FACTORS THAT INFLUENCE FEMALES' PURSUIT OF STEM FIELDS

A literature review emphasizing psychological influences

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It is not females' cognitive abilities that are falling short in science, technology, engineering, and mathematics (STEM). At the elementary, middle, and high school levels, girls today are equally or more likely than boys to take science and math classes, and they earn slightly better grades in those classes (Halpern et al. 2007, Clewell & Campbell 2002, U.S. DOE 2007). However, in early-adolescence girls begin to lose confidence in math and science despite their performance, representing a shift in attitudes as opposed to ability.

In later years, females fall far behind males in STEM fields. At the community college level, women take home just two in every five science and engineering associate's degrees (Community College Spotlight), and as freshman at four-year colleges, about twice as many men (29%) as women (15%) plan to study in STEM (NSF 2009). Although women earn nearly half of bachelor's degrees in math, half in chemistry, and the majority in biology (Hill et al. 2010), men earn 80% of bachelor's degrees in computer science, engineering, and physics (NSF 2009). Disparities are even more dramatic in the labor market (Hill et al. 2010, Halpern et al. 2007), with women comprising only about a quarter of the science and engineering workforce (Halpern et al. 2007).

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Females' low representation in STEM fields is troubling given national calls for stronger STEM education to maintain a competitive edge in the global economy (cf. Natl. Academy of Sciences 2007; U.S. Government Accountability Office 2006; U.S. DOE 2006, White House's Educate to Innovate campaign). Further, increasing women's representation in STEM fields would support women's economic stability and parity. Although women typically earn less than men regardless of field, occupational segregation accounts for the majority of America's gender wage gap (AAUW 2007). Science and engineering jobs tend to have good security and pay (Hill et al. 2010), and women who receive vocational training in technical fields are especially likely to be pulled out of sub-living-wage jobs. In fact, the ten fastest-growing jobs in the U.S. that call for at least a bachelor's degree require substantial training in math and science (ibid). It is a key moment to better understand the factors shaping women's and girls' pursuit of STEM fields.

To review the literature, I began with a Google Scholar search seeking articles:

- Published in the last five years (since 2008)
- With titles including "STEM"
- With titles including one of the following gendered-words: women, girls, females, gender, sex
- With titles excluding "cell(s)" (so as to eliminate articles about stem cells)

These parameters yielded approximately 200 articles. On a case-by-case basis, I excluded some of these articles due to topic (i.e., not about females in STEM), format (e.g., PowerPoint presentations) or national focus (e.g., studies based on European educational systems and economies). I was left with approximately 150 articles. I reviewed this full set of articles, along with the most relevant references cited within these articles. Following is my review of factors that influence female's pursuit of STEM fields, with particular attention to psychological influences, including the role of:

- Females' **confidence and interest** in STEM
- **Self-efficacy** among females in STEM
- **Role models** in STEM
- **Stereotype threat** for females in STEM
- Drawing and retaining female **faculty** in STEM
- STEM **classroom content**
- A **growth mindset** for females in STEM
- A sense of **community** among females in STEM

Each of these factors is discussed below.

CONFIDENCE AND INTEREST

Students' sense of confidence and interest in a field tend to feed one another—possessing more confidence increases interest, and greater interest bolsters confidence (Denissen et al 2007). This pair of factors—confidence and interest—appears to matter a great deal for females' pursuit of STEM fields. While females and males exhibit similar performance into the high school years, females express less interest and have less confidence in their mathematic reasoning and problem solving abilities (Catsambis 1994). In other words, women's lesser representation in STEM fields is likely attributable more to their sense of confidence and degree of interest in STEM fields than to their abilities. This gender difference is particularly pronounced among Latino students, and least evident among African Americans (ibid).

Illustrating this, Brainard and Carlin (1997) surveyed women who enrolled in a four-year college intending to pursue a degree in engineering or science, and found these women to begin their higher education with strong academic confidence. However, this confidence eroded during their first year of college and only gradually improved in later years (though it did not reach its original level even by the end of their fourth year; ibid). Women who left science and engineering most often did so in the first two years of college, despite the fact they had GPAs equal to those who stayed (ibid). To explain their departure from STEM fields, they generally sited a loss of interest, increasing interest in another field, or academic challenges and low grades (ibid).

If interest and confidence are central to females' pursuit of STEM fields, then what fosters females' continued interest and confidence? Huang and Brainard (2001) found that women's confidence in STEM is influenced more than men's by external factors: among undergraduate engineering majors at a four-year university, "perceived respect from professors […was] the strongest determinant of female academic self-confidence, whereas the perceived quality of teaching is the strongest predictor among male students" (ibid:40). In a study of sixth to twelfth grade girls, Heaverlo (2011) demonstrated that extracurricular STEM involvement and math teacher influence were associated with girls' interest and confidence in math.

Brainart and Carlin (1997) identified differences in women's STEM supports from year-to-year in college, which sheds light on areas that are particularly important *at particular times* for women pursuing STEM degrees. For example, women who stayed the course at least through their first year of college sited their continuing enjoyment of science and

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math classes, helpful faculty, awareness of science and engineering career opportunities, and their ability to work well independently as supporting their retention (ibid). However, even these women commonly reported a lack of self-confidence, not feeling accepted within their department, poor advising, intimidation, and a fear that they would loose interest in the field (ibid). By the second year of college, persistence was associated primarily with possessing a good relationship with an advisor, feeling accepted within the department, and continuing to enjoy math classes (ibid). By the third year of college, community influences such as positive experiences in student societies and at conferences and other events, a valuable relationship with a mentor, and continuing interest in classes were the primary determinants of retention (ibid). In the fourth year, all these supports remained important (advisors, mentors, positive experiences in classes and at conferences), and a new influence emerged as central as well: intention to work in engineering after graduation (ibid).

Interventions at Harvey Mudd College also appear to have had quite a bit of success for women studying computer science: “We divided our introductory course into two parallel classes, based on prior levels of programming experience. Such minor adjustments have had a large impact on increasing women's confidence. We've also found that providing early research opportunities for female students—as early as the summer after their first year—helps boost confidence as they discover they truly can do the work of a computer scientist” (Cutler 2012:4).

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SELF-EFFICACY

Fundamentally, low confidence and interest may have a lot to do with students' sense of self-efficacy (i.e., their belief in their abilities). Some years ago, Pajares and Miller (1994) demonstrated that a sense of self-efficacy mediates the effect of both gender and prior experience on performance in math: "the poorer performance and lower-self-concept of the female students were largely due to lower judgments of their capability" (ibid:200).

There appears to be a chain of influence wherein factors including expectations, interest, ability, and stress may shape women's sense of self-efficacy, which in turn may more directly effect women's studying in STEM. For example, Hackett et al (1992) identified self-efficacy as a powerful predictor of women's majoring in engineering or science. Further, they found that outcome expectations, vocational interests, and low stress levels powerfully predicted self-efficacy in math and science (which in turn predicted majoring in STEM; ibid). In a similar vein, Nauta, Epperson, and Kahn (1998) surveyed women majoring in STEM fields, and found that self-efficacy mediates the relationship between ability and career aspirations, especially for women studying mathematics, physical science, and engineering (as compared to women majoring in the biological sciences). That is, part of why ability matters for career aspirations is that ability helps to shape women's self-efficacy, which in turn influences career aspirations.

Importantly, self-efficacy is something that can be developed in students. Illustrating this, Fantz et al (2011) found that engineering students' self-efficacy was significantly improved with participation in pre-collegiate engineering classes involving hands-on experiences, real-life applications, and problem-based projects, while other quite brief extracurricular activities such as field trips and one-day workshops did not significantly influence students' self-efficacy.

ROLE MODELS

Much research has argued for the value of female role models in STEM fields. For example, Farland-Smith (2009) observed that middle-school girls exposed to female scientist role models developed more positive attitudes towards careers in science, and Kim et al (2009) drew on survey data to demonstrate that women pursuing computer science at the college level can gain from exposure to women successfully balancing STEM careers and family responsibilities. They argue that such role models can support students' confidence and provide counterfactuals to negative stereotypes (ibid). Likewise, Lockwood (2005) examined the effects of gender-matched and mismatched career role models by having college students read about a successful graduate of their university who majored in the same field as them. She found that while the gender of role models did not bear on male-participants' self-perceptions of their success-related traits, female college students were more inspired by outstanding role models who were women (as opposed to men; ibid). One particularly methodologically strong study (from Carrel et al 2009) took advantage of the random assignment of students and faculty into STEM classes at the Air Force Academy (Price 2010). This study found "that high ability female students who have their introductory STEM courses taught by a female instructor perform better in these and additional courses and are more likely to receive a degree in a

STEM field" (ibid:6). Finally, Smith and Erb (1986) examined a nation-wide sample of adolescents who were exposed to female scientist role models for two months, and found that both female and male students showed greater gains in their attitudes towards science (from pre- to post-exposure tests) as compared to students who did not interact with female scientist role models (ibid).

Work out of Harvey Mudd College helps to illuminate *why* role models might matter for women's success in STEM fields: "Each year Harvey Mudd [College] takes a large number of female students to the Grace Hopper conference, the largest conference focusing on women in computer science. When students see successful women working in a wide variety of technology fields and enjoying those fields, they begin to understand who they can become and how STEM can help them get there. Having a mentor also can increase female interest and success…[In alignment with this thinking,] Harvey Mudd [College] and Piazza, an online social-learning network, launched a six-week online mentoring program called WitsOn (Women in Technology Sharing Online) to connect undergraduate students nationwide with female mentors from industry and academe" (Cutler 2012:5).

A series of studies has shed a more nuanced light on instances in which female role models may make a particular difference. While female role models have been shown to support women's *performance and persistence* in STEM fields, research has not generally found female role models to be as important for *recruiting* women into STEM. This is an important distinction. For example, Canes and Rosen (1995) demonstrated that increases in female STEM faculty at a diverse set of four-year colleges were not followed by increases in female majors in those fields. While many of the studies cited above demonstrate a valuable role for female role models in supporting women's *continuing* STEM pursuits, Canes and Rosen observed that increasing female role models did not *draw* more women into STEM majors. In fact, Downing et al (2005) observed that *men* were often among the most influential role models reported by women in STEM. Likewise, Price (2010) found that females were no more likely to pursue STEM fields in which their introductory classes were taught by females rather than males (though interestingly, the odds that African American students pursued STEM fields were improved when introductory courses were taught by African American instructors).

Building on this work, Cheryan et al (2011) conducted two experiments on the effects of STEM role models. They found that "when attempting to convey to women that they can be successful in STEM fields, role model gender may be less important than the extent to which role models embody current STEM stereotypes" (ibid:656). This suggests that the most salient stereotypes for women considering entering STEM fields may not be gendered stereotypes, but rather stereotypes about the culture of given STEM fields or the kinds of personalities that tend to thrive in given fields. Their first experiment involved non-computer-science majors who were exposed to upperclassmen role models who either modeled clothing, hobbies, and preferences identified (in student pre-testing) as stereotypical to computer science majors, or those typical to the broader student body (ibid). They found that "women who interacted with non-stereotypical role models believed they would be more successful in computer science than those who interacted with stereotypical role models [and that] differences in women's success beliefs were mediated by their perceived dissimilarity from stereotypical role models" (ibid:656). In the second experiment, non-computer science majors interacted with female and male computer science major confederates, and again demonstrated that "role model gender had no effect on [students'] success beliefs" (ibid:656).

Why do female role models appear to support women's *retention* in STEM fields, but to bear less of an effect on *recruitment*? Part of the answer may lie in the extent to which women have identified with a STEM field, activating the detrimental effects of "stereotype threat" (further discussed below; Cheryan et al 2011). Women who have declared a STEM major or otherwise invested themselves in a STEM field are likely aware of negative stereotypes about women in STEM, and encountering a competent female role model can buffer against the detrimental effects of these stereotypes. However, for women who have not yet identified with a STEM field, gendered stereotypes may not be as salient as stereotypes about the culture or personality traits typical to STEM fields, such that valuable role models for *recruiting* women into STEM may need to counter many negative stereotypes about STEM fields, including—but not exclusive to—stereotypes about women. But once women have developed an identity aligned with a STEM field, it is likely that female role models are an effective antidote to the deleterious effects of stereotype threat (discussed below).

STEREOTYPE THREAT

Stereotype threat is a fear of confirming a negative stereotype, such as women's lesser abilities in STEM fields (Steele 1997, Steele and Aronson 1995). In the face of such fears, people tend to underperform, thereby fulfilling the stereotype (ibid). This may help

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to explain why female role models are valuable for retaining women in STEM fields, but matter less when it comes to recruiting women into STEM, as women who have yet to identify with STEM fields are less likely to be concerned about whether they fit the negative stereotypes associated with women in STEM fields. Thus, overcoming gendered stereotypes may be less of an issue for drawing women into STEM (a point at which they are likely less aware of and threatened by gendered stereotypes) than in retaining women who are already highly identified with STEM fields (and are therefore likely subject to the threat of negative stereotypes).

In accordance with this argument, Cheryan and Plaut (2010) found that feelings of belonging (or a perceived sense of similarity to students pursuing computer science) more powerfully predicted women's interest in computer science than concerns about stereotypes. The authors wrote: "Why was there a gender difference in interest in computer science? Women felt less similar to computer science majors than men, and this lack of perceived similarity accounted for why they were less interested in pursuing the field" (ibid:4).

In a similar vein, multiple studies by Cheryan and colleagues (e.g., Cheryan et al 2011, Cheryan et al 2009) conducted experiments wherein students were exposed to virtual computer science classrooms containing items deemed stereotypical (e.g., Star Trek posters and video games) or neutral (e.g., nature posters and water bottles). Women expressed less interest and lower anticipated success in computer science when exposed to the stereotyped classroom as compared to the neutral classroom, though men experienced no significant difference in their sense of belonging regardless of these

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classroom characteristics (ibid). Women's lower interest and anticipated success in stereotyped classrooms was partly explained by their lower sense of belonging in these classrooms (ibid).

Considering women already invested in a STEM field, even subtle cues can trigger stereotype threat. Marx and Roman (2002) found that women's performance on a challenging math test improved when the test was administered by a competent female experimenter (as opposed to a male), and further, that simply learning about a competent female experimenter could promote women's performance by protecting their self-appraised ability in math. Likewise, in an experimental study from McIntyre et al (2003), women performed significantly better on a challenging math test when told that women tend to make better participants in psychology experiments than do men. When females read about women who had succeeded in architecture, law, medicine, and invention, they performed better than when not presented with such examples of successful women in STEM fields (ibid). Steele (1997) found that simply indicating one's gender at the beginning of a standardized test was enough to diminish the test scores of strong female math students. Thus, for women already invested in STEM fields, the effects of stereotype threat are daunting, and female role models may well be an effective antidote.

Finally, in a recent survey in the American South, Cho et al (2009) showed eighth graders images of women identified either as working in STEM or non-STEM fields, and asked them whether they thought these women were good at their job, organized, intelligent, attractive, and creative. They observed that "students found the images of women in STEM career fields to be significantly more intelligent, significantly more creative, and significantly less attractive than images of women in non-STEM career fields" (Cho et al, 2009:4). That students were already so aware of STEM-stereotypes by the eighth grade suggests that STEM-interventions may be needed quite early in students' academic careers.

DRAWING AND RETAINING FACULTY

For female students to interact with more gender-matched role models (thereby combating the damaging effects of stereotype threat), more women must be drawn into and retained in STEM faculty positions. Therefore, it is valuable to examine what attracts women into these positions, what factors matter most for their satisfaction in these positions, and why they tend to stay or leave. Several studies speak to these issues.

To begin, Martin's (2011) analysis of 2000 STEM faculty at research universities demonstrated that female faculty's persistence was most affected by career and salary satisfaction. Career satisfaction was driven by perceptions of equity, workload, and the nature of the work itself; and salary satisfaction was not always aligned with salary amount, but simply *satisfaction* with salary amount. Finally, satisfaction was also driven by flexible career paths such as those including opportunities to take breaks to care for family.

Aligned with Martin's findings, Blakewood (2011) examined tenure-line STEM and non-STEM female faculty at research and doctoral institutions, and identified a significant relationship between STEM faculty's intention to continue in their role and their

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satisfaction with their job autonomy, compensation, and job security. These variables also predicted intending to continue as faculty in non-STEM fields, though while satisfaction with job autonomy was the strongest predictor of non-STEM faculty's intention to continue in their job, satisfaction with compensation (including both salary and benefits) was the strongest predictor of STEM female faculty's intention to continue their role. Blakewood (2011) concluded that "for women in STEM, feeling more satisfied with their salary and benefits may be the best way to entice them to stay, whereas for women in non-STEM, the flexibility to chose the types and number of classes taught may be the best was to increase the chances of staying in their current position" (p90).

In a survey of over 400 science and engineering faculty, Callister (2006) found departmental climate to matter a great deal for faculty's job satisfaction and intention to quit, *especially* for female faculty. Furthermore, "while gender influences job satisfaction and intention to quit (female faculty members report significantly lower levels of job satisfaction and higher intentions to quit), this relationship is completely mediated by department climate. This indicates that female faculty members are not inherently unsatisfied or unhappy with their jobs, but rather that it is likely that they value department climate, such that when they experience negative department climates they are more likely to experience lower job satisfaction and consider going elsewhere" (ibid:373). Similarly, Xu (2008) analyzed data for approximately 27,000 faculty from 960 colleges, and found that dissatisfaction with research support, career opportunities, and feeling a lack of freedom to express ideas all correlated highly with turnover intentions for female faculty. In a discussion of supports for female faculty in chemistry at liberal arts colleges, Beeston et al (2010) also highlight the value of flexible family leave policies (including elder care), medical leave policies, faculty development efforts, phased retirement options, travel support, sabbatical leaves, and shared academic positions.

Finally, focus groups conducted at Syracuse University underscored the important role *male* engineering faculty can play in supporting their female counterparts (Alestalo et al 2011). Themes included the value of a strong faculty community, and departments rewarding positive behavior and holding faculty accountable for their equitable behavior.

CLASSROOM CONTENT

Classroom content can also matter a great deal for recruiting and retaining women in STEM fields—including factors such as teachers typical interactions with female versus male students and sensitivity to males' and females' preferred classroom styles.

To begin, some consistent differences are observed in how teachers tend to interact with male and female students. Jones and Dindia (2004) conducted a meta-analysis of research carried out between 1970 and 2000 on sex differences in student-teacher interactions, and concluded that teachers initiate more interactions with male than female students. However, in particular, they observed more *negative* interactions between teachers and male students, which may indicate that teachers less often challenge or correct girls' thinking, perhaps in a sort of "benevolent sexism" whereby teachers make such an effort not to discourage female students that they fail to provide productive feedback (ibid, Bachman et al 2009). However, educating student-teachers about gender equity issues and gender-sensitive education has been shown to promote more equitable classroom interactions between teachers and students of both genders (Bailey et al 1999).

Additionally, a large literature documents differences in preferred classroom styles for male and female students. In reviewing the literature, Bachman et al (2009) describe how from a young age boys tend to engage more in classrooms with an emphasis on goals and hierarchy, whereas girls tend to engage in more cooperative classrooms. STEM classrooms tend to be more goal-based, hierarchical, and independent than non-STEM classrooms, thereby appealing more to boys' preferences than girls' (ibid). Likewise, in their expansive literature review, Knight et al (2011) documented that small-group learning, hands-on activities early in STEM course sequences, and practical "real life" problem solving promote females' positive attitudes, sustained interest, persistence, and achievement in STEM fields.

Brotman and Moore (2008) document how "girls are, on average, more relational and cooperative than boys and more strongly seek deep conceptual understandings and active learning experiences…Curriculum and pedagogy that is gender-inclusive therefore includes features such as active, collaborative learning, which highlights the social relevance of science and pays particular attention to incorporating the life experiences of girls" (p985). In an extensive literature review, they identified common themes in research on gender-inclusive curriculum and pedagogy: "a gender-inclusive science curriculum draws upon both girls' and boys' experiences, interests, and preconceptions; prioritizes active participation; incorporates long-term, self-directed projects; includes open-ended assessments that take on diverse forms; emphasizes collaboration and communication; provides a supportive environment; uses real-life contexts; and addresses the social and societal relevance of science" (ibid:983). However, Brotman and Moore's (2008) literature review "did not provide any evidence that these strategies work specifically for girls, and they overlap with reform efforts to create equitable and high-quality science education for all students" (p985).

Bortman and Moore (2008) further explained that "recent literature argues that, to engage girls and other marginalized groups in science, we must address issues of the nature and culture of science in the classroom and in society in general…Science is often portrayed to be especially difficult, to be something that men do, and to be completely objective and thus value-free, all of which deter girls and others from participation…This portrayal is inaccurate in that, in actuality, both scientific practice and knowledge are impacted by human beings that do and discover it, and thus by the societal and cultural values that influence human action and thought. Finally, these studies acknowledge the role of subjectivity, creativity, and personal expression in science, whose contributions to scientific thinking are not commonly recognized" (p988).

In alignment, Saucerman and Vasquez (2012) describe how women's and men's career goals have been shown to vary in some consistent ways (though they also underscore how important is it not to overemphasize these differences, as there is also great overlap in men's and women's career goals). Typically, men more heavily emphasize "agentic goals" such as making money, while women emphasize "communal goals" like helping others (Saucerman and Vasquez 2012; see also Costa et al 2001 and Schwartz and Rubel 2005). Among both women and men, careers in STEM fields are believed particularly

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poorly matched to communal goals (Diekman et al 2010). Furthermore, interventions aimed at recruiting women into STEM fields often emphasize agentic goals like the increased earning potential afforded by STEM careers (Saucerman and Vasquez 2012; see also Diekman et al 2011). While this can be valuable—indeed, educating students about projected earning in STEM fields has been shown to shape choice of major (Olitsky 2012, Arcidiacono 2010)—women's frequent valuation of more communal goals should also be considered in recruiting women into STEM. Even subtle cues can do this. For example, women's belief that careers in science can fulfill communal goals, as well as their attitudes towards science careers, both improved when women were given descriptions of a scientist's day that included collaborative work (Diekman et al 2011).

In a related vein, Weber (2012) described the multiple ways in which students can engage with a field—including cognitive engagement, wherein students develop a deep interest in mastering concepts; emotional engagement, wherein students find the content of the field inherently satisfying; and social engagement, wherein students' social worth improves through pursuit of a field. Each of these types of engagement can feed interest and confidence in a field, such that it is valuable to foster cognitive, emotional, and social engagement in considering how to best draw and retain women in STEM.

Considering specific pedagogical practices supportive of women's (and minorities') success in STEM classes (Ilumoka 2012), surveys of over 100 women revealed the value of:

- *Application-Oriented Teaching* – "classrooms in which the teacher made a

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concerted effort to forge clear and consistent linkages between STEM and everyday issues presented fewer barriers to girls and minorities”

- *Inclusive and Reassuring Illustrations* – “explicit verbal, written or graphical reference to ‘normal looking’ successful individuals in STEM, particularly those who looked like the students [as well as] speakers…who were clearly enjoying their professional careers, helped to reassure the students that STEM careers were desirable”
- *Peer Instruction* – “the presence of enthusiastic female and/or minority college level STEM majors in the STEM classroom working side by side with the teacher as teaching assistants…bridged the ‘academic and social’ gap between the students and the teacher...Students very quickly bonded with the TAs and were comfortable admitting ignorance or asking ‘stupid questions’” (p6-7).

Likewise, Heaverlo (2011) identified math teacher influence to significantly predict sixth to twelfth grade girls’ interest and confidence in math. In particular, she observed a significant role for the following variables: “My teacher creates a classroom environment that allows me to learn; My teacher encourages my responsibility and effort; The assignments given help me learn the subject being taught; My teacher encourages us to ask questions; My teacher asks questions that challenge me to think; My teacher communicates high expectations; I get help from my teacher; I am comfortable asking questions in class; I enjoy learning the material in the class” (ibid:93-4).

Having a diverse, energetic, and enthusiastic staff, and a curriculum centered on hands-on and project-based learning, real-life issues, and exposing students to the nature of STEM occupations was found effective for drawing girls into STEM fields in a recent report surveying 123 programs in 36 states, including a diversity of urban and suburban schools serving students primarily between sixth and tenth grades (Liston et al 2008). Likewise, Milgram (2011) documents the success of a project underway among California two-year colleges (the IWITTS' CalWomenTech Project), which has seen dramatic increases in women's participation in STEM programs. The project incorporates biographies of female role models in their outreach materials that "emphasize not only the path these women took to arrive at their chosen careers, but also the joy they found in their work, as well as their personal interests and family stories" (e.g., see www.iwitts.org; ibid). Counselor outreach is another key component of the program, including providing councilors with information and materials to distribute to potential students (ibid).

Finally, it is worthwhile to keep in mind that even when treated identically, males and females can *experience* an environment differently. Indeed, Wao et al (2010) found that while "women and underrepresented minorities were not treated differently, nonetheless they experienced department climate differently from their majority peers." In order to support learning and engagement, females and males may sometimes have distinct needs.

GROWTH MINDSET

In addition to the strategies outlined above, another important concept for teachers to explore with females considering STEM fields is a "growth mindset" (i.e., an understanding that academic performance can be developed over time with practice). In other words, it is vital that students understand that ability is flexible and can be learned.

In contrast, a "fixed mindset" describes the misconception that people either possess or lack ability and it cannot be cultivated with effort. As Saucerman and Vasquez (2012) describe, "when students hold a fixed mindset about their abilities, they experience decreased confidence and effectiveness when faced with an academic challenge; this pattern appears to be especially true of high academic performers. People who hold the fixed mindset call their abilities into question because they believe confusion in a subject indicates a lack of 'natural' ability."

However, research has illustrated how a growth mindset can be taught with long-term benefits for students (Blackwell et al 2007). Blackwell et al (2007) randomly assigned middle-school students to participate in eight short workshops teaching strong study skills, ways to avoid stereotypical thinking, and how the brain can develop with practice. Students randomly assigned to participate in the intervention performed significantly better than those who were not, evidence that a growth mindset truly can be taught, with real benefits to student performance (ibid).

COMMUNITY

Another factor that may help to overcome barriers to females' success in STEM fields is sharing a strong STEM community. Indeed, experiencing a sense of community appears to be a central support for many female students. Legewie and DiPrete (2011) demonstrate that high school experiences, including support for STEM interests from peers, teachers, and parents, as well as a high level of exposure to STEM courses and information about STEM career trajectories, strongly influence females' attitudes towards

STEM fields. Likewise, Hausmann et al (2007) examined students' sense of belonging and their retention in STEM fields at a four-year college, and found that a feeling of belonging predicted students' intentions to persist.

Considering the role of peers, in particular, research has found peer influences to play a substantial role in shaping students' academic attitudes and college plans (Buchmann and Dalton 2002, Bachman et al 2009, Stake and Nickens 2005). For example, in a large study of female and male STEM majors, Shapiro (2011) found that having same-major friends can support STEM students' outcomes. Having more same-major friends increased women's orientation towards science in particular (ibid). Likewise, Robnett and Leaper (2012) demonstrated that friends' support of STEM interests and motivation in STEM fields predicted students' interest in STEM careers. The influence of friends' interests and motivation were particularly pronounced when friends were females who did not support STEM interests—girls with these kinds of friendship groups had particularly low interest in STEM careers (ibid). Interestingly, friends' support of English interests and motivation did not shape career interests (ibid).

Other work has found STEM communities especially valuable for women of color. Espinosa (2008) reports that "women of color who persisted in STEM frequently engaged with peers to discuss course content, joined STEM-related student organizations, participated in undergraduate research programs, had altruistic ambitions, attended private colleges, and attended institutions with a robust community of STEM students. Negative predictors of persistence include attending a highly selective institution" (p209). Likewise, in a small study of racial/ethnic minority STEM majors, Cole and Espinoza

(2009) found that “tutoring another college student enhanced the academic performance of women but had no affect for men,” so may be a particularly valuable strategy for engaging women in STEM majors.

Conversely, women who experience highly competitive or isolating STEM environments may be especially likely to leave STEM fields. Shapiro and Sax (2011) argue that the large lecture classes often graded on a curve and commonly designed to “weed students out” all contribute to a competitive culture in undergraduate STEM tracks that discourages collaborative work and may turn many women away from STEM pursuits. In parallel, isolation has been discussed as detrimental to women’s pursuit of STEM fields. Fabert et al (2011) argue that female doctoral students in STEM fields may utilize remote communication (e.g., email and Skype) and student self-isolation as a means to appear competent (i.e., “I don’t need help; I’m doing great”), but that this can prevent students from comparing their experiences against others’ and developing competencies through interaction.

Multiple interventions have aimed to provide a greater sense of community and reduce experiences of isolation for women pursuing STEM fields, and some of these interventions have had quite promising outcomes. Kahveci et al (2006) evaluated the effectiveness of a program designed to support undergraduate women pursuing STEM fields. The program initiates in students’ first year of college, and includes living together on campus during the first year and many activities aimed at encouraging community among students and between students and female STEM faculty, such as: a one-credit course wherein female scientists from the university share their research with participants, and opportunities to participate in lectures, panel discussions, mentoring, advising assistance, research internships, tutoring, and field trips (ibid). Kahveci et al (2006) found the program was associated with significant improvements in female students' retention in STEM majors.

Likewise, Stake and Nickens (2005) studied the effects of a college summer science enrichment program on supportive STEM peer networks. The program included fulltime activities designed to foster cooperative relationships and a sense of community—it provided students with a forum to build friendships among similarly STEM-interested peers. They found that for both male and female participants, both previous peer relationships and new relationships with program participants were associated with the development of more positive expectations for becoming a scientist (ibid).

Finally, Iowa State University instituted a program for women transferring from community college into STEM majors (Crystal 2011). Based on research showing that "the retention of women is affected by strong connection to a community [such that] increasing the awareness of programs and resources; connections to study groups and peer mentoring; and an engaging curriculum are all effective practices for the retention of women in STEM," the program offered a residential option, study sessions, faculty dinners, field trips, tours, academic support, and weekly evening meetings led by well-qualified peer mentors, all with positive response. Similarly, Hausmann et al (2007) randomly assigned students to an intervention designed to enhance their sense of belonging in STEM majors—"through written communications from university administrators emphasizing that they were valued members of the university community…[and with] small gifts for daily use (e.g., ID holders, magnets, decals, etc.) that displayed the university's name, logo, and colors" (ibid:808). While sense of belonging declined for all students, the decline was smaller for students who received these belonging-promoting interventions.

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