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WOMEN'S ASPIRATIONS TOWARDS "STEM" CAREERS: A MOTIVATIONAL ANALYSIS

INTRODUCTION

Increasingly, over the past 50 years, women have been studying and working in professions once dominated by men. In 80% of Organisation for Economic Co-operation and Development (OECD) nations women now equal or exceed the numbers of men completing tertiary level education (OECD, 2010). This trend has positive implications for women's quality of life by increasing their chances of employment and their earning potential. However, this trend of women's increased participation in university and vocational settings is not seen across all subject domains. While women outnumber men in language-arts and education, women are persistently underrepresented in science, technology, engineering, and mathematics (STEM) fields of study and employment (OECD, 2010). On average, among OECD countries, women attain 30% of STEM degrees; however, in some countries the rate is as low as 9% (OECD, 2010). STEM domains are becoming increasingly important for societies that want to create a worldly power and status because the work conducted in these areas supports scientific discoveries, technological innovations, and economic development (Roeser, 2006). Therefore, STEM jobs tend to be more highly paid and gain more socio-cultural distinction than the sectors in which women are overrepresented.

Despite numerous government-level initiatives to balance gendered participation in the STEM workforce, the gender disparity has remained a persistent trend over many years and hence has been the focus of much investigation. The majority of this research has been dedicated to the domain of mathematics because it is a fundamental constituent of learning and participation levels can be tracked from the early stages of school through to tertiary studies. More recently, science has received increasing research attention. However, by comparison, engineering and technology remain relatively understudied, which is concerning given that those are the subjects in which women's involvement tends to be the least. Research suggests that girls first begin to lose interest in mathematics and science during junior high school (Jacobs, 2002; Watt, 2004). Deciding to opt out of these subjects makes it very difficult to re-join them in later years and thus girls tend to restrict their educational and vocational

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options from an early age (Sells, 1980). At times of educational transition, such as the completion of high school and university, girls and women are more likely to decide not to continue with mathematics and science studies (Hoffmann, Krapp, Renninger, & Baumert, 1998; Kessels & Hannover, 2007). A pipeline metaphor has been used to illustrate this progressive loss of women from STEM-related fields (Simpkins & Davis-Kean, 2005). Women slowly leak out of the pipeline across the course of their education, and more often at transition points (Hoffmann, Krapp, Renninger, & Baumert, 1998; Kessels & Hannover, 2007), until there is only a small number left who enter the STEM workforce. Even then, many women choose to leave these occupations, often citing a sector that is inattentive to family obligations (Frome, Alfeld, Eccles, & Barber, 2006, 2008), which further exacerbates the underrepresentation of women in the STEM workforce. The pipeline metaphor gives a clear visual representation of a process that leads to disproportionate gendered participation. However, the pipeline metaphor does not acknowledge girls' and women's ownership of the decisions they make. A leaky pipeline indicates females tend to fall through the cracks, thus placing women as passive and reactive; whereas, women may forge these cracks themselves through proactive decision-making. Girls may be looking ahead to the end of the pipeline and be put off by what they envisage to be there (Watt, Eccles, & Durik, 2006). Indeed, girls often report opting out of mathematics and science in school because they want to be involved in helping professions (Eccles, Barber, & Jozefowicz, 1998). Despite numerous initiatives to maintain girls' participation in STEM fields, girls continue to choose to leave these subjects. Hence, we need to understand why this continues to happen and what can be done to make STEM career paths more attractive to women. In this chapter, we shall look down the pipeline using a motivational lens to assess why men continue to outnumber women in the STEM workforce. We will explore three different explanations for the gender gap: ability, socialisation, and motivation. Within these explanations we will review theoretical frameworks and propose a theoretical integration. Finally, we will draw some conclusions about the current situation for girls and women and how their situation may be improved.

ABILITY DIFFERENCES

For many years, differences in the mathematics and science abilities of males and females sparked debate as an explanation for females' lesser participation. Some research indicated boys tended to perform better on aptitude tests (National Science Foundation, 2006), whereas girls performed better on achievement tests and school grades (Young, 1991, 1994). Abilities in mental rotation and spatial perception predict mathematics achievement scores, and gender differences in one have been used to explain gender differences in the other (Ceci, Williams, & Barnett, 2009) as males tend to perform slightly better on three-dimensional mental rotation tasks and tests of spatial ability (Hyde, 2005; Linn & Peterson, 1985). However, these differences are often misrepresented as biologically based indicators of males' superior mathematics

abilities when there are many other explanations. Moreover, gaps in the spatial ability performance between boys and girls have shown declines over time (Hyde, Fennema, & Lamon, 1990). Lastly, these skills do not predict success in mathematics intensive fields and hence fail to explain the gender discrepancy in STEM participation (Ceci et al., 2009). The culmination of years of differing experiences of girls and boys can account for many differences in behaviour. Different responses to testing situations, such as females being more cautious in double-checking their answers or activation of stereotype threat (Murphy, Steele, & Gross, 2007), can also explain differences in performance. A further line of enquiry to explain ability differences has been differing brain development and the influence of hormones. However, differences in brain composition and hormones are insufficient to explain the gender differences in mathematics careers (Ceci et al., 2009). Recent meta-analyses have demonstrated that boys and girls have similar achievement for mathematics and science across their years of schooling (Else-Quest, Hyde, & Linn, 2010; Hyde & Linn, 2006). These researchers have warned that studies which examine only statistically significant gender differences without considering the magnitude of effects, omit the critical indicator of real-world applicability (Hyde & Linn, 2006). Through such sustained research efforts, and results that reveal inconsequential effect sizes, it is now widely accepted that girls and boys from OECD nations perform similarly in STEM-related subjects, and that explanations beyond ability differences must be pursued.

THEORETICAL ABILITY FRAMEWORKS

The gender differences model, that males and females differ to large degrees psychologically, has fascinated psychologists for many years. The gender differences model gained the attention of media and the wider population after the publication of popular books such as *Men Are From Mars, Women Are From Venus* (Gray, 1992) and *You Just Don't Understand: Women and Men In Conversation* (Tannen, 1991), which both argued for immense psychological differences between men and women. The seminal review of 2000 studies by Maccoby and Jacklin in 1974 identified sex differences in four specific areas: verbal abilities, visual spatial abilities, mathematical abilities, and aggression. Since then, meta-analysis has revolutionised the study of psychological variables by allowing researchers to aggregate findings across previous empirical studies, and thereby estimate effect sizes for psychological variables of interest. Instead of a gender differences model, recent meta-analyses support a hypothesis of *gender similarities* (Hyde, 2005), whereby men and women, boys and girls, are similar on most psychological variables. According to this theory, males and females are more alike than they are different. Indeed, Hyde's (2005) meta-analysis showed that 78% of gender differences have a magnitude within the range of small or close-to-zero ($d \leq 0.35$). The areas within which Hyde (2005) found the largest gender differences for were motor performance and sexuality. These results are even more striking when we note that the majority of studies included in Hyde's (2005) meta-analysis had assessed one of the four areas of gender differences studied earlier by Maccoby and Jacklin (1974). Other meta-analyses have highlighted the importance of context, because manipulation of the testing environment, age, and culture can all diminish gender differences (Bettencourt & Miller, 1996; LaFrance, Hecht, & Paluck, 2003). Together, these results dispel the pillars of the gender differences hypothesis, showing that gender differences are neither large nor stable, lending weight to the hypothesis of gender similarities, and pointing to the need to examine explanations beyond ability to understand gendered participation and achievement in advanced mathematics and sciences.

SOCIALISATION EXPLANATIONS

The impact of girls' social environments doubtless plays an important role in their involvement in STEM-related fields. These influences include broad contextual cultural influences as well as proximal influences such as parents, teachers, and peers.

Broad Contextual Influences

Many studies demonstrate varying differences in performance between boys and girls from different country settings. There is emerging evidence that girls who receive education in countries which have greater gender equality show better achievement and more positive attitudes towards mathematics. Guiso and colleagues (2008) conducted a study using a large international data sample and measured gender inequality of each nation using the Gender Gap Index (GGI). The GGI is a measure of the divide between women and men in educational attainment, health, economic opportunity, economic participation, and political empowerment. The difference between mathematics performance of boys and girls was smaller for countries that had more equality as measured by the GGI. Else-Quest, Hyde, and Linn (2010) conducted a meta-analysis of cross-national patterns of gender differences in mathematics also using large international data samples that canvassed over 490,000 14–16 year olds in 69 countries. Results showed that in nations where girls have more equal access to education and where women participate at the same rate as men in upper level employment and government, girls and boys tend to perform similarly, and gender gaps in mathematics self-confidence are smaller. These large-scale studies provide strong evidence for the influential role of socio-cultural factors on students' measured performance in STEM-related subjects.

The cultural and religious customs that define a country can also influence the accessibility of education for girls. Mukhopadhyay (2004) outlined the partrifocal family structure of India and the impact this has on girls' participation in tertiary education. Similar to Western nations, the gender gap also exists in STEM fields in India (Mukhopadhyay, 1994). Educational decisions are treated as family matters, instead of individual decisions, involving the collective investment of family resources and long-term goals. Educational decisions tend to favour sons over daughters because concerns about girls' marriageability, social representation, and family honour tend to work against them. However, the education of girls can also create positive outcomes for the family. Girls' earning potential can offset dowry demands, lifting some financial burden off the family. In addition, educated girls who remain unmarried are not viewed as financial burdens.

Proximal Influences

The attitudes of parents and teachers have been found to differ by child gender, such that mothers underestimated the mathematics abilities of their sixth grade daughters, while overestimating the same abilities of sons (Frome & Eccles, 1998). Similar results were found when parents were asked to estimate different aspects of their children's intelligence. Mothers and fathers believed their sons had higher mathematics and spatial skills than their daughters (Furnham, Reeves, & Budhani, 2002). This is particularly concerning since girls can be more influenced by their mother's perceptions of their abilities than their actual achievement grades (Jacobs & Eccles, 1992). However, in studies conducted with high mathematics achieving girls and boys, encouragement from parents was more likely to vary by ability than by gender. A longitudinal study showed that parents' occupational expectations were related to their teenager's job aspirations two years later and their actual job choices thirteen years later (Jacobs, Chhin, & Bleeker, 2006). Earlier research has suggested that teachers tend to favour boys in mathematics classes (Becker, 1981) but there is less support for this more recently (Ceci et al., 2009). Teachers' expectations of success can be a great support for girls in mathematics and science classes during the school years (Fouad et al., 2010). Another proximal influence that has been explored is the lack of female role models for girls in mathematics- and science-related fields. Since men hold the majority of STEM career positions, and the women that hold STEM jobs have often had to make personal and family sacrifices (Sonnert, 1995), girls aspiring to STEM vocations do not have role-models demonstrating how to manage career and family life (Blickenstaff, 2005). Because children and adolescents spend the majority of their time with their parents and teachers, it is important to consider the influences these proximal socialising agents have on students' thoughts about STEM-related fields.

THEORETICAL SOCIALISATION FRAMEWORKS

There are many theories focused on how gender-typed behaviours develop; the likely reality is that there is interplay between the factors emphasised in these models. Integrating gender socialisation theory, gender schema theory, and social role theory may be useful to help explain why boys persist with STEM subjects, whereas girls are more likely to desist. The integration of these theories suggests that a girl, who has feminine behaviours highly reinforced, was mainly exposed to women and men in gender typical roles, and developed strong gender schema about gender-typed behaviours, would be more likely to steer clear of male-dominated arenas such as mathematics and science.

Gender socialisation theory (Stockard, 1999) posits that the differential reinforcement of certain behaviours during development leads to gender differences in the behaviour of girls and boys. Parents, teachers, and other important individuals in a child's life, model and reinforce gender-typed behaviours. During pre-school and primary school, girls are likely to be engaged in activities that promote fine motor skills (e.g., drawing) and verbal skills, whereas boys' play tends to involve gross motor activities, blocks, sports, and action figures (Early et al., 2010; Ruble, Martin, & Berenbaum, 2006). *Social role theory* (Eagly, 1987) concerns children's conceptions of gender-typed behaviours. Societal norms regarding gender-specific roles are clearly visible to children in their everyday lives and influence gender differences in disposition and behaviour. Mothers report engaging in more physical care and emotional support than fathers (Moon & Hoffman, 2008), which serves to reinforce to children that women are nurturers. Research shows girls are more likely to express emotions and take on nurturing roles, while boys learn to be assertive and independent. Through the reinforcement and modelling of gender-typed behaviours, children begin to develop gender schema. *Gender schema theory* (Bem, 1993) proposes that as children develop and become more aware of their gender and cultural and societal gender norms they create gender schema of appropriate masculine and feminine behaviours. Gender schema guide encoding, processing, and interpretations of gendered behaviours. As such, these lenses serve to create a self-identity that is consistent with the gendered schema (Bem, 1993). Depending on the nature of early childhood input, children's gender schema may become more or less gender segregated. Schema are important because they influence intentions and behaviours (Markus, 1977).

MOTIVATIONAL EXPLANATIONS

Values

Girls' and women's valuing for and interest in STEM fields are additional important considerations. Eccles, Barber and Jozefowicz (1998) found that young women placed higher value on people oriented jobs and were therefore more likely to aspire to careers in health than mathematics. Similarly, girls interviewed in a qualitative study were more interested in life science instead of physical science because they aspired to care for people or animals (Baker & Leary, 1995). It seems a long-term goal of many girls is to work in helping professions. Students' interests are highly predictive of their choices and persistence (Eccles et al., 1983). Boys' interest in mathematics remains higher than that of girls throughout high school (Frenzel, Goetz, Pekrun, & Watt, 2010; Nagy, Watt, Eccles, Trautwein, Lüdtke, & Baumert, 2010; Watt, 2004). This elevated interest of boys can culminate in more experiential knowledge of mathematics-related domains (e.g., physics) by the

time they reach college, due to their more avid consumption of media, books, and hobbies centred on mathematics (Hazari, Sonnert, Sadler, & Shanahan, 2010). Women studying science and engineering at university are more likely to persist with their studies if they recall enjoying science and mathematics in high school and continue to enjoy these subjects at university (Brainard & Carlin, 1998). One study conducted in Germany showed that teenage girls had higher levels of interest in biology than their male counterparts, and that the course choices of these students in high school predicted their avenues of study at university (Nagy, Trautwein, Baumert, Köller, & Garrett, 2006). Watt and colleagues (2012) recently conducted a longitudinal comparison of motivational beliefs and educational and occupational outcomes between Australian, American, and Canadian high school students. Gender differences in motivational beliefs tended to favour boys, in line with gender stereotypes. However, the importance value of mathematics emerged as a more influential value for girls than boys in predicting their mathematics-related career plans for those who lived in Australia and Canada. These results indicate that girls' valuing of STEM subjects at an early age can lead to positive effects on their STEM participation later in life.

Self-perceptions

Self-perceptions include confidence in and expectations about ones' abilities. Results from large international data of high school students have shown that boys are more self-confident than girls in mathematics (Else-Quest et al., 2010) and maintain higher ability expectancies than girls over the course of high school (Frenzel et al., 2010; Nagy et al., 2010; Watt, 2004). In turn, these beliefs affect subsequent educational and occupational plans (Watt et al., 2012). In countries where there is gender equality in education and upper level employment, boys' and girls' mathematics self-confidence are more closely aligned (Else-Quest et al., 2010). In a longitudinal study, girls' lower self-efficacy beliefs for biology and physics during high school were found to improve over the course of college, independently of their achievement levels, until they exceeded those of boys by the end of their second college year (Larose, Ratelle, Guay, Senécal, & Harvey, 2006). It may be that if girls can be encouraged to persevere with STEM subjects beyond high school, and have more of a chance to perform well in a range of fields, their self-efficacy for these subjects will improve.

"Cost" Deterrents

The perceived drawbacks or negative aspects of engaging in STEM fields can significantly deter girls and women from STEM fields. These 'costs' have received minimal research attention (Roeser, 2006). During the 1970s, a psychologist at Harvard University, Matina Horner, argued for 'fear of success' as a psychological barrier that impacted on women's career advancement. Horner (1970) based this assertion on results from her research, which showed that when placed in competitive environments, men became more motivated, whereas women became more anxious. Men also reacted more negatively than women to a female succeeding in a male-dominated field. As an indication of the social climate during that time in history, male participants described successful women as unattractive, unpopular, unfeminine, and overaggressive. Horner's (1970) methodology was replicated more recently in a study which found no quantitative differences between men and women's responses for the success of others in traditional and non-traditional vocational fields (Engle, 2003). Nowadays, for many women, diminished family time due to inflexibility of male-dominated STEM workforces is a significant cost that prompts them to leave those fields (Frome et al., 2008). The impact of costs on girls' and women's STEM-related decisions needs to be more systematically explored. Costs could be categorised as external (contextual) barriers, aspects of the environment that contribute to a lack of affordances; and internal (psychological) barriers, such as gender schemata, domain-specific self-efficacies, and interests. These costs are likely to change across the course of people's lives as a function of age, work experience, child rearing, and other influences (Roeser, 2006).

Cultural Values

Research into motivational differences between East Asian and Western students was prompted due to the finding of Asian students outperforming their Western counterparts on large-scale international academic testing projects, such as PISA. Higher valuing of effort became widely accepted as an important factor explaining East Asian students' higher achievement (Lau & Chan, 2001) with Western learners viewed as more interest-oriented (Schiefele, 1991). However, large-scale comparisons, such as the Trends in International Mathematics and Science Study (TIMSS), which compares the knowledge and skills of 4th and 8th grade students in 60 countries, provide evidence for students of all cultures valuing hard work, rather than Asian students in particular. Martin and Hau (2010) brought a different lens to this debate and investigated differences of 'kind' and differences of 'degree' in achievement motivation of Chinese and Australian 12 and 13-year-old students. Results showed small differences of 'degree', such that Chinese students reported lower achievement motivation than Australian students. However, there were no differences of 'kind', indicating that Australian and Chinese students have similar motivational profiles and structure. Other researchers have specifically investigated cross-cultural differences in students' interest for certain subjects. When comparing American, Taiwanese, and Japanese 11th grade students, Evans, Schweingruber, and Stevenson (2002) found that results mirrored those of studies conducted with only Western participants; boys preferred mathematics, science, and physical education, whereas girls had more interest in English, music, and art. These results indicate that the gendered socialisation of motivations is relatively robust across cultural settings.

THEORETICAL MOTIVATION FRAMEWORKS

Within the field of motivation research, there is a myriad of theories, each with its own terminology, seeking to explain people's behaviours and choices. For a reader who is unfamiliar with this body of work, it can be a very daunting task to wade through the wealth of information presented from different perspectives. We selected and categorised the theories of most relevance to girls'/women's participation in STEM fields. The theories presently discussed are grouped into those explaining motivation from a basis of expectations and those that examine reasons for engagement.

Expectancies

Motivation theories that focus on expectancy are largely concerned with an individual's sense of efficacy and perceived competence for completing a task (Eccles & Wigfield, 2002). Self-Efficacy Theory (Bandura, 1986, 1997) was seminal in this line of social cognitive inquiry. Self-Efficacy Theory (SET) proposes that outcome expectations and efficacy expectations of success influence individuals' goal setting, activity choices, effort, and persistence (Bandura, 1997). Self-Efficacy Theory has proved useful when applied to behaviour in many different research areas, such as schools, health, and sports. A closely related model is Social Cognitive Career Theory (SCCT; Lent, Brown, & Hackett, 1994), which built on the principles of SET. Self-efficacy beliefs and outcome expectations continue to play a central role but SCCT is specifically focused on academic and career development. Person, contextual, and experiential factors are thought to influence academic and career-related interests, goals, actions, and outcomes (Lent et al., 1994). Mau (2003) used SCCT as the conceptual framework for analysis of longitudinal data, which tracked students' career aspirations from high school until 2 years post-high school and found that boys were more likely to persist with science and engineering career aspirations than girls, and those who persisted with their science and engineering aspirations had higher levels of academic achievement, mathematics self-efficacy, socioeconomic status, and parental expectations.

Reasons for Engagement

Another branch of motivation theories focuses on variables such as intrinsic motivation, interests, and goals. A prominent model is Self-Determination Theory (Deci & Ryan, 1985), which posits that people are intrinsically motivated to seek out competence, autonomy, and relatedness, which are critical variables for understanding the content and process of goal pursuits. Research demonstrates that children in autonomy supportive classrooms are more intrinsically motivated (Deci & Ryan, 1985), have higher self-esteem and perceived competence (Ryan & Grolnick, 1986), and are more likely to stay in school (Hardre & Reeve, 2003). Another prominent theory is goal theory, which has influenced classroom research.

The main distinction is between performance goals and mastery goals (Ames, 1992). Individuals with performance goals seek to outperform others and maximise favourable perceptions of their competence, while those with mastery goals are more concerned with developing their own learning and skill set. Students with mastery goals show high levels of interest and persistence, feel comfortable asking for help, and value cooperation (Harackiewicz, Barron, Tauer, Carter, & Elliot, 2000; Wolters, 2004). However, one positive outcome that students pursuing mastery goals do not show is that of enhanced academic achievement (Hulleman, Schrager, Bodmann, & Harackiewicz, 2010). This may be because students with mastery goals are more concerned with pursuing their academic interests, instead of top test scores (Senko & Harackiewicz, 2002). In contrast, students pursuing performance goals have shown increased academic performance but this result is not consistent (Greene, Miller, Crowson, Duke & Akey, 2004; Harackiewicz et al., 2000). The relationships between achievement and mastery versus performance goals can be explained by a further distinction between these goal types: approach versus avoidance goals. Performance-approach goals encompass a striving to outperform others, whereas performance-avoidance goals denote an evasion of performing worse than others. Mastery-approach goals involve a propensity towards improving learning and skills, whereas mastery-avoidance goals involve a striving to avoid diminished learning and skill acquisition. Research has shown that avoidance framing of performance goals and mastery goals is associated with negative outcomes. Performance-avoidance goals are linked to high test anxiety, low achievement, and low interest (Pekrun, Elliot, & Maier, 2006; Möller & Elliot, 2006).

THEORY INTEGRATION

The reviewed ability, socialisation and motivational theories have forged knowledge and research concerning the underrepresentation of women in STEM education and careers. However, there is a need to amalgamate similar constructs and present a unified framework that accounts for as many influences as possible. Previous models have been criticised for omitting motivational tendencies and failing to consistently include objective achievement outcomes with which to compare individual's perceptions. The Expectancy-Value model proposed by Eccles (2005) and Eccles and colleagues (1983) overcomes these limitations by linking expectancies and values to an extensive range of psychological and social factors, and has therefore received substantial research attention over the past two decades. This model proposes that an individual's expectations for success and the value s/he attributes to a task, influences choices, performance, and persistence for that task. An individual's subjective reasons for engaging in a task/subject are influenced by her/his identity, goals, self-schema, and affective memories. These factors are related to the wider cultural milieu; in particular, the caregiver's beliefs, and the individual's perception of these beliefs, as well as the individual's beliefs of their own abilities. Eccles and her colleagues have conducted a sustained program of research in this area and shown that expectations

for success and task values both predict achievement and course plans; effects which are over and above the influences of previous achievement (Eccles 1987; Eccles, Adler, Futterman, Goff, & Kaczala, 1983; Eccles, Adler, & Meece, 1984; Meece, Wigfield, & Eccles, 1990). Expectations for success and task values also predict career aspirations (Eccles et al., 1998). Girls and boys in the latter stage of high school who aspire to health careers, or mathematics and engineering careers, held high success expectations for their science abilities. What differentiated students with science aspirations were their values. Students aspiring to health careers placed a high value on people oriented jobs; a result that was more pronounced for girls than boys. Students aspiring to mathematics and engineering careers placed higher value on mathematics and computer tasks. Girls with such aspirations were more likely to place lower value on people oriented jobs (Eccles et al., 1998).

CONCLUSION AND OUTLOOK

Bringing motivational, sociocultural, and ability theories and research together, we gain a clearer picture of why girls and women underparticipate in STEM subjects and careers. There is interplay between these factors, which shape girls' and women's self-identities and influence the decisions they make. Roeser (2006) described these as the "inside-out" and "outside-in" phenomena of self and identity. "Inside-out" influences are one's beliefs and values, whereas "outside-in" influences are the social forces that affect our life choices. From the research, we can see that interests and self-perceptions (inside-out phenomena) are important to the educational and career decision-making of girls and women. Currently, most girls and women's preferences lie with helping professions and subjects that have clear real-world applicability. For many women, it seems, STEM subjects and careers do not embody these traits. Research also indicates that girls and women perform better in countries that strive for gender equality, thus social interactions and the affordances and constraints of girls and women's social worlds (outside-in phenomena) play an important role. The current social climate surrounding STEM subjects and workplaces often positions girls and women as less able than men (even though there is a wealth of evidence to the contrary) and fails to provide them with the instruction and opportunities needed to develop values that lead to continued participation. Therefore, the question arises, what can we do to make these avenues more attractive to girls and women?

Multipronged Efforts to Enhance Girls and Women's Participation in STEM

The research conducted to date makes it clear that efforts to increase girls' and women's participation in STEM fields need to address the "inside-out" influences as well as "outside-in" factors at both ends of the pipeline. That is, making individual-perceptual and sociocultural influences a priority when girls are in high school and when women are finishing university to enter the workforce. These objectives can be pursued through multiple avenues, such as government initiatives, modifications to classroom instruction, and providing clear and relevant information about STEM career paths. If the "outside-in" factors can be more conducive to girls' and women's STEM participation, the "inside-out" influences will be more likely to develop accordingly.

Numerous initiatives are already in place to help monitor the gender balance in STEM subjects and workplaces. The OECD publishes its annual comparison between member countries regarding access to and participation in learning, quality of learning environments, financial investment in education, and the output of educational institutions. A further initiative of the OECD is the Programme for International Student Assessment (PISA), which compares the achievement of 15-year-old students in the areas of reading, mathematics, and science. A similar study, the Trends in International Mathematics and Science Study (TIMSS), which is facilitated by the International Association for the Evaluation of Educational Achievement (IEA), compares the achievement of fourth and eighth graders for participating countries. All of these initiatives are aimed at improving educational policies and outcomes by exposing countries to alternative education systems and hone what is most appropriate for their context. These initiatives provide vital insight; however, it seems there is still more room for improvement. Governments could also introduce policies that make STEM workplaces more accepting of the family-time women and mothers' desire.

There are also changes to be made to the manner in which STEM subjects are taught and approached during the school years. The current research surrounding girls' STEM-related values and self-perceptions shows that they are more interested in the humanitarian or real-world application of these subjects. The difficulty with subjects such as mathematics and physics is that they are often taught in abstract and decontextualised ways, making these subjects less likely to engage girls (Watt, 2005). Furthermore, education is becoming increasingly assessment-based with the introduction of national and international achievement standards. These changes tend to create more narrow curricula, specific views of intelligence, and increased competition (Roeser, 2006). There is then little room for the fostering of educational values amidst all the forms of assessment, which is concerning given the impact values have on the decisions we make. Boaler (1998) conducted a longitudinal comparison of teaching styles in mathematics classrooms of two United Kingdom schools. One school followed very formalised, textbook-based teaching methods, whereas the other school taught mathematics with open-ended, problem-solving exercises. Students who were taught mathematics in the formalised setting had difficulty realising connections between classroom mathematics and the mathematics they encountered in their everyday lives. Students who were taught mathematics in a contextualised manner developed more flexible forms of knowledge that they could apply to problems both within and outside the classroom. Tailoring curricula to address the interests of girls has been shown to have a positive effect on their valuing of physics (Haussler & Hoffman, 2002). Taking on a more active class role through answering questions and teaching classmates is one adaptation that helped girls value physics more (Stadler, Duit, & Benke, 2000). Larose and colleagues (2006) found that women who were studying technology courses with a biology or physics focus at university showed increased self-efficacy for science and increased clarification of their career goals over the course of university. The classroom climate that is created by the teacher has a large impact on girls' interests and beliefs for their subjects. In our work, conducted with an Australian sample, we found that girls' perceptions of relatedness to their science teacher affected their interest in the subject and perceptions of classroom negativity were detrimental to their ability expectancies (Spearman & Watt, in press). University learning environments are often less competitive than high school classrooms, with more meaningful content that is more relevant to students' vocational goals. Therefore, trying to bring some of these positive elements into high school classrooms may be conducive to increasing girls' interest in STEM subjects.

Adolescents often have inaccurate ideas about the level of skills required for STEM careers and may be put off certain careers paths based on these misconceptions. Providing students with more information about the particulars of STEM careers and linking these jobs to socially relevant uses may serve to enhance girls' interest in STEM subjects and make it more likely they will continue with them in the future. Furthermore, if this real-world information about STEM careers could be delivered by women who are passionate about their work and capable of maintaining a balance between family and work, girls would have positive role models on which to base their aspirations.

Prognosis

There is now a wealth of research surrounding sociocultural and motivational factors that influence girls' and women's participation in STEM fields. Girls and boys have similar abilities for mathematics and science; however, boys' interest and self-efficacy for these subjects often exceeds that of girls. As well, girls' and women's STEM-related career decisions appear more based on the importance value they attach to those fields. Multipronged initiatives need to be set in place to create learning environments that are more conducive to developing girls' STEM values to the same level of boys. If their interests can be fostered from an early age, girls will be more likely to continue STEM subjects through high school and onto university. Initiatives also need to ensure the careful guiding of women through the pipeline and to ensure that the endpoint is attractive to women; work content that has real-world applicability and workplaces that allow women to also be mothers and carers.

REFERENCES

Ames C. (1992). Classrooms: goals, structures, and student motivation. *Journal of Educational Psychology, 84*, 261–271.

Baker D., & Leary, R. (1995). Letting girls speak out about science. *Journal of Research in Science Teaching, 32*(1), 3–27.
Bandura, A. (1986). The explanatory and predictive scope of self-efficacy theory. *Journal of Social and Clinical Psychology, 4*(3), 359–373.
Bandura, A. (1997). *Self-Efficacy: The Exercise of Control.* New York: Freeman.
Becker, J.R. (1981). Differential treatment of females and males in mathematics classes. *Journal for Research in Mathematics Education, 12,* 40–53.
Bem, S.L. (1993). *The lenses of gender: Transforming the debate on sexual inequality.* New Haven: Yale University Press.
Bettencourt, B.A., & Miller, N. (1996). Gender differences in aggression as a function of provocation: A meta-analysis. *Psychological Bulletin, 119,* 422–447.
Blickenstaff, J.C. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and Education, 17*(4), 369–386.
Boaler, J. (1998). Alternative approaches to teaching, learning and assessing mathematics. *Evaluation and Programming Planning, 2,* 129–141.
Brainard, S.G., & Carlin, L. (1998). A six-year longitudinal study of undergraduate women in engineering and science. *Journal of Engineering Education, 87*(4), 369–375.
Ceci, S.J., Williams, W.M., & Barnett, S.M. (2009). Women's underrepresentation in science: Sociocultural and biological considerations. *Psychological Bulletin, 135*(2), 218–261.
Deci E.L., Ryan R.M. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior.* New York: Plenum.
Eagly, A. (1987). *Sex differences in social behavior: A social-role interpretation.* Hillsdale: Erlbaum.
Early, D.M., Irukaa, I.U., Ritchiea, S., Barbarin, O.A., Winna, D.C., Crawford, G.M., Frome, P.M., et al. (2010). How do pre-kindergarteners spend their time? Gender, ethnicity, and income as predictors of experiences in pre-kindergarten classrooms. *Early Childhood Research Quarterly, 25,* 177–193.
Eccles J.S. (1987). Gender roles and women's achievement-related decisions. *Psychology of Women Quarterly, 11,* 135–172.
Eccles, J.S. (2005). Studying gender and ethnic differences in participation in math, physical science, and information technology. *New Directions for Child and Adolescent Development, 110,* 7–14.
Eccles, J.S., Adler, T., Futterman, R., Goff, S., Kaczala, C., et al. (1983). Expectancies, values, and academic behaviours. In J.T. Spence (Ed.), *Achievement and Achievement Motivation* (pp. 75–146). San Francisco: Freeman.
Eccles, J.S., Adler, T., & Meece, J. (1984). Sex differences in achievement: A test of alternate theories. *Journal of Personality and Social Psychology, 46*(1), 26–43.
Eccles, J.S., Barber, B., & Jozefowicz, D. (1998). Linking gender to educational, occupational, and recreational choices: Applying the Eccles et al. model of achievement-related choices. In W.B. Swann, J.H. Langlois, L.A. Gilbert (Eds.), *Sexism and Stereotypes in Modern Society: The Gender Science of Janet Taylor Spence* (pp. 153–92). Washington, DC: American Psychological Association.
Eccles, J.S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53,* 109–132.
Else-Quest, N.M., Hyde, J.S., & Linn, M.C. (2010). Cross-national patterns of gender differences in mathematics: A meta-analysis. *Psychological Bulletin, 136*(1), 103–127.
Engle, J. (2003, April). *"Fear of success" revisited: A replication of Matina Horner's study 30 years later.* Paper presented at the Annual Meeting of the American Educational Research Association. Chicago, IL.
Evans, E.M., Schweingruber, H., & Stevenson, H.W. (2002). Gender differences in interest and knowledge acquisition: The United States, Taiwan, and Japan. *Sex Roles, 47*(3/4), 153–167.
Fouad, N., Hackett, G., Smith, P.L., Kantamneni, N., Fitzpatrick, M., Haag, S., & Spencer, D. (2010). Barriers and supports for continuing in mathematics and science: Gender and educational level differences. *Journal of Vocational Behavior, 77,* 361–373.
Frenzel, A.C., Goetz, T., Pekrun, R., & Watt, H.M.G. (2010). Development of mathematics interest in adolescence: Influences of gender, family, and school context. *Journal of Research on Adolescence, 20*(2), 507–537.

Frome, P.M., & Eccles, J.C. (1998). Parents' influence on children's achievement-related perceptions. *Journal of Personality and Social Psychology, 74*(2), 435–452.
Frome, P.M., Alfeld, C.J., Eccles, J.S. & Barber, B.L. (2006). Why don't they want a male dominated job? An investigation of young women who changed their occupational aspirations. In H.M.G. Watt & J.S. Eccles, (Eds.). Understanding women's choice of mathematics and science related careers: Longitudinal studies from four countries. *Educational Research and Evaluation, 12*(4), 359–372.
Frome, P.M., Alfeld, C.J., Eccles, J.C., & Barber, B.L. (2008). Is the desire for a family-flexible job keeping young women out of male-dominated occupations? In H.M.G. Watt & J.S. Eccles (Eds.), *Gender and Occupational Outcomes: Longitudinal Assessments of Individual, Social, and Cultural Influences* (pp. 195–214). Washington, DC: American Psychological Association.
Furnham, A., Reeves, E., & Budhani, S. (2002). Parents think their sons are brighter than their daughters: Sex differences in parental self-estimations and estimations of their children's multiple intelligences. *The Journal of Genetic Psychology, 163*(1), 24–39.
Gray, J. (1992). *Men are from Mars, women are from Venus: A practical guide for improving communication and getting what you want in your relationships.* New York: HarperCollins.
Greene, B.A., Miller, R.B., Crowson, H.M., Duke, B.L., & Akey, K.L. (2004). Predicting high school students' cognitive engagement and achievement: Contributions of classroom perceptions and motivation. *Contemporary Educational Psychology, 29,* 462–482.
Guiso, L., Monte, F., Sapienza, P., & Zingales, L. (2008). Culture, gender, and math. *Science, 320,* 1164–1165.
Hardre, P.L., & Reeve, J. (2003). A motivational model of rural students' intentions to persist in, versus drop out of, high school. *Journal of Educational Psychology, 95*(2), 347–356.
Harackiewicz, J.M., Barron, K.E., Tauer, J.M., Carter, S.M., & Elliot, A.J. (2000). Short-term and long-term consequences of achievement goals: Predicting interest and performance over time. *Journal of Educational Psychology, 92,* 316–330.
Haussler, P., & Hoffmann, L. (2002).An intervention study to enhance girls' interest, self-concept and achievement in physics classes. *Journal of Research in Science Teaching, 39*(9), 870–888.
Hazari, Z., Sonnert, G., Sadler, P.M., & Shanahan, M. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching, 47*(8), 978–1003.
Hoffmann, L., Krapp, A., Renninger, A., & Baumert, J. (Eds.). (1998). Interest and learning. *Proceedings of the Seeon Conference on Interest and Gender,* Kiel, Germany: IPN.
Horner, M.S. (1970). Femininity and successful achievement: A basic inconsistency. In J.M. Bardwick, E. Douvan, M.S. Horner, & D. Gutmann. (Eds.), *Feminine Personality and Conflict.* Belmont, CA: Brooks/Cole Publishing Company.
Hulleman, C.S., Schrager, S.M., Bodmann, S.M., & Harackiewicz, J.M. (2010). A meta-analytic review of achievement goal measures: Different labels for the same constructs or different constructs with similar labels? *Psychological Bulletin, 136,* 422–449.
Hyde, J.S. (2005). The gender similarity hypothesis. *American Psychologist, 60,* 581–592.
Hyde, J.S., Fennema, E., & Lamon, S.J. (1990). Gender differences in mathematics performance: A meta-analysis. *Psychological Bulletin, 107*(2), 139–155.
Hyde, J.S., & Linn, M.C. (2006). Gender similarities in mathematics and science. *Science, 314,* 599–600.
Jacobs, J.E., Lanza, S., Osgood, D.W., Eccles, J.S., & Wigfield, A. (2002). Changes inchildren's self-competence and values: Gender and domain differences across grades one through twelve. *Child Development, 73*(2), 509–527.
Jacobs, J.E., Chhin, C.S., & Bleeker, M.M. (2006). Enduring links: Parents' expectations and their young adult children's gender-typed occupational choices. *Educational Research and Evaluation, 12*(4), 395–407.
Jacobs, J.E., & Eccles, J.S. (1992). The impact of mothers' gender-role stereotypic beliefs on mothers' and children's ability perceptions. *Journal of Personality and Social Psychology, 63,* 932–944.
Kessels, U., & Hannover, B. (2007). How the image of math and science affects the development of academic interests. In M. Prenzel (Eds.), *Studies on the educational quality of schools. The final report on the DFG Priority Programme* (pp. 283–297). Münster: Waxmann.

LaFrance, M., Hecht, M.A., & Paluck, E.L. (2003). The contingent smile: A meta-analysis of sex differences in smiling. *Psychological Bulletin, 129,* 305–334.
Larose, S., Ratelle, C.F., Guay, F., Senécal, C., & Harvey, M. (2006). Trajectories of science self-efficacy beliefs during the college transition and academic and vocational adjustment in science and technology programs. *Educational Research and Evaluation, 12*(4), 373–393.
Lau, K.L., & Chan, D.W. (2001). Motivational characteristics of under-achievers in Hong Kong. *Educational Psychology, 22,* 417–430.
Lent, R.W., Brown, S.D., & Hackett, G. (1994). Toward a unifying social-cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior, 45,* 79–122.
Lightdale, J.R., & Prentice, D.A. (1994). Rethinking sex differences in aggression: Aggressive behavior in the absence of social roles. *Personality and Social Psychology Bulletin, 20,* 34–44.
Linn, M.C., & Petersen, A.C. (1985). Emergence and characterization of sex differences in spatial ability: A meta-analysis. *Child Development, 56,* 1479–1498.
Maccoby, E.E., & Jacklin, C.N. (1974). *The psychology of sex differences.* Stanford, CA: Stanford University Press.
Markus, H. (1977). Self-schemata and processing information about the self. *Journal of Personality and Social Psychology, 35,* 63–78.
Martin, A.J., & Hau, K. (2010). Achievement motivation among Chinese and Australian school students: Assessing differences of kind and differences of degree. *International Journal of Testing, 10*(3), 274–294.
Mau, W.C. (2003). Factors that influence persistence in science and engineering career aspirations. *The Career Development Quarterly, 51*(3), 234–243.
Meece, J.L., Wigfield, A., & Eccles, J.S. (1990). Predictors of math anxiety and its consequences for young adolescents' course enrollment intentions and performances in mathematics. *Journal of Educational Psychology, 82,* 60–70.
Möller, A.C., & Elliot, A.J. (2006). The 2 × 2 achievement goal framework: An overview of empirical research. In A. Mittel (Ed.), *Focus on educational psychology* (pp. 307–326). New York, NY: Nova Science.
Moon, M., & Hoffman, C.D. (2008). Mothers' and fathers' differential expectancies and behaviors: Parent x child gender effects. *The Journal of Genetic Psychology,* 2008, *164*(3), 261–279.
Mukhopadhyay, C. (1994). Family structure and Indian women's participation in science and engineering. In C. Mukhopadhyay & S. Seymour (Eds.), *Women, Education and Family Structure in India.* (pp. 103–132), Boulder: Westview Press.
Mukhopadhyay, C. (2004). A feminist cognitive anthropology: The case of women and mathematics. *Ethos, 32*(4), 458–492.
Murphy, M.C., Steele, C.M., & Gross, J.J. (2007). Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psychological Science, 18*(10), 879–885.
Nagy, G., Trautwein, U., Baumert, J., Köller, O., & Garrett, J. (2006). Gender and course selection in upper secondary education: Effects of academic self-concept and intrinsic value. *Educational Research and Evaluation, 12*(4), 323–345.
Nagy, G., Watt, H.M.G., Eccles, J., Trautwein, U., Lüdtke, O., & Baumert, J. (2010). The development of students' mathematics self-concept in relation to gender: Different countries, different trajectories? *Journal of Research on Adolescence, 20*(2), 482–506.
National Science Foundation. (2006). *Science and engineering indicators 2006* (Vol. 1 NSB 06-01, Vol. 2, NSB 06-01A). Arlington, VA: National Science Foundation.
OECD. (2010). *Education at a Glance: OECD Indicators.* OECD Publishing.
Pekrun, R., Elliot, A.J., & Maier, M.A. (2006). Achievement goals and discrete achievement emotions: A theoretical model and prospective test. *Journal of Educational Psychology, 98,* 583–597.
Roeser, R.W. (2006). On the study of educational and occupational life-paths in psychology: Commentary on the special issue. *Educational Research and Evaluation, 12*(4), 409–421.
Ruble, D.N., Martin, C.L., & Berenbaum, S.A. (2006). Gender development. In N. Eisenberg, W. Damon, & R.M. Lerner (Eds.), *Handbook of child psychology: Vol. 3. Social, emotional, and personality development* (6th ed., pp. 858–932). Hoboken, NJ: John Wiley & Sons Inc.

Ryan, R.M., & Grolnick, W.S. (1986). Originsand pawns in the classroom: Self-report and projective assessments of individual differences in children's perceptions. *Journal of Personality and Social Psychology, 50,* 550–558.
Schiefele, U. (1991). Interest, learning, and motivation. *Educational Psychologist, 26*(3–4), 299–323.
Sells, L.W. (1980). Mathematics: The invisible filter. *Engineering Education, 70,* 340–341.
Senko, C., & Harackiewicz, J.M. (2002). Performance goals: The moderating roles of context and achievement orientation. *Journal of Experimental Social Psychology, 38*(6), 603–610.
Simpkins, S.D., & Davis-Kean, P.E. (2005). The intersection between self-concepts and values: Links between beliefs and choices in high school. *New Directions in Child and Adolescent Development, 110,* 31–47.
Sonnert, G. (1995). What makes a good scientist?: Determinants of peer evaluation among biologists. *Social Studies of Science, 25*(1), 35–55.
Spearman, J., & Watt, H.M.G. (in press). Perception shapes experience: The influence of actual and perceived classroom environment dimensions on girls' motivations for science. *Learning Environments Research.*
Stadler, H., Duit, R., & Benke, G. (2000). Do boys and girls understand physics differently? *Physics Education, 35*(6), 417–422.
Stockard, J. (1999). Gender socialization. In J.S. Chaftez (Ed.), *The Handbook of the Sociology of Gender.* (pp. 215–227). New York: Plenum Publishers.
Tannen, D. (1991). *You just don't understand: Women and men in conversation.* New York: Ballantine Books.
Watt, H.M.G. (2004). Development of adolescents' self-perceptions, values, and task perceptions according to gender and domain in 7th- through 11th-grade Australian students. *Child Development, 75*(5), 1556–1574.
Watt, H.M.G. (2005). Explaining gendered math enrollments for NSW Australian secondary school students. In R.W. Larson & L.A. Jensen (Series Eds.) & J.E. Jacobs & S.D. Simpkins (Vol. Eds.), Leaks in the Pipeline to Math, Science, and Technology Careers, *New Directions for Child and Adolescent Development, 110,* 15–29.
Watt, H.M.G., Eccles, J.S., & Durik, A.M. (2006). The leaky mathematics pipeline for girls: A motivational analysis of high school enrolments in Australia and the USA. In P. Wynarczyk (Ed.), An international investigation into gender inequality in science, technology, engineering and mathematics (STEM). *Equal Opportunities International, 25*(8), 642–659.
Watt, H.M.G., Shapka, J.D., Morris, Z.A., Durik, A.M., Keating, D.P., & Eccles, J.S. (2012). Gendered motivational processes affecting high school mathematics participation, educational aspirations, and career plans: A comparison of samples from Australia, Canada, and the United States. *Developmental Psychology, 48*(6), 1594–1611. [Special section: Educational and occupational planning and choice as core developmental tasks during the transition to adulthood] doi: 10.1037/a0027838
Wolters, C.A. (2004). Advancing achievement goal theory: Using goal structures and goal orientations to predict students' motivation, cognition, and achievement. *Journal of Educational Psychology, 96,* 236–250.
Young, J.W. (1991). Gender bias in predicting college academic performance: A new approach using item response theory. *Journal of Educational Measurement, 28,* 37–47.
Young, J.W. (1994). Differential prediction of college grades by gender and by ethnicity: A replication study. *Educational and Psychological Measurement, 54,* 1022–1029.

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