred by males. Similar results have also been found in the South African context, where Grade 7 boys preferred chemistry and physics and Grade 7 girls biology and astronomy (Reddy, 2017).

Gender differences have also been found in relation to *self-efficacy*, where studies have found that female students have lower self-efficacy than male students in physics, while findings concerning other STEM disciplines are mixed (Cheryan et al., 2017; Kalender et al., 2020; Nissen, 2019; Nissen & Shemwell, 2016; Verdín et al., 2020). This is important since self-efficacy is highly correlated with performance, student persistence, and career aspirations, especially in physics (Henderson et al., 2020). In a longitudinal study carried out in the United States, Kalender et al. (2020) surveyed about 1,400 students in an introductory physics course to examine female and male students' self-efficacy scores and the extent to which self-efficacy is related to learning outcomes and gender differences in conceptual post-test scores. The findings showed that initial self-efficacy differences showed a direct effect on outcomes and that self-efficacy had the strongest total gender effect on conceptual learning. Marshman et al. (2018) examined the self-efficacy of male and female students with similar performance in introductory physics courses. They found that female students had significantly lower self-efficacy compared to their male students in all grade groups. In fact, female students receiving A's had similar self-efficacy to male students receiving C's.

Besides cognitive factors, sociocognitive factors were found to explain women's underrepresentation in science (Kelly, 2016). For example, a recent study applied the sociocognitive construct of self-determination to analyze six undergraduate female students' experiences leading to their choice of physics study, along with factors affecting their persistence in the context of an undergraduate physics program in the United States (Nehmeh & Kelly, 2020). The findings of the study revealed that the support of faculty, research opportunities, and peer socialization contributed to the development of self-determination. Hindrances to the participants' undergraduate experiences included negative gender stereotypes, persistent self-doubt, minority status, and unwelcoming classroom cultures. Similar findings were produced in a study carried out by Tellhed et al. (2017), who tested self-efficacy and social belongingness expectations as mediators of gender differences in interest in STEM in a representative sample of 1,327 Swedish high school students. The findings of this study showed that gender differences in interest in STEM majors strongly related to women's lower self-efficacy for STEM careers and, to a lesser degree, to women's lower social belongingness. These results imply that more attention is needed toward counteracting gender stereotypical competence beliefs while interventions need to focus on the social belongingness of students.

Social and cultural factors have been examined in chemistry as well. For example, Rüschenpöhler and Markic (2020) examined gender relations, the impact of secondary school students' cultural backgrounds and the impact of chemistry self-concept on learning processes in Germany. The findings of this mixed-methods study with 48 students showed that chemistry self-concept is strongly related to learning-goal orientations. Contrary to existing research evidence, the results of this study showed that the gender gap in relation to self-concept traditionally described in the literature was not found. Instead, the study provided evidence of how the interaction of gender and cultural background might influence chemistry self-concepts. Culture was central in a study situated in Kazakhstan, in Central Asia, exploring the experiences of female university students enrolled in STEM majors (Almukhambetova & Kuzhabekova, 2021). In carrying out this study the researchers were interested in how different cultures existing within the university and outside the university influence the girls pursuing education in STEM majors and how they deal with the conflicting ideological discourses in this unique context. With data collected through interviews with 14 purposefully selected women, the researchers provided evidence of the influence that three conflicting discourses had on the participants' experiences: the Western discourse emphasizing progressive norms and equal opportunities; the Soviet discourse that expects women to be educated and combine professional duties with family responsibilities; and the traditional discourse, which expects women to be attractive and prioritize family life and sees working in STEM as socially awkward.

Gendered/Sexual Harassment and Microaggressions

Several studies have identified sources of gendered discrimination in science, particularly in physics, astrophysics, and planetary science fields. Aycock et al. (2019) surveyed undergraduate women at a physics conference in the United States and found that three quarters of them had experienced at least one form of sexual harassment. They determined that experiences of sexual harassment can predict negative sense of belonging and imposter syndrome among women physicists. Similarly, Clancy et al. (2017) found that women of color frequently reported feeling unsafe in their workplaces in astronomy and planetary science fields, and this sometimes led to women skipping professional events and reporting a loss of career opportunities.

Repeated acts of sexual or gendered harassment in the form of "subtle and unintentional expressions" of sexism (Sue, 2010) are known as gender microaggressions. Barthelemy et al. (2016) detail the various types of microaggressions women experience in physics, reported from interviews with women in physics and astronomy. They found several microaggressive themes in women's narratives. For instance, women reported sexual objectification and detailed how this impacts possibilities for being viewed as professionals in the field. Women reported the use of sexist language and sexist jokes. Assumptions of inferiority were reported frequently along with restrictive gender roles where women were assumed to not have the physics strength or the spatial cognition skills to conduct physics. Similarly, women reported invisibility wherein participants reported not being heard or listened to by their peers. Finally, a form of microaggression women in this study reported is the denial of sexism, wherein peers refute the need for support for women in physics, denying that gender is an issue for them.

Part I: Summary and Synthesis

Research on gender gaps in science participation and achievement has long been an important part of research on gender and science education – and will probably continue to be so as long as such gaps exist. One strand of research has been predominantly focused on documenting differences in performance and participation, without dwelling deeper into the underlying causes to such differences. The preferred research methodology is large-scale quantitative studies. This research has been essential for revealing inequalities, and a strength is that this research can be generalized and generates easily communicable results. However, if the problem is represented as limited to numbers, the solution is likely to focus on, in Londa Schiebinger's words, "to fix the numbers" (Schiebinger, 2014). The research we have reviewed suggests that numerical parity is no guarantee that there will not be gender differences in participation. Hence, it is crucial for studies to take a wider perspective on participation (or achievement, for that matter). We suggest that studies that examine classroom interactions and the role that gender plays in structuring these continues to be an area that is understudied and useful to advancing the field. Even as science classrooms reach gender parity both in secondary schools and in post-secondary contexts, these studies can illuminate the gender inequities that are still produced in science learning contexts, showing that the problem is not one of numbers that can be easily fixed. Studies that seek to understand gender gaps have also uncovered a range of discriminatory practices ranging from unconscious bias to gender-based harassment. While this research firmly confirms that sociocultural factors (such as societal expectations on female/male differences in ability) are far more likely to explain gender gaps in science than biological differences (see also discussion in Wang and Degol [2017)], the quest for cognitive differences between men and women continues. We do not find evidence that such research contributes considerably to the understanding of gender inequities in science teaching and learning.

We wish to highlight that the studies reviewed in Part I largely rely on a taken-for-granted understanding of gender as another way to say "women and men", or even "women". The theorization of gender is limited and there is the risk that notions of gender as something binary and static are reinforced. To some extent, gender is problematized in terms of characteristics typically associated with men and women, but gender is mostly treated as categories. Consequently, research participants who do not fit neatly into the categories are at the risk of being made invisible. Further, such work has been criticized for reinforcing differences and not being able to count beyond two, with little room for investigating nuances in how gender is performed. The lack of clear definitions of gender and/or an explicit theoretical foundation is also problematic in that it potentially contributes to a lack of precision in findings. Partly as a response to perceived limitations with the scholarship focused on understanding gender gaps, science education researchers have sought theoretical inspiration from gender studies and cultural anthropology, conceptualizing gender and identity as performative. This is the scholarship we turn to next.

Part II: Identity-Based Approaches

In the past two decades there has been a growing interest in identity-based approaches to exploring how gender matters in science education and examining girls' and women's engagement with science. Quite a few researchers have used an identity lens to explore girls and women's self-identification with science as well as recognition by others (Brickhouse & Potter, 2001; Gonsalves & Danielsson, 2020; Scantlebury & Baker, 2007). For our discussion on identity, we take as a departure point the section in Kathryn Scantlebury's (2014) chapter "Gender and individuals". Whereas Scantlebury suggests that identity studies focus on individuals' engagement with learning science and career pathways, we suggest that *science identity* (Carlone & Johnson, 2007) as a broad concept now frames a range of research focused on gender and its intersections with other social identities. As such, we argue that the construct of science identity is of great importance when studying engagement with science because identity offers itself as a tool for examining the ways in which various cognitive and affective experiences influence the ways in which individuals might see themselves as science persons and also recognized by others (Avraamidou, 2020). Next, we review key studies in identity-based research that examined how gender identity might shape science participation across contexts and age levels. We begin with studies focused on performances of femininities and masculinities and then move on to studies that seek to scale up identity-based approaches, either by doing large-scale quantitative studies or by the development of teaching and learning interventions.

Femininity and Science

Femininity as a unit of analysis and investigations that seek to understand how cultural understandings of femininity in relation to science have consequences for students' identity work has been a consistent focus of study in science education research. In recent years, studies have begun to examine the cultural image of certain sciences, like physics, that appear to be particularly hostile to women (Archer et al., 2017; Archer et al., 2020a; Francis et al., 2017; Gonsalves, 2014). The cultural image of physics as "hard" (Whitten et al., 2003) or a "culture of no culture" (Traweek, 1988) has contributed to its persistent exclusion of femininity, which is deemed incompatible with physics (e.g., Francis et al., 2017).

Research that explores this supposed incompatibility draws predominantly from Butler (1999), who understands gender as performative, and performativity as salient to understanding the production of social identities (e.g., Archer et al., 2012b). The focus on performativity, and particularly the regulatory practices that govern intelligible notions of identity, permit an investigation into the various strategies or positions that girls especially must perform to be recognized as "intelligible" in science (Archer et al., 2017; Carlone, Johnson et al., 2015). An exception to this is the work of Simon et al. (2017), who investigated STEM majors' scores on masculine or feminine personality scales and the correlations with odds of majoring in a STEM field, and perceptions of a chilly climate in that field. The results of this study show that women who scored highly on the femininity scale were less likely to go into STEM careers, but this was not true for men who had a positive correlation between scoring highly on the femininity scale and going into STEM. The authors argue that this points to the different meanings of femininity and masculinity when embodied in women and men – it appears that men and women are rewarded differently for their feminine and masculine personality dimensions. For example, men who had more abundant feminine personality characteristics were associated with more positive perceptions of academic climate. They also reported that they received fairer treatment from their professors, more attention in class, and had more friends. Women who scored highly on the femininity index, on the other hand, had fewer friends in STEM than those who scored lower. The authors point to a "femininity penalty" for female STEM majors, that is not present in male counterparts.

This finding echoes qualitative work that has identified the various ways that femininity has been constructed as incompatible with science in its female embodied form. Francis et al. (2017) identified constructions of femininity as "superficial" and associated with an overall denigration of girly/super-feminine girls. Girly girls were deemed to be focused on their friends, lacking "strength of character", and would be dissuaded from science because of its association with "manual and/or dirty work" (p. 1104). The contradiction between girly girls and science has been documented elsewhere (Gonsalves, 2014), where girliness is regarded in contradiction with science. Gonsalves (2014) found that women doctoral students in physics were positioned as "Other" because of gender norms, while some women were found to be compromising their femininities and performing gender neutrality or "androgynous" performance in order to fit into the dominant culture of their department. In a recent study, Godec (2020) described hyper-femininity as involving an investment in personal appearance, flirtatiousness, and popularity. Godec notes that hyper-femininity is not always (hetero)sexual and takes care to note that it is distinct from emphasized femininity (Connell, 2013). Emphasized femininity (discussed next) can include more restrained performances of "good girls" or "nice girls" and relates more concretely to a middle-class femininity. Godec (2020) argues that hyper-femininity is reprimanded and positioned at odds with science. Thus, in contexts where hyper-femininity is rewarded with popularity and friendship, "cool girls" will reject science to embrace hyper-femininity.

Balancing Performances of Femininity

Researchers have identified multiple constructions of femininity in relation to science, some that are not entirely regarded as incompatible with science identities.

In a UK study of with working-class girls between 11 and 13 from diverse ethnic backgrounds, Godec (2018) found that five science-identifying girls negotiated their identification and engagement with science through several different discursive strategies: (1) rendering gender invisible, (2) drawing attention to the presence of women in science, (3) reframing "science people" as caring and nurturing, and (4) cultural discourses of desirability of science. Reframing "science people" as nurturing and caring makes identifying with science more "intelligible" but simultaneously reifies the desirable femininity as contradictory to "dirty" fields, like engineering. A similar formulation of science identity in relation to femininity can be seen in the "pleasers" identified by Carlone et al. (2015). In a fourth-grade class, girls performed different versions of femininity and identified a proper femininity (e.g., the proper way of being a girl in a school science class) as pleasing. Pleasers performed well scientifically and were recognized for their scientific performances. However, as girls moved along in their schooling trajectories, they continued to perform as pleasers but did not make further bids to be recognized scientifically. Pleasing was a dominant theme in research investigating emphasized femininity (Connell, 2013) in science. For example, Dawson et al. (2019) identified the "good girl student" identity performance among secondary students, which focuses on politeness and completion of tasks. However, these girls were largely concerned with maintaining a good student identity rather than connecting to science in any meaningful way. These middle school girls engaging with learning at a science museum seemed to resist meanings of science or scientists that were threatening to their "good girl student" performances. In the museum, there appeared to be limited available discourses of appropriate feminine behavior; as a result, girls risked compromising their good girl behavior to carry out learning tasks in the exhibits.

These kinds of performances of femininity have also been noted in workplace contexts. Mattsson (2015) describes a similar balancing of pleasing forms of femininity with engagement in science practices in the health sciences. Mattson notes that women researchers used the expression "good girls" to describe how hardworking they are. Hard work was celebrated (e.g., when publications or awards were received), but women also noted that they needed to balance achievements in order to not be seen as problematic by male colleagues. Thus, women took on roles as "responsible caregiver" in the department to dampen their effects of being bold intellectuals:

> According to this logic, the women in the Unit – successful and highly productive researchers – risked becoming problematic in the eyes of their male peers, but by being caring and responsible they established a form of middle-class femininity that made their subordinate feminine position clear.
>
> *(p. 692)*

It is worth noting that constructions of femininity should be regarded as local, as well as culturally and context specific. For example, research in British contexts suggests that working-class femininities are constructed in conflict with science (Dawson et al., 2019; Godec, 2020), while some cultural constructions of femininity (e.g., among first-generation youth from South Asian contexts) are seen as compatible with science identities (Godec, 2018). Moshfeghyeganeh and Hazari (2021) suggest that expressions of femininity in Muslim majority countries can have constructive intersections with physics identities and may in fact promote participation and persistence in physics. All local constructions of femininities, however, require strategies to navigate science, and build science identities, which we elaborate on next.

Strategies Used to Navigate Femininity and Science (Especially Physics)

Predominant in the literature investigating femininity and science were various strategies women and girls took to navigate discourses that denigrate femininity and position it outside of science. In an early study, Archer et al. (2012a) describe students positioning themselves as "feminine scientists" in attempt to balance identification with science with "appropriate" heteronormative femininity. The success of these performances depended on whether the girls were able to draw on aesthetic resources, such as being fashionable, sporty, or good-looking. Often, girls accomplished this by finding ways to render their science performances as "cool", so their identities as science people could be balanced out with positioning themselves as "normal girls". For girls invested in hyper-femininity in ways that position them outside of science, Godec (2020) found that their brief engagements with science can be supported by "popularity capital". Resources related to popular culture (and usually not available in school contexts) were mobilized to support engagement in science in ways that aligned with hyper-femininity. In these brief engagements, girls could hybridize science with their non-science interests and create possibilities shifts toward insiderness.

On the contrary, Archer and colleagues also identified strategies of "bluestocking scientists" – girls who were unable to draw on aesthetic embodied resources, and as such positioned themselves as "non-girly" and focused instead on academic success. These girls positioned themselves as different to other girls, thus aligning with common strategies to position femininity as "other" to science. Similarly, in a 2017 study, Archer and colleagues identified girls doing "geek chic" as a strategy to reconcile their "non-girly" gender performances with socially acceptable ways of being good at science. In this way, girls described being comfortable working in male-dominated environments and did not anticipate being put off by this in further education. Gender performances in relation to science that lean toward the masculine or position girls as "non-girly" do so while subjugating other gender performances; in particular, they denigrate hyper-femininity. However, Dawson and colleagues (2019) suggest that some masculine performances in science can also be transgressive rather than hegemonic. Their analysis of girls doing gender and science in a museum suggests that assertive performances interpreted as masculine can be strategies to challenge the limited identity positions available to them.

Finally, among faculty, Mattsson (2015) found that "sameness" operates as a protective strategy to cement women's presence in faculty. In this study, women faculty members in medicine were thought to adopt strategies of aesthetic sameness in which "They were united in a femininity that rendered them alike as white, middle-class, heterosexual women, that made them well adapted to the faculty of medicine, and that secured their position as women researchers" (p. 695). Mattson suggests that women in this unit "cloned" a collective femininity that strengthened their presence in the context of academia and as researchers in medicine.

Theorizing and Investigating Masculinities in Science Education

In some senses, investigating connections between masculinity and science/science education is not a novel research area. Feminist philosophers of science have long theorized and explored the masculine connotations of science (Harding, 1986; Schiebinger, 1991). Likewise, it is well-known that young people tend to see science as "for boys" (Archer et al., 2012b; Calabrese Barton & Tan, 2009), and it has been argued that physics education embodies an understanding of physics as a masculine activity (Hasse, 2002). Recent research studies have also confirmed how pupils view physics as a subject is strongly associated with masculinity (Archer et al., 2020a; Francis et al., 2017). The association between physics and masculinity is also entangled with notions of nerdiness (Johansson, 2018), connected to an interest in particular forms of science fiction (Hasse, 2015) and ways of using humor in physics teaching (Johansson & Berge, 2020). Research has also shown that the association of masculinity with science requires female science teachers to navigate students' and colleagues' stereotypical perceptions of women's incompatibility with science (Mim, 2020). Yet, studies of how men and boys relate to the teaching and learning of science is surprisingly sparse and the application of theories from masculinity studies unusual within science education. However, science education scholars are increasingly starting to utilize empirical studies to scrutinize constructions of masculinity within science, but in order to analyze how students from nondominant backgrounds may be marginalized, but also how to analyze the norms of particular science teaching and learning contexts.

Masculinity and Outsideness

In this section we focus on studies that in various ways highlight how masculinity performances are not always unproblematic in relation to science. Archer et al. (2014) has explored the role of masculinity within boys' negotiations of science aspirations, from a theoretical perspective of gender as performative (Butler, 1999) and masculinities as a "doing" (Connell, 2005). They identified five discursive performances of masculinity related to the boys' aspirations, two of which directly concern their relationship to science (termed "young professors" and "cool/footballer scientists"). Similarly, Archer et al. (2016) analyzed performances of masculinity, in this case in the context of school trips to science museums. Mark (2018) does not explicitly theorize masculinity, but the examination of how one African American male youth engaged in an informal STEM program intervention from a perspective of identity development shares an interest with Archer et al. (2014) and Archer et al. (2016), highlighting how male students from nondominant student populations relate to science. This line of scholarship thereby challenges the taken-for-granted association between masculinity and science by highlighting a range of masculinity performances, which to different extents are possible to combine with science participation. Further, the studies foreground the importance of considering the intersections of masculinity with class and race/ethnicity. For example, Archer et al. (2014) stress the importance of disrupting the association between science and middle-class "brainy" masculinity in order to make science more accessible to students from working-class backgrounds. In a forum paper written in response to Mark (2018), Rosa (2018) further stresses the complex dynamics of potentially utilizing the masculine connotations of science to attract men from non-hegemonic backgrounds to the discipline "while simultaneously working to deconstruct patriarchal views that seem to reinforce this very STEM image". A commonality across these studies is that they focus on increasing and widening participation in science by illuminating the identity work of students from nondominant backgrounds.

Masculinity and Insideness

One strand of research focuses on individuals from dominant backgrounds within science communities, who often are positioned as the invisible norm (Archer et al., 2020b; Carlone, Webb et al., 2015; Gonsalves et al., 2016), with the aim of scrutinizing norms and investigating how insideness is produced. Carlone et al. (2015) examined the school science trajectories of four scientifically talented and interested boys from fourth to sixth grades, asking the question "What kind of boy does science?" Theoretically, the article utilizes feminist and critical men's studies literature (Connell, 2005; Letts, 2001), conceptualizing masculinity performances as varying across time and context. They are also interested in how different masculinity performances are valued over others, and what constitutes a hegemonic masculinity (Connell, 2005) is a particular context. As such, the study seeks to trouble taken-for-granted notions of the link between science and masculinity. The analysis of the four boys' identity work shows that "being smart" is necessary but not sufficient in order to be positioned as scientific. The analysis also shows how science subject positions are related to class and ethnic positionings. Gonsalves et al. (2016) also have a similar research agenda, in that they focus on how different masculinities are produced and valued in particular contexts, in their case various experimental practices in physics higher education and research. They argue that:

> Men and cultures dominated by men within academic disciplines and research communities should also be analyzed as political categories and political subjects. In order to understand why physics in particular is still dominated by men, the cultures and actions that are associated with masculinity are analyzed.
>
> *(p. 2)*

Empirically, the article draws on case studies of three different physics contexts, and an important finding across all three case studies is a strong emphasis on physical skill, including the capability to engage with instruments designed for larger (male) bodies. By conceptualizing masculinity as performative, across both men and women, they are able to consider how masculine ideals are also negotiated and taken up by female physicists. Another study seeking to unpack the relationship between science and masculinity is Ottemo et al. (2021), who drawing on poststructural gender theory, explore how notions of corporeality, style, and aesthetics are articulated within two different computer engineering and physics higher-education settings. The authors investigate the co-production of disciplines and gendered forms of subjectivity, and while most informants understand their respective disciplines as gender neutral, they also acknowledge that being a student in the discipline is highly gendered. The analysis brings to the fore how notions of corporeality and style are central to such gendering. Archer et al. (2020b) take a different theoretical perspective by utilizing a Bourdieusian lens to explore how physics identity is shaped by habitus, capital, and field. The chapter investigates how and why White, middle-class boys are more likely than many other students to end up in physics, through a longitudinal case study of Victor, from age 10 to 18. The authors show how Victor's trajectory is strongly shaped by the cultivation of a particular kind of embodied masculine habitus, which also structures what is possible and desirable for boys like him.

Large-Scale Studies of Identity and Gender

As a means to extending the use of identity-based approaches beyond small-scale qualitative studies, researchers have begun to operationalize the concept of identity in ways that make up-scaling possible.

Drawing on social identity theory, Seyranian et al. (2018) examined the longitudinal effects of STEM identity and gender on flourishing and achievement in college physics in the United States. Data were collected from 160 undergraduate students enrolled in an introductory physics course who completed a baseline survey with self-report measures on course belonging, physics identification, and flourishing as the beginning of the course and a post-survey at the end of the academic term. Additional data were collected through force concept inventories and the use of physics course grades. The findings of this study showed that women reported less course belonging and less physics identification than men even though no gender disparities emerged for course grades. In addition, students with higher physics identification were more likely to earn higher grades, and students with higher grades reported more physics identification at the end of the term. For women, higher physics identification was associated with more positive changes in flourishing over the course of the term. These findings point to gender disparities in physics, especially in terms of belonging, and suggest that strong STEM identity may be associated with academic performance. Similar findings were produced in Kalender et al.'s (2019) study, which examined physics identity alongside other motivational constructs of male and female students (N=559) by administering a survey in introductory calculus-based physics courses at a large research university in the United States. The findings of this study showed that female students reported significantly lower identity scores than male students. The analysis revealed a statistically significant gender difference (lower for female students) for both physics identity items in the survey related to students' perceptions of both being a physics person and being recognized by others as a physics person.

Another large-scale study in the context of university physics in the United States is the one by Hazari et al. (2017), who examined when girls (N > 900) became interested in physics careers through a survey. The findings showed that the highest percentage of participants became interested in physics careers during high school and sources of recognition included the following: self-recognition, a perceived recognition from others, and a perceived recognition for other students around them. Interestingly, the most important source of recognition appeared to be the students' high school teacher. These findings point to the crucial role of high school teachers in supporting students, and especially girls, to develop strong physics identities. These findings conquer with the findings of a systematic review of empirical research, mostly large case studies (N=47) in the United States, published in the period of 2006–2017, that focused on the experiences of female students in STEM during middle school and high school, drawing on social identity theory (Kim et al., 2018).

In these studies, identity and/or identification with science is theorized in ways that are concomitant with the studies previously reviewed in Part II of the chapter, but gender is nonetheless treated in a categorical way, with a focus on (statistically significant) differences between male and female students.

Interventions Aimed at Supporting Science Identity and Belonging

In addition to up-scaling through large-scale quantitative studies, there is also a line of research seeking to extend small-scale explorative studies by the development of interventions that aim to support girls' science identity and belonging. The motivation for such studies is typically to come to terms with the underrepresentation of women in science fields and has targeted interventions toward girls and women in both informal and formal learning contexts.

Levine et al. (2015) studied the impact that a camp aimed at providing hands-on chemistry learning opportunities and featuring female chemistry role models and field trips had on middle school girls' excitement and appreciation for science. They found that short-term effects were positive, but they were unable to ascertain any longer-term impacts or shifts in identity work and career interest. Todd and Zvoch (2019) sought to measure the impact of an informal science intervention on middle school girls' science affinities. This study suggests that role messages, peer learning, and hands-on science experiments, which were featured in the program, are critical for girls' science identity and self-efficacy development. The emphasis on these features, rather than content knowledge, is thus understood to be critical to the program's success in improving girls' self-efficacy and science attitudes. While these interventions suggest short-term gains in terms of interest and attitudes, we do not know what the long-term impact is on how girls view science in their lives and whether science becomes a part of their career paths. In addition, we cannot know from these kinds of studies what the impact might be on girls' identity work in science.

Adopting sociocultural frameworks highlighting the importance of attending to identity, some recent research in physics education has aimed to construct formal learning environments for girls that focuses on strategies to develop a sense of self as a physicist. Following a 2013 study by Hazari et al., suggesting that talking about underrepresentation can be critical to supporting girls' identity development in physics, Lock and Hazari (2016) have investigated the impact that classroom conversations about women's minoritization in physics can have on girls' physics identities. This study reports that opportunities to gather and talk about underrepresentation can be an effective strategy to "buffer" against the ill effects of minoritization that women feel in male-dominated fields like physics. They found that explicit opportunities to discuss underrepresentation can shift young women's figured worlds about the norms in physics and open up possibilities for identity shifts to insiderness in physics. Similarly, Wulff et al. (2018) demonstrate that constructing deliberate environments for young women to engage in physics learning in small, single-sex groups at a Physics Olympiad appeared to create possibilities for them to access increased opportunities for recognition and thus to develop their physics identities. Despite the emphasis on identity work in formal and informal learning contexts, these studies do not interrogate binary constructions of gender, or what Traxler et al. (2016) call the "gender-binary deficit model", and the constructions of masculinities and femininities in science learning contexts.

Part II: Summary and Synthesis

Unlike the studies reviewed in the previous part that have treated gender as a category, the studies reviewed in Part II have treated gender as "performance" and hence researchers engaged with the constructs of "femininity" and "masculinity" to examine science participation through the lens of science identity. Over the past 20 years, science education research has seen a large increase in studies adopting identity-based approaches (Danielsson et al., in review). Theoretically, many studies are inspired by cultural anthropology (Gee, 2000; Holland et al., 2001; Lave, 1996), and in the studies reviewed in Part II such a theoretical vantage point is often combined with a poststructuralist perspective of gender (Butler, 1999). This allows for detailed and nuanced investigations of how gender is performed in particular contexts. Embarking from the fact that science has historically been constructed as masculine, researchers have examined how women navigate their presence in science environments or how they author their science identities. The findings of this set of studies, largely qualitative, point to the fact that femininity has been constructed as incompatible with science identity, and hence those performing more feminine identities have been constructed as "other" in science. However, as another set of studies showed, femininity is not a binary construct. Instead, femininity, being culture-dependent, is enacted through different kinds of performances with unique characteristics, and each of those shape how those performing such identities are recognized (or not) in science contexts. These studies have been very successful in showcasing the great variety in how students engage with science in various contexts.

Theoretically situated in similar underpinnings, another set of studies have adopted a large-scale, quantitative approach to examining women's science identity. Despite their usefulness in producing more generalizable claims, these studies have treated gender as a category instead of performance, and hence fail to provide insights about the nuance, complexity, and specificity of gender performances and how those might cause misrecognition and make certain bodies vulnerable. Moreover, when utilizing a performative view of gender, there is scope for decentering gender performances from sexed bodies, but among the reviewed studies, those that center femininity tend to focus on girls and studies that center masculinity tend to focus on boys. As such, there is a risk that gender binaries are reproduced by the very studies that seek to critique them, in that girls' doings are equated with femininities and boys' with masculinities. This risk might be even greater in studies that operationalize gender and identity in ways that make the concepts possible to adapt to large-scale quantitative studies – at the same time that such studies are pivotal for extending findings beyond the scope of small-scale qualitative case studies.

Part III: Emerging Perspectives

In studies of gender and science education we can discern two main approaches; the treatment of gender as something categorical (basically equated to "men and women") and the conceptualization of gender as performative and, as such, interrelated with identity performances in a broader sense. Both these approaches have been present in science education research for at least 20 years and can be considered consolidated fields of research. Getting sight of emerging perspectives is more challenging, but in this third part of the review we would like to highlight three contemporary trends: intersectional perspectives, queer perspectives, and posthumanism. Identity-based approaches to studies of gender in science education have since the beginning to some extent attended to intersections between gender and race/ethnicity (see, for example, Brickhouse & Potter, 2001), but we have chosen to include intersectionality among the emerging perspectives, as intersectionality recently has been more theoretically pronounced in science education and also empirically extended beyond studies of gender and race/ethnicity.

Intersectional Approaches

In the past couple of years, we witness more and more studies adopting intersectional approaches to examining gender in science participation. As a term, coined by Kimberlé Crenshaw in 1989 to counter the disembodiment of Black women from law, intersectionality captured the inadequacy of legal frameworks to address inequality and discrimination resulting from the ways race and gender intersected to shape the employment experiences of Black women (Crenshaw, 1989). Since then, intersectionality theory has transcended the boundaries of legal research and the US context and found application in various other geographical contexts and disciplines. Ringrose and Renold (2010) argued that feminist researchers invested in understanding women's experiences must continue to develop intersectional approaches that challenge "regulative gender and (hetero)sexual discourses, as these are cross-cut by race, class, cultural and other specificities" (p. 591).

Charleston et al.'s (2014) study examined the role of race and gender in the academic pursuits of 15 African American women in STEM. The findings of the study showed that the participants faced a series of racial and gender challenges related to their educational trajectories, felt marginalized as persons of color, and shared a sense of cultural isolation in departments heavily populated by White males, which essentially points to the double bind: the simultaneously experienced sexism and racism in STEM careers. Similar findings were produced in Rosa and Mensah's (2016) study, which explored the life histories of six African American women in physics. The analysis of the interview data revealed specific commonalities in their experiences. The first one is that all participants felt isolated in the academy, especially as members of study groups in which they felt excluded. The second one is that they all participated in after-school or summer school programs where they were exposed to a science environment at an early age. Lastly, all participants had opportunities to engage in summer research programs along with their academic training and to be members of a community of practice. Collectively, what these three studies show, is the sexism and racism that women of color face throughout their STEM career trajectories, and at the same time they highlight the importance of examining gender in conjunction with race, especially for women of color, when examining STEM career trajectories.

In order to examine the role of safe social places or counterspaces that women seek during their STEM trajectories, Ong et al. (2018) analyzed interview data collected from 39 women of color in the United States. These women were purposefully selected to comprise a group of varying racial/ethnic groups, career stages, and STEM disciplines. In dealing with negative experiences in STEM, the participants looked for counterspaces that provided critical support for their persistence in STEM, however. These counterspaces occurred in a variety of settings and served different functions: (1) counterspaces in peer-to-peer relationships, (2) counterspaces in mentoring relationships, (3) counterspaces in national STEM diversity conferences, (4) counterspaces in STEM and non-STEM campus student groups, and (5) STEM departments as counterspaces. These findings offer useful insights, especially for STEM university departments seeking to be counterspaces for women of color.

Similar findings are found in other levels of education, such as teacher education, STEM university education, as well as school science. A key study in teacher preparation is the one carried out by Moore-Mensah (2019), who examined the journey of an African American female (Michelle) in science teacher education by looking at her educational history from childhood to teacher education and professional life as an elementary teacher with a focus on how she viewed herself as a science learner and as a science teacher. The findings of this study exemplified issues related to underrepresentation of both Black preservice teachers as well as instructors and the emotional impact that this underrepresentation had on Black preservice teachers. The findings also showcased how specific courses on teacher preparation might serve as transformative experiences. One such example is provided in this work, which is a course taught by the author, who is an African American woman, and which provided opportunities for discussions about the intersections of race, ethnicity, gender, and class in their role on the development of science teachers.

In contrast with Moore-Mensah's study, Wade-Jaimes and Schwartz's (2019) ethnographic study with a group of seventh-grade African American girls illustrated how dominant discourses of education, science, race, and gender led to the exclusion of these girls. The findings of the study showed that although the girls tried to engage in scientific practices, they did not receive positive recognition from their teacher. In fact, the students were recognized for copying from sources and memorizing facts, which encouraged a passive and noncreative participation in science, which favored specific types of students. Most of the girls, however, did not fit within that type of student, and hence did not receive positive recognition from their teacher. This finding illustrates how narrow, limiting, and exclusionary the dominant discourse of school science is.

As evidenced in this brief review of key studies that adopted intersectional approaches to examining girls' and women's participation in science, these have predominantly focused on the experiences of Black women and women of color. This points to a gap in knowledge when it comes to other types of identity intersections, for example, ethnic identity, religious identity, social class, disability, and motherhood. A couple of studies aiming to address these types of identity intersections provide evidence of a different set of barriers that women in science face.

Using science identity as a unit of analysis, Avraamidou (2020) explored the barriers, difficulties, and conflicts that Amina, a young Muslim immigrant woman in Western Europe, confronted throughout her trajectory in physics and the ways in which her multiple identities intersected. The main sources of data consisted of three long biographical interviews, which were analyzed through a constant comparative method. The findings of the study illustrated that Amina was confronted with various barriers across her journey in physics, with the intersection of religion and gender being the major barrier to her perceived recognition due to cultural expectations, sociopolitical factors, and negative stereotypes. Moreover, Amina's social class, religion, gender performance, and ethnic status positioned her as Other in various places throughout her trajectory in physics, and consequently hindered her sense of belonging. Two more recent publications also consider the impact that religion has on women's experiences, especially in physics. Avraamidou (2021) continues the exploration of women's experiences in physics, using explicitly intersectional frameworks to consider the "politics of recognition" and the local and contextual ways that bodies, identities, and associated cultural objects can contribute to misrecognition in physics. For example, Amina's story suggests that her Muslim identity (and associated cultural artifacts, like the hijab) contributed to her misrecognition in Western physics contexts. In contrast, in a study conducted with women in physics in Muslim majority countries, Moshfeghyeganeh and Hazari (2021) revealed a relative absence of such gender identity conflicts and negotiations. Taken together, these findings complicate notions that femininity is incongruent with physics and suggest that, rather, femininity needs to be understood in relation to science within the cultural contexts in which it is done.

In another understudied population, Castro and Collins (2021) investigated the experiences of Asian American women in STEM. In this study, the researchers interviewed 23 women who self-identified as Asian Americans and were either in a doctoral program or within five years of earning their degrees in STEM fields at the time of the study. The study is one of the very few studies that examine Asian Americans experiences with science in the US contexts where Asian Americans are commonly portrayed as a monolithic group and as incapable of assimilating into American society. Similarly with the findings of the studies reviewed earlier, the findings of the study provided evidence of how Asian American women are not validated in STEM, are perceived as outsiders, and experience microaggressions and harassment because of not fitting the "White male logic systems".

Queer Theory and LGBTQ+ Issues in Science Education

The teaching and learning of science intersect with issues of sexuality in several different ways, most directly as related to in the representation and experience of LGBTQ+ individuals in science disciplines (e.g., Barthelemy, 2020) and sex and sexuality as a teaching content in biology (e.g., Reiss, 1998). In addition, queer theory is used to explore the entanglement of sex, gender, and sexuality with science education. Queer theory seeks to deconstruct sexuality and gender, and to destabilize binary constructs, such as gay/straight. In studies of science education queer theory first appeared in the early 2000s. Early work includes Letts's (2001) analysis of heteronormativity as part of the hidden curriculum in primary school science. Later, Bazzul and Sykes (2011) used queer theories to analyze how gender and sexuality were addressed in biology textbooks.

LGBTQ+ Students and Teachers in Science Education

Sansone and Carpenter (2020) use survey data to analyze the representation of LGB individuals in STEM fields. They found that men in same-sex couples were less likely to have completed a bachelor's degree in a STEM field compared to men in different-sex couples, but found no difference for women in same-sex and different-sex couples. They also found that the representation of gay men in STEM fields were positively associated with female representation in those STEM fields. Sansone and Carpenter conclude that:

> Taken together, these patterns are highly suggestive that the mechanisms underlying the very large gender gap in STEM fields such as heteropatriarchy, implicit and explicit bias, sexual harassment, unequal access to funding, and fewer speaking invitations are related to the factors driving the associated gap in STEM fields between gay men and heterosexual men.
> *(p. 12)*

There are also studies of the experiences of LBTQ+ individuals in STEM. In a national survey of LGBTQA individuals in STEM careers in the United States, Yoder and Mattheis (2016) found that participants who described their workplace as welcoming and safe reported greater openness to colleagues and students. They also found that participants who worked in STEM fields with a higher proportion of women were more likely to be out to colleagues. Consequently, in line with Sansone and Carpenter (2020), they also make a connection between the gender gap and the experiences of LGBTQA individuals, hypothesizing that a better gender parity in a workplace also fosters a more inclusive climate for LGBTQA individuals. In a qualitative survey study of the field of physics specifically 71 out of 324 respondents reported some form of exclusionary behavior or harassment, most often based on their gender expression or being a woman (Barthelemy, 2020). A survey of biology college instructors in the United States found that over half of the biology instructors surveyed were out to their work colleagues, but less than 20% were out to their students (Cooper et al., 2019). In interviews following the survey, instructors reported that reasons for being out in class included providing students with LGBQ role models in science, but some were also worried about students developing negative views of the instructor if they were out in class. Studies of students are more unusual, but a study of student retention among students who identify as a sexual minority (for example, lesbian, gay, bisexual, or queer) using US national longitudinal survey data showed that sexual minority students were less likely to be retained in STEM compared to their heterosexual peers.

To summarize, the studies of LGBTQ+ teachers and professionals, and to a lesser extent students, in STEM fields are mostly quantitative, sometimes with qualitative components. The purpose of the studies is typically to uncover inequalities, within an agenda of inclusion. Sexuality is problematized in the sense that the use and definition of acronyms (e.g., LGBQ, LGBTQA) are discussed, but mostly sexuality is operationalized as a variable that can be neatly captured by multiple-choice questions. It can also be noted that all studies reviewed have been carried out in the US context.

Queering Science Teaching and Learning

In the handbook chapter from 2014, Scantlebury called for an increase in the use of queer theory within science education research. The development of this area has been slow, but a major contribution was made recently by an anthology collecting work that queers STEM education (Letts & Fifield, 2019). The chapters concern a variety of disciplinary areas, such as environmental education and higher-education physics, and both informal and formal education, from elementary to higher education. An important objective of the volume is also to move the discussion beyond a project of equal rights for LGBTQ people, to use queer theory and allied perspectives as a way to question what is perceived as normal and release new possibilities for reimagining the world. Gunckel (2019b) argues that "queering the constructions that legitimize the discrimination in the first place, and thus insists that we (re)imagine and (re)construct our world to eliminate the normal/queer binary altogether" (p. 150). Further, Knaier (2019) stresses that problems caused by restricting two-category systems of boys/girls or masculine/feminine cannot be solved by adding more categories, but that the categorizing in itself is problematic. Instead, she proposes that we move beyond gender, not by ignoring or erasing gender identities, but by using queer theory to challenge the idea of normative gender and sex identities. Götschel (2019) brings queer theory into the higher-education physics classroom, leveraging its potential to scrutinize what is supposed to be normal and what is invisible or silenced and thereby making the familiar strange. In particular, she is interested in its potential for reflecting on the discursive production of physical knowledge and questioning hegemonic narratives of physics and physicists. In the context of biology teaching, Reiss (2019) and Gunckel (2019a) both argue that a consideration of queer theory can provide both a richer understanding of the content at hand and a more inclusive teaching. Reiss (2019) argues that conventional teaching about sex and sexuality in biology tend to represent poor science, and queering the way sex and sexuality is taught in school science will allow for a richer understanding of (human) sexuality and what it is to be a sexual person. Such a teaching could have implications both for students' views of science and of themselves and their sexuality. In summary, Reiss concludes that queer approaches to teaching about sex and sexuality within the science curriculum can "aid human flourishing, enable students to gain more powerful knowledge, and address social injustices' (p. 265). Gunckel (2019a) analyzes an elementary school science lesson about crayfish and shows how a focus on dichotomies and categorization hides the diversity of sexual morphologies and reproductive processes, something that not only is poor science but, she argues, can also be harmful to students who have non-normative bodies and identities.

A related strand of research unpacks how gender is discursively produced in classrooms, and studies have highlighted the ways that classroom talk and interactions discursively produce masculinity and femininity in science contexts. Orlander (2016) investigates how the ways teachers communicate invoke masculinity and femininity in examples from biology and how this constructs notions of "natural" sexual behavior in humans. Orlander (2020) examines how masculinities and femininities are mobilized in argumentation in science classrooms, in the context of debates around sustainable development. These studies suggest that disciplinary content is imbued with masculinities and femininities, in which masculinity and heteronormativity is privileged, and send normative messages about gender roles through science.

Posthumanism

Scantlebury's (2014) chapter identified material feminism as a new direction for gender and science education research. Scantlebury provides an overview of the manner in which language and discourse have been granted "too much power", according to Barad (2003), and highlights calls for research to engage with matter/material. In the years since the publication of Scantlebury's chapter, "new materialist" approaches to studying gendered participation in science education have begun to emerge. Other approaches relying on video ethnographic data and participant observation instead focus on embodied performances of gender and identity. Barad (2007), whose theoretical work has influenced new materialist orientations to research in science education, argues that we must also investigate the entanglement of discourse, language, embodiment, and matter. New materialist approaches to research in science education thus give possibilities to understand the identity performances of participants who do not possess language resources to narrate identity work. In very recent years, we have begun to see research taking new materialist perspectives to understand the gendered identity work of youth and very young children in relation to science and technology.

Godec et al. (2020) have investigated the role that physical and digital materiality play in the identity performances of young people engaged in STEM learning in informal settings. While this research does not seek to understand gendered interactions with materials, the research draws on aspects of gender theory to understand how materials shape tech identity performances. Particularly, this group mobilizes the concepts of identity performativity (Butler, 1993; Butler, 1999) and intra-activity (Barad, 2007) to understand the ubiquitous presence and importance of materiality in the contexts of young people's STEM identifications. The findings suggest that reading material-discursive entanglements as identity performances can yield insights into the importance of intra-actions with matter in contexts where these might yield new forms of recognition that contribute to identity performances. These researchers additionally described intra-actions with the digital, thereby raising the possibility for nondiscursive and nonmaterial intra-actions to contribute to identity recognition. This work also raised equity issues when it came to gendered intra-actions with technological matter and the digital. The researchers noticed that even though youth were offered access to technology (e.g., via coding events), young women participating in the club tended toward verbal, pen-and-paper, and photographic modes of intra-actions, suggesting that these young people tended to engage with technology in ways that reproduce dominant gender relations.

Importantly, recognition emerges as a salient concept for investigating gendered intra-actions with materiality. Günther-Hanssen and colleagues (Günther-Hanssen, 2020; Günther-Hanssen et al., 2020) describes the intra-action between a preschool girl and a swing in ways that produce embodied understandings of physical phenomena, but also provide opportunities for the girl to be recognized as an insider to science phenomena (at least to the researcher and to the teacher observing her movements). These intra-actions, however, also create outsiderness when the girl's movements and intra-actions with the swing are usurped by a boy who uses the swing to gain attention from his peers. Gonsalves (2020) describes similar possibilities that intra-actions with materials in physics laboratories provide for recognition as an insider or expert in new ways. Investigating different forms of tinkering both in and outside of the lab, Gonsalves suggests that viewing tinkering through the lens of material-discursive intra-actions can yield new and unexpected possibilities to learn how students may become recognized as competent in physics on instruments "built with gender in mind" (Berg & Lie, 1995).

Scantlebury et al. (2019) use the concept of "material moments" (Taylor, 2013) to investigate how intra-actions produce space and time in classroom through moments of intra-action. By asking questions about space (how students are included and excluded in classroom spaces) and time (how students' movements through school are marked by time) in the intra-actions with matter (blackboards and textbooks) they explore how iterative diffractive readings of text can yield understandings about why students "get bored" with science. These readings highlight material-discursive practices in the classroom that send messages to students about the (gendered) forms of engagement in science that are welcomed (e.g., note taking) at the expense of their interest.

Part III: Summary and Synthesis

The studies reviewed in this section urge researchers to expand our understanding of issues related to gender and science learning beyond experiences that foreground binary formulations of gender and even performances of gender as central organizing concepts. This work challenges the primacy placed on gender in research and invites us to consider more broadly how the intersections of race, class, sexuality, identity, and gender interact to create environments where recognition is afforded or constrained in various ways. Additionally, this work challenges some of the primary constructs researchers use to investigate experiences of recognition. For example, Avraamidou (2021) suggests that current conceptualizations of recognition are themselves limited by a binary formulation where research focuses on opportunities where one is recognized or not. This approach masks complex interactions that can result in different forms of recognition, notably, misrecognition. These findings demand approaches to identity research that investigate these complexities and move beyond binary formulations both in how we treat gender and in how we seek to understand experience. Thus, we suggest that recent trends in research invite us to move *beyond gender* as a primary organizing concept, and rather to advance frameworks that seek to unpick the complexities of experiences, events, and interactions that shape individuals' modes of becoming in science learning environments.

In this section, we have reviewed three emerging perspectives that contribute richness and complexity to our understanding of minoritized learners' experiences in science. While the integrated treatment of gender and race/ethnicity is not new to science education research, a more explicit consideration of intersectionality provides depth to our understanding of the kinds of identities, bodies, and cultural objects are considered "in place" or "out of place" (e.g., Avraamidou, 2021) in science. There is also an emerging scholarship around gender and queer/LGBTQ+ perspectives that concerns both the identities of students/teachers and the science content as such. Still, studies of how gender intersects with other markers of identity, such as social class, age, and dis/ability, are largely missing. The material turn has slowly started to make its way into science education research, but considering how materiality and (human and animal) bodies are at the heart of science as a discipline, there is plenty of room for additional explorations of the entanglement of science learning, gender, identities, and bodies. In particular, questions around what it means for a body to be sexed/gendered in relation to materials in science learning spaces calls for increased attention, and posthumanism here provides a powerful theoretical vantage point.

Discussion and Future Directions

In the years since Scantlebury's (2014) chapter, there has been a sustained interest in gender issues within science education research. Studies that map and seek to understand gender disparities continue to form a substantial part of this research, but we have also witnessed a consolidation of identity-based approaches. Still, the conversation between studies in Part I and Part II of this chapter have been limited. This is perhaps not surprising given that the division between the two first parts of the review largely follows the divide between cognitive and sociocultural perspectives on (science) learning. But given the complexity of the issue of understanding (gendered) students' relationship to science as not only a (potentially gendered) body of knowledge but also a (gendered) cultural enterprise, the creation of silos of research that do not communicate with one another is unfortunate. While studies within the different traditions may be theoretically incompatible – for example, the implicit assumption about gender as binary and static that underlie some studies in Part I does not sit comfortably with a performative perspective of gender – work on stereotype threat, unconscious bias, and sense of belonging can be informative to studies using identity-based approaches. In synthesizing empirical evidence on gender and science education, one thing becomes clear: women's underrepresentation in science cannot be explained by cognitive differences or simply a lack of interest, but it is an issue of women being constructed as outsiders in science. This is illustrated through both international study results (e.g., PISA), which show that girls are less confident than boys in their science abilities even though they score higher in science tests, as well as small-scale studies that show that women are not recognized as competent science persons and that they face a series of barriers and constraints throughout their studies/careers in science.

In terms of disciplinary contexts, the majority of studies reviewed are found in the context of physics. This is perhaps not surprising given the fact that physics remains the most male-dominated scientific field. But this focus of research carries the assumption that gender perspectives are only useful in areas where there are inequalities in gender ratio. In terms of geographical contexts, the majority of the studies are situated in the Global North, specifically the United States, Canada, and Western Europe. As noted earlier, while intersectional studies are gaining increased traction, such studies still predominantly concern the intersection between gender and race/ethnicity. Further, studies almost exclusively deal with gender and science in terms of gender as something relevant to individuals and their relationship to science. Apart from a few notable exceptions, gender in the disciplinary content is not problematized. Empirical research gaps identified concerning gender and science education thus include:

- Studies of science disciplines other than physics, including boys' and men's gender performances in the female-dominated discipline of biology as well as studies of interdisciplinary areas
- Studies situated in a broader variety of national contexts
- Studies concerning the intersection of gender and social class, age, dis/ability, and religious affiliation that operationalize intersectionality to move beyond additive conceptions
- Studies of gender in the disciplinary content in biology, both in terms of assumptions carried by this content (such as companion meanings concerning heterosexuality) and in terms of the meeting between the content and students' sexed and gendered bodies (with a particular relevance for transgender and nonbinary students)
- Studies in the context of science teacher education and professional development

Methodologically, the field reviewed in this chapter is strikingly heterogeneous. Very broadly speaking we can discern large-scale quantitative studies (often operationalizing gender in terms of men/women), small-scale qualitative studies (often drawing on identity-based approaches), and intervention studies. However, few studies cross these methodological divides, and large-scale quantitative studies drawing on identity-based approaches are just starting to emerge. We also note that study designs often fall back on binary definitions of gender, even when made explicit that this is something the researchers are seeking to avoid. As intervention studies based in identity-based approaches to gender become more common it will be important to involve teachers in collaborative studies, to ensure that models for practice are based in systematic and reflected development that bridge across theory and practice (for example, by utilizing the idea of didactic modeling, see Sjöström, 2019). Thus, for a methodological point of view, we identify the need for:

- Mixed-methods studies that combine qualitative and quantitative elements
- Large-scale studies informed by identity-based approaches
- Study designs (both in quantitative and qualitative studies) that allow for the inclusion of transgender and nonbinary participants
- Collaborative studies involving researchers and teachers, including such studies set in the context of science teacher education and professional development
- An increased attention to how findings can be made transferable, both in terms of how large-scale quantitative studies can be made relevant for teachers and in terms of how small-scale qualitative studies can be made relevant for policy and for practitioners in other contexts

So far, we have discussed empirical and methodological gaps identified, with recommendations for future research. But how far will this take us? Filling the gaps outlined earlie will create a more solid and complete research basis for gender and science education as the field is currently understood and practiced. It is, however, notable that our synthesis of emerging perspectives remains similar to those outlined by Kathryn Scantlebury in her 2014 chapter in this handbook. For instance, we have found that emerging trends in gender research have focused on efforts to ensure that the "gender-binary deficit model" is not reproduced, and researchers have focused on identity negotiations in gender performances. However, science itself (and its practices) has been left untroubled and unchallenged by this identity turn in gender research. Furthermore, in our synthesis we notice an increasing distance from the critical feminist theories that laid the groundwork for research into gender issues in science. For example, in the late 1990s and early 2000s it was common to find gender research grounded in the work of Evelyn Fox-Keller (Keller, 1982, 1987), who challenged the masculine underpinnings of science, or Sandra Harding's work (e.g. Harding, 1991), which went further to critique science as an enterprise. Harding's criticism of *science-as-usual* challenges the ethics, goals, and functions of science and sees adding more women (by promoting equitable pedagogical and employment practices) as complicit with our culture's failure to confront the status quo in science. From a theoretical point of view, our recommendation is therefore to turn the critical gaze back at science. Feminist philosophers of science here provide a theoretical grounding for doing so; it is worth both returning to and building on the past (Harding, 1991; Keller, 1982) and looking into more contemporary developments in this field (Archer & Kohler, 2020; Barad, 2007).

In this context, it is worth repeating that "what the problem is represented to be" (Bacchi, 2012) is a key question to consider, both when research problems are justified and when implications for practice are presented. For example, if researchers – ourselves included – keep justifying gender studies in science education by existence of various forms of gender gaps, the problem is assumed to concern the number of men and women in a discipline. Much research today is still grounded in this goal of gender mainstreaming, asking questions about how to get more women into science or how to retain them once there. Maybe it is the narratives about the "need" to bring more students into science – which in effect contributes to solidifying the position of science as a superior – that ought to be disrupted? While critical of social practices that continue to discourage women in science or pedagogical practices that make them feel like science is "not for me", this kind of gender research has lost sight of the critique of science's history as an enterprise that is rooted in racism and the oppression of women and gender-diverse people (e.g., Carter et al., 2019), and settler colonialism (Bang & Marin, 2015). While the effect of bringing gender studies in science education research into the mainstream is overall very positive, we caution that losing sight of these critical perspectives may lead to practices aiming to promote gender equality (e.g., interventions that reproduce stereotypical ideas about gender roles) without changing the culture of science that women and other minoritized groups are entering. If we were to conclude this chapter with just one recommendation for studies of gender in science education, it would be: Bring feminism back!

References

Almukhambetova, A., & Kuzhabekova, A. (2021). Negotiating conflicting discourses. Female students' experiences in STEM majors in an international university in Central Asia. *International Journal of Science Education*, 1–24.

Andersson, S., & Johansson, A. (2016). Gender gap or program gap? Students' negotiations of study practice in a course in electromagnetism. *Physical Review Physics Education Research*, *12*(2), 020112.

Archer, L., Dawson, E., Seakins, A., DeWitt, J., Godec, S., & Whitby, C. (2016). "I'm being a man here": Urban boys' performances of masculinity and engagement with science during a science museum visit. *Journal of the Learning Sciences*, *25*(3), 438–485.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012a). "Balancing acts": Elementary school girls' negotiations of femininity, achievement, and science. *Science Education*, *96*(6), 967–989.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012b). Science aspirations, capital, and family habitus how families shape children's engagement and identification with science. *American Educational Research Journal*, *49*(5), 881–908.

Archer, L., DeWitt, J., & Willis, B. (2014). Adolescent boys' science aspirations: Masculinity, capital, and power. *Journal of Research in Science Teaching*, *51*(1), 1–30.

Archer, L., Moote, J., Francis, B., DeWitt, J., & Yeomans, L. (2017). The "exceptional" physics girl: A sociological analysis of multimethod data from young women aged 10–16 to explore gendered patterns of post-16 participation. *American Educational Research Journal*, *54*(1), 88–126. https://doi.org/10.3102/0002831216678379

Archer, L., Moote, J., & MacLeod, E. (2020a). Learning that physics is "not for me": Pedagogic work and the cultivation of habitus among advanced level physics students. *Journal of the Learning Sciences*, 1–38.

Archer, L., Moote, J., & MacLeod, E. (2020b). Lighting the Fuse: Cultivating the masculine physics habitus – A case study of victor aged 10–18. In *Physics Education and Gender* (pp. 29–51). Springer.

Archer, S. M., & Kohler, A. (2020). Feminist science studies. *Companion to Feminist Studies*, 247–263.

Avraamidou, L. (2020). "I am a young immigrant woman doing physics and on top of that I am Muslim": Identities, intersections, and negotiations. *Journal of Research in Science Teaching*, *57*(3), 311–341.

Avraamidou, L. (2021). Identities in/out of physics and the politics of recognition. *Journal of Research in Science Teaching* (online first).

Aycock, L. M., Hazari, Z., Brewe, E., Clancy, K. B., Hodapp, T., & Goertzen, R. M. (2019). Sexual harassment reported by undergraduate female physicists. *Physical Review Physics Education Research*, *15*(1), 010121.

Bacchi, C. (2012). Introducing the "what's the problem represented to be?" approach. In *Engaging with Carol Bacchi: Strategic interventions and exchanges* (pp. 21–24). The University of Adelaide Press.

Bang, M., & Marin, A. (2015). Nature – Culture constructs in science learning: Human/non-human agency and intentionality. *Journal of Research in Science Teaching*, *52*(4), 530–544.

Barad, K. (2003). Posthumanist performativity: Toward an understanding of how matter comes to matter. *Signs: Journal of Women in Culture and Society*, *28*(3), 801–831.

Barad, K. (2007). *Meeting the universe halfways. Quantum physics and the entanglement of matter and meaning*. Duke University Press.

Barthelemy, R. S. (2020). LGBT+ physicists qualitative experiences of exclusionary behavior and harassment. *European Journal of Physics*, *41*(6), 065703.

Barthelemy, R. S., McCormick, M., & Henderson, C. (2016). Gender discrimination in physics and astronomy: Graduate student experiences of sexism and gender microaggressions. *Physical Review Physics Education Research*, *12*(2), 020119.

Bazzul, J., & Sykes, H. (2011). The secret identity of a biology textbook: Straight and naturally sexed. *Cultural Studies of Science Education*, *6*(2), 265–286.

Berg, A.-J., & Lie, M. (1995). Feminism and constructivism: Do artifacts have gender? *Science, Technology, & Human Values*, *20*(3), 332–351.

Brickhouse, N. W., & Potter, J. T. (2001). Young women's scientific identity formation in an urban context. *Journal of Research in Science Teaching*, *38*, 965–980.

Butler, J. (1993). Critically queer. *GLQ: A Journal of Lesbian and Gay Studies*, *1*(1), 17–32.

Butler, J. (1999). *Gender Trouble. Feminism and the subversion of identity*. Routledge.

Calabrese Barton, A., & Tan, E. (2009). Funds of knowledge and discourses and hybrid space. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *46*(1), 50–73.

Carli, L. L., Alawa, L., Lee, Y., Zhao, B., & Kim, E. (2016). Stereotypes about gender and science: Women ≠ scientists. *Psychology of Women Quarterly*, *40*(2), 244–260.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*(8), 1187–1218.

Carlone, H. B., Johnson, A., & Scott, C. M. (2015). Agency amidst formidable structures: How girls perform gender in science class. *Journal of Research in Science Teaching*, *52*(4), 474–488.

Carlone, H. B., Webb, A. W., Archer, L., & Taylor, M. (2015). What kind of boy does science? A critical perspective on the science trajectories of four scientifically talented boys. *Science Education*, *99*(3), 438–464. https://doi.org/10.1002/sce.21155

Carter, D. F., Dueñas, J. E. R., & Mendoza, R. (2019). Critical examination of the role of STEM in propagating and maintaining race and gender disparities. *Higher Education: Handbook of Theory and Research*, 39–97.

Castro, A. R., & Collins, C. S. (2021). Asian American women in STEM in the lab with "White men named John". *Science Education*, *105*(1), 33–61.

Charleston, L., Adserias, R. P., Lang, N. M., & Jackson, J. F. (2014). Intersectionality and STEM: The role of race and gender in the academic pursuits of African American women in STEM. *Journal of Progressive Policy & Practice*, *2*(3), 273–293.

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others? *Psychological Bulletin*, *143*(1), 1.

Clance, P. R., & Imes, S. A. (1978). The imposter phenomenon in high achieving women: Dynamics and therapeutic intervention. *Psychotherapy: Theory, Research & Practice*, *15*(3), 241.

Clancy, K. B., Lee, K. M., Rodgers, E. M., & Richey, C. (2017). Double jeopardy in astronomy and planetary science: Women of color face greater risks of gendered and racial harassment. *Journal of Geophysical Research: Planets*, *122*(7), 1610–1623.

Connell, R. W. (2005). *Masculinities*. Polity.

Connell, R. W. (2013). *Gender and power: Society, the person and sexual politics*. John Wiley & Sons.

Cooper, K. M., Brownell, S. E., & Gormally, C. (2019). Coming out to the class: Identifying factors that influence college biology instructor decisions about revealing their LGBQ identities in class. *Journal of Women and Minorities in Science and Engineering*, *25*(3).

Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. *University of Chicago Legal Forum*, *139*.

Curran, F. C., & Kellogg, A. T. (2016). Understanding science achievement gaps by race/ethnicity and gender in kindergarten and first grade. *Educational Researcher*, *45*(5), 273–282. https://doi.org/10.3102/0013189x16656611

Danielsson, A., King, H., Godec, S., & Nyström, A.-S. (accepted). The identity turn in science education research: A review of a consolidating field. Accepted for publication in Cultural Studies in Science Education.

Dawson, E., Archer, L., Seakins, A., Godec, S., DeWitt, J., King, H., Mau, A., & Nomikou, E. (2019). Selfies at the science museum: Exploring girls' identity performances in a science learning space. *Gender and Education*, 1–18.

Day, J., Stang, J. B., Holmes, N., Kumar, D., & Bonn, D. (2016). Gender gaps and gendered action in a first-year physics laboratory. *Physical Review Physics Education Research*, *12*(2), 020104.

Deemer, E. D., Thoman, D. B., Chase, J. P., & Smith, J. L. (2014). Feeling the threat: Stereotype threat as a contextual barrier to women's science career choice intentions. *Journal of Career Development*, *41*(2), 141–158.

Eaton, A. A., Saunders, J. F., Jacobson, R. K., & West, K. (2020). How gender and race stereotypes impact the advancement of scholars in STEM: Professors' biased evaluations of physics and biology post-doctoral candidates. *Sex Roles*, *82*(3), 127–141.

Eddy, S. L., Brownell, S. E., & Wenderoth, M. P. (2014). Gender gaps in achievement and participation in multiple introductory biology classrooms. *CBE – Life Sciences Education*, *13*(3), 478–492.

Eliasson, N., Karlsson, K. G., & Sørensen, H. (2017). The role of questions in the science classroom – How girls and boys respond to teachers' questions. *International Journal of Science Education*, *39*(4), 433–452.
Eliasson, N., Sørensen, H., & Karlsson, K. G. (2016). Teacher – student interaction in contemporary science classrooms: Is participation still a question of gender? *International Journal of Science Education*, *38*(10), 1655–1672.
Fox, C. W., & Paine, C. T. (2019). Gender differences in peer review outcomes and manuscript impact at six journals of ecology and evolution. *Ecology and Evolution*, *9*(6), 3599–3619.
Francis, B., Archer, L., Moote, J., DeWitt, J., MacLeod, E., & Yeomans, L. (2017). The construction of physics as a quintessentially masculine subject: Young people's perceptions of gender issues in access to physics. *Sex Roles*, *76*(3), 156–174. https://doi.org/10.1007/s11199-016-0669-z
Gee, J. P. (2000). Identity as an analytic lens for research in education. *Review of Research in Education*, 99–125.
Godec, S. (2018). Sciencey girls: Discourses supporting working-class girls to identify with science. *Education Sciences*, *8*(1), 19.
Godec, S. (2020). Home, school and the museum: Shifting gender performances and engagement with science. *British Journal of Sociology of Education*, *41*(2), 147–159.
Godec, S., Patel, U., Archer, L., & Dawson, E. (2020). Young peoples' tech identity performances: Why materiality matters. *International Journal of STEM Education*, *7*(1), 1–12.
Gok, T. (2014). Peer instruction in the physics classroom: Effects on gender difference performance, conceptual learning, and problem solving. *Journal of Baltic Science Education*, *13*(6), 776.
Gonsalves, A. J. (2014). "Physics and the girly girl – There is a contradiction somewhere": Doctoral students' positioning around discourses of gender and competence in physics. *Cultural Studies of Science Education*, *2*(9), 503–521.
Gonsalves, A. J. (2020). Constructing inside-ness to physics: How matter comes to matter in physics identity work. *Cultural Studies of Science Education*, *15*(4), 911–921.
Gonsalves, A. J., & Danielsson, A. (2020). *Physics education and gender: Identity as an analytic lens for research*. Springer.
Gonsalves, A. J., Danielsson, A., & Pettersson, H. (2016). Masculinities and experimental practices in physics: The view from three case studies. *Physical Review Physics Education Research*, *12*(2), 020120.
Götschel, H. (2019). Teaching queering physics: An agenda for research and practice. In *STEM of desire* (pp. 125–145). Brill Sense.
Graves, A. L., Hoshino-Browne, E., & Lui, K. P. (2017). Swimming against the tide: Gender bias in the physics classroom. *Journal of Women and Minorities in Science and Engineering*, *23*(1).
Grunspan, D. Z., Eddy, S. L., Brownell, S. E., Wiggins, B. L., Crowe, A. J., & Goodreau, S. M. (2016). Males under-estimate academic performance of their female peers in undergraduate biology classrooms. *PLoS ONE*, *11*(2), e0148405.
Gunckel, K. L. (2019a). Repairing elementary school science. *Theory Into Practice*, *58*(1), 71–79.
Gunckel, K. L. (2019b). What does queer theory have to do with teaching science in elementary schools? In *STEM of desire* (pp. 147–159). Brill Sense.
Günther-Hanssen, A. (2020). A swing and a child: How scientific phenomena can come to matter for preschool children's emergent science identities. *Cultural Studies of Science Education*, *15*(4), 885–910.
Günther-Hanssen, A., Danielsson, A. T., & Andersson, K. (2020). How does gendering matter in preschool science: Emergent science,'neutral'environments and gendering processes in preschool. *Gender and Education*, *32*(5), 608–625.
Harding, S. (1986). *The science question in feminism*. Open University Press.
Harding, S. (1991). *Whose science? Whose knowledge? Thinking from women's lives*. Cornell University Press.
Hasse, C. (2002). Gender diversity in play with physics: The problem of premises for participation in activities. *Mind, Culture, and Activity*, *9*(4), 250–269.
Hasse, C. (2015). The material co-construction of hard science fiction and physics. *Cultural Studies of Science Education*, *10*(4), 921–940.
Hazari, Z., Brewe, E., Goertzen, R. M., & Hodapp, T. (2017). The importance of high school physics teachers for female students' physics identity and persistence. *The Physics Teacher*, *55*(2), 96–99.
Henderson, R., Sawtelle, V., & Nissen, J. M. (2020). Gender & self-efficacy: A call to physics educators. *The Physics Teacher*, *58*(5), 345–348.
Henderson, R., Stewart, G., Stewart, J., Michaluk, L., & Traxler, A. (2017). Exploring the gender gap in the conceptual survey of electricity and magnetism. *Physical Review Physics Education Research*, *13*(2), 020114.
Hofer, S. I. (2015). Studying gender bias in physics grading: The role of teaching experience and country. *International Journal of Science Education*, *37*(17), 2879–2905. https://doi.org/10.1080/09500693.2015.1114190
Holland, D., Lachicotte Jr, W., Skinner, D., & Cain, C. (2001). *Identity and agency in cultural worlds*. Harvard University Press.

Ivie, R., White, S., & Chu, R. Y. (2016). Women's and men's career choices in astronomy and astrophysics. *Physical Review Physics Education Research*, *12*(2), 020109.

Jacobs, J. E. (2005). Twenty-five years of research on gender and ethnic differences in math and science career choices: What have we learned? *New Directions for Child and Adolescent Development*, *2005*(110), 85–94.

Johansson, A. (2018). Negotiating intelligence, nerdiness, and status in physics master's studies. *Research in Science Education*, 1–22.

Johansson, A., & Berge, M. (2020). Lecture Jokes: Mocking and reproducing celebrated subject positions in physics. In *Physics education and gender* (pp. 97–113). Springer.

Kalender, Z. Y., Marshman, E., Schunn, C. D., Nokes-Malach, T. J., & Singh, C. (2019). Gendered patterns in the construction of physics identity from motivational factors. *Physical Review Physics Education Research*, *15*(2), 020119.

Kalender, Z. Y., Marshman, E., Schunn, C. D., Nokes-Malach, T. J., & Singh, C. (2020). Damage caused by women's lower self-efficacy on physics learning. *Physical Review Physics Education Research*, *16*(1), 010118.

Kang, J., Hense, J., Scheersoi, A., & Keinonen, T. (2019). Gender study on the relationships between science interest and future career perspectives. *International Journal of Science Education*, *41*(1), 80–101.

Kanny, M. A., Sax, L. J., & Riggers-Piehl, T. A. (2014). Investigating forty years of STEM research: How explanations for the gender gap have evolved over time. *Journal of Women and Minorities in Science and Engineering*, *20*(2).

Keller, E. F. (1982). Feminism and science. *Signs: Journal of Women in Culture and Society*, *7*(3), 589–602.

Keller, E. F. (1987). On the need to count past two in our thinking about gender and science. *New Ideas in Psychology*, *5*(2), 275–287.

Kelly, A. M. (2016). Social cognitive perspective of gender disparities in undergraduate physics. *Physical Review Physics Education Research*, *12*(2), 020116.

Kim, A. Y., Sinatra, G. M., & Seyranian, V. (2018). Developing a STEM identity among young women: A social identity perspective. *Review of Educational Research*, *88*(4), 589–625.

Knaier, M. L. (2019). What makes girls and boys so desirable?: STEM education beyond gender binaries. In *STEM of desire* (pp. 209–221). Brill Sense.

Lave, J. (1996). Teaching, as learning, in practice. *Mind, Culture, and Activity*, *3*(3), 149–164.

Leslie, S.-J., Cimpian, A., Meyer, M., & Freeland, E. (2015). Expectations of brilliance underlie gender distributions across academic disciplines. *Science*, *347*(6219), 262–265.

Letts, W. (2001). When science is strangely alluring: Interrogating the masculinist and heteronormative nature of primary school science. *Gender and Education*, *13*(3), 261–274.

Letts, W., & Fifield, S. (2019). *STEM of desire: Queer theories and science education*. Brill| Sense.

Levine, M., Serio, N., Radaram, B., Chaudhuri, S., & Talbert, W. (2015). Addressing the STEM gender gap by designing and implementing an educational outreach chemistry camp for middle school girls. *Journal of Chemical Education*, *92*(10), 1639–1644.

Lock, R. M., & Hazari, Z. (2016). Discussing underrepresentation as a means to facilitating female students' physics identity development. *Physical Review Physics Education Research*, *12*(2), 020101.

Makarova, E., Aeschlimann, B., & Herzog, W. (2019). The gender gap in STEM fields: The impact of the gender stereotype of math and science on secondary students' career aspirations. *Frontiers in Education, 4*, Article 60.

Maries, A., Karim, N. I., & Singh, C. (2018). Is agreeing with a gender stereotype correlated with the performance of female students in introductory physics? *Physical Review Physics Education Research*, *14*(2), 020119.

Mark, S. L. (2018). A bit of both science and economics: A non-traditional STEM identity narrative. *Cultural Studies of Science Education*, *13*(4), 983–1003.

Marshman, E. M., Kalender, Z. Y., Nokes-Malach, T., Schunn, C., & Singh, C. (2018). Female students with A's have similar physics self-efficacy as male students with C's in introductory courses: A cause for alarm? *Physical Review Physics Education Research*, *14*(2), 020123.

Mattsson, T. (2015). "Good girls": Emphasised femininity as cloning culture in academia. *Gender and Education*, *27*(6), 685–699.

Mensah, F. M. (2019). Finding voice and passion: Critical race theory methodology in science teacher education. *American Educational Research Journal*, *56*(4), 1412–1456.

Meyer, M., Cimpian, A., & Leslie, S.-J. (2015). Women are underrepresented in fields where success is believed to require brilliance. *Frontiers in Psychology*, *6*, 235.

Miller, D. I., Eagly, A. H., & Linn, M. C. (2015). Women's representation in science predicts national gender-science stereotypes: Evidence from 66 nations. *Journal of Educational Psychology*, *107*(3), 631.

Miller, D. I., & Halpern, D. F. (2014). The new science of cognitive sex differences. *Trends in Cognitive Sciences*, *18*(1), 37–45.

Mim, S. A. (2020). Masculinity of science: Unveiling gendered challenges of female science teachers in Bangladesh. *Gender and Education*, 1–16.

Moshfeghyeganeh, S., & Hazari, Z. (2021). Effect of culture on women physicists' career choice: A comparison of Muslim majority countries and the West. *Physical Review Physics Education Research*, *17*(1), 010114.

Nehmeh, G., & Kelly, A. M. (2020). Facilitating the self-determination of undergraduate women in physics: The role of external validation. *Research in Science & Technological Education*, 1–22.

Nissen, J. M. (2019). Gender differences in self-efficacy states in high school physics. *Physical Review Physics Education Research*, *15*(1), 013102.

Nissen, J. M., & Shemwell, J. T. (2016). Gender, experience, and self-efficacy in introductory physics. *Physical Review Physics Education Research*, *12*(2), 020105.

Ong, M., Smith, J. M., & Ko, L. T. (2018). Counterspaces for women of color in STEM higher education: Marginal and central spaces for persistence and success. *Journal of Research in Science Teaching*, *55*(2), 206–245.

Orlander, A. A. (2016). "So, what do men and women want? Is it any different from what animals want?" Sex education in an upper secondary school. *Research in Science Education*, *46*(6), 811–829.

Orlander, A. A. (2020). When "scary" science "just feels wrong": How the facts in a masculine fact-based debate couldn't stop science students' feminine feelings. *Cultural Studies of Science Education*, *15*(1), 265–285.

Ottemo, A., Gonsalves, A. J., & Danielsson, A. T. (2021). (Dis) embodied masculinity and the meaning of (non) style in physics and computer engineering education. *Gender and Education*, 1–16.

Potvin, G., & Hazari, Z. (2016). Student evaluations of physics teachers: On the stability and persistence of gender bias. *Physical Review Physics Education Research*, *12*(2), 020107.

Potvin, G., Hazari, Z., Tai, R. H., & Sadler, P. M. (2009). Unraveling bias from student evaluations of their high school science teachers. *Science Education*, *93*(5), 827–845.

Quinn, D. M., & Cooc, N. (2015). Science achievement gaps by gender and race/ethnicity in elementary and middle school: Trends and predictors. *Educational Researcher*, *44*(6), 336–346. https://doi.org/10.3102/0013189x15598539

Ramsey, L. R. (2017). Agentic traits are associated with success in science more than communal traits. *Personality and Individual Differences*, *106*, 6–9.

Reddy, L. (2017). Gender differences in attitudes to learning science in grade 7. *African Journal of Research in Mathematics, Science and Technology Education*, *21*(1), 26–36.

Reilly, D., Neumann, D. L., & Andrews, G. (2015). Sex differences in mathematics and science achievement: A meta-analysis of National Assessment of Educational Progress assessments. *Journal of Educational Psychology*, *107*(3), 645.

Reilly, D., Neumann, D. L., & Andrews, G. (2019). Investigating gender differences in mathematics and science: Results from the 2011 Trends in Mathematics and Science Survey. *Research in Science Education*, *49*(1), 25–50.

Reiss, M. J. (1998). The representation of human sexuality in some science textbooks for 14–16 year olds. *Research in Science & Technological Education*, *16*(2), 137–149.

Reiss, M. J. (2019). Thinking like a fox: Queering the science classroom when teaching about sex and sexuality. In *STEM of desire* (pp. 255–267). Brill Sense.

Reuben, E., Sapienza, P., & Zingales, L. (2014). How stereotypes impair women's careers in science. *Proceedings of the National Academy of Sciences*, *111*(12), 4403–4408.

Ringrose, J., & Renold, E. (2010). Normative cruelties and gender deviants: The performative effects of bully discourses for girls and boys in school. *British Educational Research Journal*, *36*(4), 573–596.

Rosa, K. (2018). Science identity possibilities: A look into Blackness, masculinities, and economic power relations. *Cultural Studies of Science Education*, *13*(4), 1005–1013.

Rosa, K., & Mensah, F. M. (2016). Educational pathways of Black women physicists: Stories of experiencing and overcoming obstacles in life. *Physical Review Physics Education Research*, *12*(2), 020113.

Rüschenpöhler, L., & Markic, S. (2020). Secondary school students' chemistry self-concepts: Gender and culture, and the impact of chemistry self-concept on learning behaviour. *Chemistry Education Research and Practice*, *21*(1), 209–219.

Sansone, D., & Carpenter, C. S. (2020). Turing's children: Representation of sexual minorities in STEM. *PLoS ONE*, *15*(11), e0241596.

Scantlebury, K. (2014). Gender matters: Building on the past, recognizing the present, and looking towards the future. In N. Lederman & S. Abell (Eds.), *Handbook of research on science education* (Vol. II, pp. 187–203). Routledge.

Scantlebury, K., & Baker, D. (2007). Gender issues in science education research: Remembering where the difference lies. *Handbook of Research on Science Education*, *1*, 257–285.

Scantlebury, K., Danielsson, A. T., Hussénius, A., Gullberg, A., & Andersson, K. (2019). Using spacetimemattering to engage science education with matter and material feminism. In *Material practice and materiality: Too long ignored in science education* (pp. 39–50). Springer.

Schiebinger, L. (1991). *The mind has no sex? Women in the origins of modern science*. Harvard University Press.

Schiebinger, L. (2014). Gendered innovations: Harnessing the creative power of sex and gender analysis to discover new ideas and develop new technologies. *Triple Helix*, *1*(1), 9. https://doi.org/10.1186/s40604-014-0009-7

Schwab, K., Samans, R., Zahidi, S., Leopold, T. A., Ratcheva, V., Hausmann, R., & Tyson, L. D. (2017). *The global gender gap report 2017*. World Economic Forum.

Seyranian, V., Madva, A., Duong, N., Abramzon, N., Tibbetts, Y., & Harackiewicz, J. M. (2018). The longitudinal effects of STEM identity and gender on flourishing and achievement in college physics. *International Journal of STEM Education*, *5*(1), 1–14.

Simon, R. M., Wagner, A., & Killion, B. (2017). Gender and choosing a STEM major in college: Femininity, masculinity, chilly climate, and occupational values. *Journal of Research in Science Teaching*, *54*(3), 299–323.

Sjöström, J. (2019). Didactic modelling for socio-ecojustice. *Journal for Activist Science and Technology Education*, *10*(1).

Skibba, R. (2019). Women in physics. *Nature Reviews Physics*, *1*(5), 298–300.

Smith, J. L., Brown, E. R., Thoman, D. B., & Deemer, E. D. (2015). Losing its expected communal value: How stereotype threat undermines women's identity as research scientists. *Social Psychology of Education*, *18*(3), 443–466.

Sue, D. W. (2010). *Microaggressions and marginality: Manifestation, dynamics, and impact*. John Wiley & Sons.

Taasoobshirazi, G., Puckett, C., & Marchand, G. (2019). Stereotype threat and gender differences in biology. *International Journal of Science and Mathematics Education*, *17*(7), 1267–1282.

Taylor, C. A. (2013). Objects, bodies and space: Gender and embodied practices of mattering in the classroom. *Gender and Education*, *25*(6), 688–703.

Tellhed, U., Bäckström, M., & Björklund, F. (2017). Will I fit in and do well? The importance of social belongingness and self-efficacy for explaining gender differences in interest in STEM and HEED majors. *Sex Roles*, *77*(1), 86–96.

Todd, B. L., & Zvoch, K. (2019). The effect of an informal science intervention on middle school girls' science affinities. *International Journal of Science Education*, *41*(1), 102–122.

Traweek, S. (1988). *Beamtimes and lifetimes. The world of high energy physicists*. Harvard University Press.

Traxler, A. L., Cid, X. C., Blue, J., & Barthelemy, R. (2016). Enriching gender in physics education research: A binary past and a complex future. *Physical Review Physics Education Research*, *12*(2), 020114.

Traxler, A. L., Henderson, R., Stewart, J., Stewart, G., Papak, A., & Lindell, R. (2018). Gender fairness within the force concept inventory. *Physical Review Physics Education Research*, *14*(1), 010103.

Valla, J. M., & Ceci, S. J. (2014). Breadth-based models of women's underrepresentation in STEM fields: An integrative commentary on schmidt (2011) and Nye et al. (2012). *Perspectives on Psychological Science*, *9*(2), 219–224. https://doi.org/10.1177/1745691614522067

Verdín, D., Godwin, A., & Benedict, B. (2020). Exploring first-year engineering students' innovation self-efficacy beliefs by gender and discipline. *Journal of Civil Engineering Education*, *146*(4), 04020006.

Voyer, D., & Voyer, S. D. (2014). Gender differences in scholastic achievement: A meta-analysis. *Psychological Bulletin*, *140*(4), 1174.

Wade-Jaimes, K., & Schwartz, R. (2019). "I don't think it's science:" African American girls and the figured world of school science. *Journal of Research in Science Teaching*, *56*(6), 679–706.

Wang, M.-T., & Degol, J. L. (2017). Gender gap in Science, Technology, Engineering, and Mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational Psychology Review*, *29*(1), 119–140. https://doi.org/10.1007/s10648-015-9355-x

Wang, M.-T., Eccles, J. S., & Kenny, S. (2013). Not lack of ability but more choice: Individual and gender differences in choice of careers in science, technology, engineering, and mathematics. *Psychological Science*, *24*(5), 770–775.

Whitten, B. L., Foster, S. R., Duncombe, M. L., Allen, P. E., Heron, P., McCullough, L., Shaw, K. A., Taylor, B. A. P., & Zorn, H. M. (2003). What works? Increasing the participation of women in undergraduate physics. *Journal of Women and Minorities in Science and Engineering*, *9*(3&4), 239–258.

Witteman, H. O., Hendricks, M., Straus, S., & Tannenbaum, C. (2019). Are gender gaps due to evaluations of the applicant or the science? A natural experiment at a national funding agency. *The Lancet*, *393*(10171), 531–540.

Wulff, P., Hazari, Z., Petersen, S., & Neumann, K. (2018). Engaging young women in physics: An intervention to support young women's physics identity development. *Physical Review Physics Education Research*, *14*(2), 020113.

Yoder, J. B., & Mattheis, A. (2016). Queer in STEM: Workplace experiences reported in a national survey of LGBTQA individuals in science, technology, engineering, and mathematics careers. *Journal of Homosexuality*, *63*(1), 1–27.