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The authors summarize common factors that contribute to women's selection of and persistence in STEM majors. The chapter concludes with a consideration of the utility of this information for institutional researchers and how they might further study issues of gender and STEM on their own campuses.

Major Selection and Persistence for Women in STEM

Casey A. Shapiro, Linda J. Sax

The U.S. federal government identifies many science, technology, engineering, and math (STEM) majors as "areas of national need" that are "crucial to national innovation, competitiveness, and well-being and in which not enough students complete degrees" (Goan, Cunningham, and Carroll, 2006, p. 1). Even with the national push to recruit and retain students in STEM, too few students enter college with the desire to pursue STEM majors, and even fewer complete STEM degrees. According to the Higher Education Research Institute (HERI) national figures on students' intended major in 2009, only 24 percent of students entering college report an interest in majoring in STEM (Pryor and others, 2009). Moreover, we can expect about half of these students to actually earn a STEM degree, as research has shown that 50 percent or more of the students who enter college with STEM career aspirations either switch to a non-STEM field or leave postsecondary education altogether (Chen and Weko, 2009; Sax, 1994b).

Women seem to be affected by these trends even more than their male counterparts. Although women comprise approximately 57 percent of college students nationwide (King, 2010), their growing presence in higher education has not translated consistently to representation within STEM fields. Among first-year college students nationwide, only 17.3 percent of women report planning to major in a STEM field, compared to 32.2 percent among men (Pryor and others, 2009). Gender disparities are especially pronounced in the fields of engineering, physical sciences, and computer sciences, all of which are designated by the U.S. government as areas of need for national innovation, competitiveness, and well-being (Goan, Cunningham, and Carroll, 2006). Further, the gender gap for students entering STEM mirrors the gap in actual STEM degree attainment five years after entering college (Huang, Taddese, and Walter, 2000).

Underrepresentation of women in STEM in the United States has economic consequences, both individually and nationally. For example, given the ongoing connection between individuals' technological skills and their economic opportunities (Bystydzienski and Bird, 2006), women's economic independence may be hindered by underparticipating in the technological industries of the twenty-first century (Weinman and Cain, 1999). Further, in light of the national call to action for research in science and technology, women's underrepresentation in STEM signifies a loss of potential talent and innovation that may have an impact on the ability of the United States to remain globally competitive in science and engineering.

Furthermore, the technological and scientific professional workforce stands to benefit from diverse perspectives. In 2005, women constituted 47 percent of the college-educated U.S. labor force, but only 27 percent of the entire science and engineering workforce (National Science Board, 2008). Creating opportunities for more women to enter and be successful in STEM fields will contribute to diversifying STEM perspectives, ultimately making scientific research more vigorous and complete (Blickenstaff, 2005).

Given that women's underrepresentation in the STEM workforce is largely rooted in their selection of college major, this chapter summarizes the factors that contribute to women's selection of and persistence in STEM majors. We begin with a review of how the educational context shapes women's interest in STEM, and then we move to an overview of the major social and cultural influences beyond the classroom. The chapter concludes with a discussion of the utility of this information for institutional researchers and how they might further study issues of gender and STEM on their own campuses.

The Role of Educational Settings in Women's Pursuit of STEM

A significant portion of the literature examining factors related to women's decision to major in STEM focuses on formal and informal educational settings. In particular, women's experiences with the curriculum as well as their academic interactions with instructors and peers are influential in shaping women's interest in and longer-term commitment to STEM (Astin and Sax, 1996; Kinzie, 2007; Margolis, Fisher, and Miller, 2000; Sax, 1994a, 1994b, 2001; Seymour and Hewitt, 1997). Thus this section focuses on four commonly identified predictors of women's interest in and decision to enter a STEM major: (1) middle and high school preparation and curriculum, (2) culture and pedagogy in college-level STEM, (3) interactions with teachers and faculty, and (4) peer-and-curriculum connections.

Middle and High School Preparation and Curriculum. Preparation in science and mathematics during the middle and high school years is often cited as an important influence on women's decisions to enter or exit STEM majors in college. In fact, Astin and Sax (1996) note that past academic achievement and ability are the "most consistent and important predictors of students' interest in science" (p. 106).

Critical junctures for women's interest and participation in STEM occur as early as middle school. Kinzie (2007) found that in eighth grade women's pathways into or out of STEM are already beginning to be formed. Kinzie suggests that math achievement is particularly important, as low math achievement in eighth grade may play a role in the number of math courses women take in high school, thereby limiting the number of women who have adequate preparation to enter college-level math and science courses.

Differential experiences in STEM continue for women and men at the high school level. In their qualitative study of more than 450 students from seven institutions, Seymour and Hewitt (1997) found that inadequate high school preparation in science and mathematics was an important factor for those who left science, mathematics, and engineering majors. Interestingly, a higher percentage of women reported concerns with inadequate high school preparation than did men (Seymour and Hewitt, 1997).

Inadequate early preparation is also problematic for women in computer science (Margolis, Fisher, and Miller, 2000). Margolis and her colleagues found that at Carnegie Mellon, a university with a highly selective computer science programming department, 40 percent of first-year men majoring in computer science reported having passed the Advanced Placement computer science test while in high school, which allowed them to "pass out" or "test out" of an introductory-level programming class in college. However, none of the first-year women had placed out of this introductory-level programming class. Thus, among first-year computer science majors, men reported having more advanced knowledge of the field than women, which can negatively influence women's confidence in their abilities to succeed in that field.

As demonstrated by these and many other studies, women's differential STEM course taking and preparation in the precollege years can limit their ability to access STEM careers later on. Women who do not take the math and science courses needed to access a career in science, math, and engineering are often unable to stay in the science/mathematics pipeline (Huang and Brainard, 2001).

Culture and Pedagogy in College-Level STEM. The unique culture of undergraduate science courses has been identified as a factor influencing STEM major selection and success. In particular, the competitive nature often fostered in STEM courses is an aspect of science pedagogy that can deter women from selecting or remaining in a STEM major (Seymour and Hewitt, 1997; Strenta and others, 1994). Seymour and Hewitt (1997) suggest that "women do not find competition a meaningful way to receive feedback" (p. 263) and may even find it to be offensive.

What aspects of science pedagogy cause the environment to feel too competitive for many women? First, STEM courses are often taught in a large, lecture format, which adds to a fierce competition for grades and weeding out of students from STEM majors (Seymour and Hewitt, 1997). Astin and Sax (1996) also note that faculty in the sciences are more likely to grade on a curve, which promotes competition among students. Additionally, the weed-out system discourages collaborative work, instead reinforcing the notion that individuals should take responsibility only for their own learning (Seymour and Hewitt, 1997).

Strenta and others (1994) also found that regardless of gender, students described science and engineering professors as relatively unresponsive, not dedicated, and not motivating compared to faculty in the humanities and social sciences. The classroom climate can disproportionately affect women in STEM, producing feelings of depression about their work and lower self-confidence among STEM women compared to women in the humanities (Strenta and others, 1994). More recent evidence also indicates that the sciences have yet to fully embrace more collaborative teaching styles. Nelson Laird, Garver, and Niskodé (2007) found that faculty in the hard disciplines (for example, agriculture, biology, chemistry, and engineering) spend on average 16 percent more time lecturing and significantly less time using active learning practices compared to the faculty in soft disciplines (e.g., communications, education, English, and sociology).

For women, having access to real-world applications of science may be particularly important to reinforcing their decision to major in STEM (Hyde and Gess-Newsome, 2000; Margolis, Fisher, and Miller, 2000). Whether in the classroom or in a lab setting, when faculty use practical and active teaching strategies, women report gains in learning and confidence (Hyde and Gess-Newsome, 2000). These teaching techniques have been found to help women connect theory to practical real-life situations, which increases their self-reported learning and confidence in their abilities to succeed in their chosen STEM field (Hyde and Gess-Newsome, 2000).

Margolis, Fisher, and Miller (2000) also stress the importance of connecting computer science to the real world and applying it to social contexts in order to retain women in computer science. Indeed, the opportunity to improve the social world could be "a powerful incentive" to study STEM (Miller, Rosser, Benigno, and Zieseniss, 2000, p. 140). However, women often do not perceive STEM as a vehicle for improving the human condition, a perception that discourages many of them from persisting in STEM fields (Sax, 1994b, 2001).

Interactions with Teachers and Faculty. In addition to the pedagogy used in many STEM courses, faculty also can have an impact on women's interest and retention in STEM majors through their classroom interactions. Ideally, such interactions will promote student interest in STEM, especially if students view faculty as role models for their own future STEM careers. Indeed, students who encounter role models within the scientific community are more likely to follow up on their initial science aspirations (Astin and Sax, 1996). Research also suggests that female role models have more positive effects on women's math performance than do male role models (Marx and Roman, 2002).

Unfortunately, because women faculty are underrepresented in STEM, female students have limited access to same-sex role models and mentors compared to men. As Blickenstaff (2005) explains, "a low proportion of women in a discipline probably sends a message to girls that the discipline is unattractive to women, and they should avoid it too" (p. 376). One way to combat this perception is to expose female students to women who are successful in STEM careers while also successful at combining work and family responsibilities (Kahveci, Southerland, and Gilmer, 2007; Kim, Fann, and Misa-Escalante, 2009). Faculty and professional role models can help women students by bolstering their confidence and encouraging them to see themselves as successful in STEM majors and careers in the future, allowing them to overcome some of the negative stereotypes about having a career in STEM, and encouraging discussion of their own experiences and strategies for working through barriers in STEM fields (Kim, Fann, and Misa-Escalante, 2009).

Although faculty as role models can bolster women's interest in STEM, students' interactions with instructors can also have negative ramifications for their interest and retention in STEM majors. In their influential report, Hall and Sandler (1982) describe the "chilly climate" for women in college classrooms, which put women at a "significant educational disadvantage" (p. 3). The authors explain that regardless of the context (classroom, lab, and so on), some student-faculty interactions may bolster women's confidence, intellectual development, and aspirations, while others can dampen women's ambitions, which Hall and Sandler argue is especially significant for those women in areas that are traditionally viewed as masculine fields, including science and engineering.

Subtle discriminatory practices have been documented specifically within STEM majors (Seymour and Hewitt, 1997; Wasburn and Miller, 2004–05). Faculty have been described as excluding women from activities in the classroom and subjecting them to different grading practices than their male peers (Seymour and Hewitt, 1997). Wasburn and Miller

(2004–05) found that nearly one-third of female respondents felt professors in their technology classes treated female and male students unequally. Furthermore, 20 percent of the female respondents did not feel comfortable asking questions in class, and almost one-quarter did not feel comfortable going to their technology professor for assistance outside of class, which ultimately had negative implications for their persistence in technology majors. Faculty interactions can also negatively affect women's mathematical self-confidence (Sax, 1994a, 2008), discourage women from persisting in science, and make them feel unwelcome in the classroom (Seymour and Hewitt, 1997), which, as noted previously, has also been shown to influence women's decisions to leave STEM fields.

Peer-and-curriculum Connections. The peer culture cultivated in educational settings can also have implications for women's commitment to STEM. As noted earlier, the pedagogy often employed in STEM classrooms tends not to facilitate positive interactions among peers (Seymour and Hewitt, 1997; Strenta and others, 1994). More specifically, many STEM courses encourage competition for grades, which promotes an emphasis on individual success rather than on collaborative learning (Strenta and others, 1994; Astin and Sax, 1996, Seymour and Hewitt, 1997). Such an environment can be especially discouraging to women, who tend to prefer more cooperative forms of learning (Barker and Garvin-Doxas, 2004).

Peer interactions have also been shown to affect the classroom climate. In fact, Colbeck, Cabrera, and Terenzini (2001) suggest that the "chilly climate" for women in engineering results from peer interactions rather than from student-faculty interactions. Colbeck and colleagues found significant gender differences in students' perceptions of how peers interacted with male and female engineering students, whereby women were significantly more likely to report that male students treated female students differently, both generally and in collaborative learning situations. However, this differential treatment did not have a significant effect on women's academic and career outcomes. In other words, women who perceive a negative classroom climate may nevertheless remain steadfast in their commitment to STEM (Seymour and Hewitt, 1997; Wyer, 2003).

Another consideration of the peer culture from a curricular perspective is the impact that the proportion of females in STEM majors has on women's interest and retention in STEM. It might seem logical that women benefit from having more women enrolled in STEM majors; however research on this topic has yielded largely mixed results. Cohoon (2001) examined computer science departments across the state of Virginia and found that from both faculty and student perspectives the proportion of females enrolled in the major was the strongest predictor of women's attrition from computer science majors, such that computer science departments with a higher proportion of females enrolled were more likely to retain those women at a rate comparable to men. The authors conclude that the proportion of female students in the major matters, as having more women enrolled in the major provides same-sex peer support, which can encourage persistence in computer science (Margolis, Fisher, and Miller, 2000).

Sax (1996) also found that the proportion of women in one's major predicted women's persistence in the major; however, the impact of gender composition was minimal on other cognitive and affective outcomes (for example, academic and mathematical self-confidence, academic achievement, satisfaction with the major). Sax's research revealed that the effect of gender composition is typically explained by other aspects of the major (for example, level of competitiveness, faculty attributes, and precollege orientations of students enrolled in the major).

Forces Beyond the Classroom

In addition to educational environments, women's interactions and experiences outside the classroom can affect their interest and retention in STEM majors (Brainard and Carlin, 1998; Han, Sax, and Kim, 2007; Margolis, Fisher, and Miller, 2000; Seymour and Hewitt, 1997; Zhao, Carini, and Kuh, 2005). This section focuses on four key predictors of women's interest and decision to enter a STEM major: (1) self-confidence, (2) sense of belonging in the STEM culture, (3) family influences and expectations, and (4) peers and social/cocurricular connections.

Self-Confidence. Women consistently express lower levels of academic and mathematical confidence than their male peers, even when their demonstrated academic and mathematical abilities are equal to men's (Sax, 1994a, 2008). This also holds true for women's self-reported cognitive gains, such that women tend to report higher college grade point averages (GPA) compared to men yet tend to perceive fewer gains in their quantitative and analytical skills during college (Zhao, Carini, and Kuh, 2005). Thus one could argue that there is a discrepancy between women's perceived ability and their demonstrated achievement (Astin and Sax, 1996). In other words, women may not leave science and engineering majors for lack of academic ability, but rather because of a lack of scientific self-confidence (Brainard and Carlin, 1998).

Sense of Belonging in the STEM Culture. Research has consistently documented the importance of women's sense of belonging within STEM (Brainard and Carlin, 1998; Han, Sax, and Kim, 2007; Margolis, Fisher, and Miller, 2000; Seymour and Hewitt, 1997). Women are often exposed to attitudes about what it means to major or have a career in STEM, which can negatively influence their STEM-related self-concept (Astin and Sax, 1996). Students report these gendered attitudes can start early in one's academic career in the form of gender socialization either toward or away from science (Kim, Fann, and Misa-Escalante, 2009). Additionally, stereotypes of what it means to be an "engineer" continue to be primarily defined in terms of men (Tonso, 2006). It is this notion along with assumptions about the lifestyle of STEM careers that may conflict with gendered stereotypes regarding women's roles in the home, making STEM majors and careers less appealing to women (Kim, Fann, and Misa-Escalante, 2009).

In their study of computer science students, Margolis, Fisher, and Miller (2000) found that women lost confidence and interest in computer science because they felt they did not fit with the stereotypical view of a computer scientist. Piatek-Jimenez (2008) also found that women's stereotypical views about mathematical careers influenced their desire to have a career as a mathematician. In other words, women tend not to identify with traditional notions of what it means to have a career in STEM and may therefore choose not to pursue majors or careers in STEM.

Related to these influences are the explicit and implicit messages about the masculine nature of math and science. Explicit messages can include stereotypes that math is a masculine field and therefore not a discipline in which females can excel (Nosek, Banaji, and Greenwald, 2002). Women may not consciously acknowledge these masculine stereotypes of STEM, but implicitly these perceptions can influence the type of major they select (Nosek, Banaji, and Greenwald, 2002). Furthermore, when internalized by men and women, these perceptions can have an impact on women's sense of identification with STEM (Margolis, Fisher, and Miller, 2000; Nosek, Banaji, and Greenwald, 2002; Wyer, 2003).

Despite traditionally masculine views about science, it is important to note that women have made significant strides in certain areas of STEM, such as biological science, chemistry, and agricultural science (National Science Foundation, 2008). Some argue that this shift in women's participation in biological sciences is due to the nature of the field, which tends to more directly and explicitly address human problems (Miller, Rosser, Benigno, and Zieseniss, 2000).

Family Influences and Expectations. As noted previously, role models can influence women's desire to enter and be retained in STEM majors during college. Parents can also serve as role models for women interested in STEM. In fact, a woman is more likely to pursue a career in STEM if one or both of her parents had a career in these fields (Astin and Sax, 1996). For both men and women, having a father who is an engineer was associated with persistence toward a career in STEM (Sax, 1994b). Seymour and Hewitt (1997) also note the importance of having practical role models and mentors for women, including professional women in their own family.

However, parents are not always a positive influence. Historically, many parents have accepted the stereotype that men are more apt to succeed in STEM than women (Vetter, 1996). Vetter argued that in terms of their children's achievements in mathematics and science, "as a group, parents have lower educational aspirations for daughters than for sons" (p. 32). These lowered expectations can manifest in differential pressure from parents for their daughters and sons to persist in STEM, often resulting in women feeling less pressure from parents to complete a STEM major (Seymour and Hewitt, 1997).

Students' own notions about family and work can also influence their interest in majoring STEM fields (Han, Sax, and Kim, 2007). Even when men and women report equal levels of academic ability, first-year college women are still more likely to anticipate that conflicts between work and family responsibilities will be a barrier to career success (Hawks and Spade, 1998). Therefore, it seems that early in college women already perceive careers in STEM as incompatible with successfully raising a family, a perception that has implications for their desire to major in STEM in college.

Peers and Social/Cocurricular Connections. In addition to the role of peers in the academic setting (discussed earlier), the peer culture outside the classroom plays a role in women's lives and career decision making (Riegle-Crumb, Farkas, and Muller, 2006). According to Riegle-Crumb, Farkas, and Muller (2006), high school women's friendship groups influence their advanced-course-taking patterns, especially in the areas of math and science. Specifically, friendship groups that have a high combination of female friends and performance in math and science facilitate women's persistence in advanced courses, such as calculus and physics. Thus one could argue that for girls there is a relationship between high school friendship groups and the math and science preparation courses that are often needed to access a career in STEM.

Peers can also serve as role models for undergraduate women interested in STEM (Kahveci, Southerland, and Gilmer, 2007). Interactions with peers can provide women with an avenue to exchange information, find study partners, and create informal peer role models (Hyde and Gess-Newsome, 2000; Kahveci, Southerland, and Gilmer, 2007). Formal big-sister little-sister programs that connect older and younger female students in engineering also seem to help female students persist (Brainard and Carlin, 1998). However, Seymour and Hewitt (1997) found that women in STEM are often surrounded by peers who make them feel unwelcome, take them less seriously, or treat them with hostility. Margolis, Fisher, and Miller (2000) also found that interacting with male peers can often unravel women's confidence, especially when male students make comments that reinforce women's notions that they don't belong, such as "You only got into computer science because you are a girl" (p. 117). In fact, Margolis argues that "peer support is . . . vital" (p.124), as having a community of other women and sympathetic men in their major to share their struggles helps women feel they are not alone.

Women's Participation in STEM: An Agenda for Institutional Researchers

As described throughout this chapter, women's underrepresentation in STEM results from a complex array of forces stemming from education, family, and the larger society. These influences are generally outside the control of campus-based institutional researchers, but there is an opportunity, through documentation and new research, for institutional researchers to promote women's participation in STEM in college. Consider these recommendations for campus-based institutional research offices.

Document the Participation of Women in STEM. Though it is common practice for institutional research offices to track enrollment of students in STEM, even broken down by gender, it is less common to examine gender differences in *persistence* within STEM. Given that students often do not declare their major until their junior year, a more complete picture of the STEM pipeline in college may require more than just tracking students by major field. Presuming that STEM-based course-taking patterns can be identified, researchers should consider using student transcripts to analyze gender differences in course-taking patterns that lead to STEM major selection and ultimate degree attainment. Researchers should also look for gender-based patterns in the decision *not* to pursue STEM. Are there specific course-taking patterns that lead to the selection of certain non-STEM majors, and does this differ by gender?

Be Attuned to Variations Within STEM Fields. Even though gender disparities persist in historically male-dominated fields such as physical science, computer science, and engineering, women have made significant progress in certain STEM fields, such as the biological sciences and chemistry. Thus any analysis of gender differences within STEM must distinguish *among* the various STEM fields.

Assess the Climate for Women in STEM. Researchers have historically observed a "chilly climate" for women in STEM fields, and yet today women are thriving within STEM departments at numerous colleges across the country. In other words, the climate for women in STEM has not remained chilly everywhere. Institutional research or assessment offices should regularly assess the climate for all students in STEM, with a particular eye on the experiences of underrepresented students such as women and students of color. Again, keeping in mind variations *within* STEM, institutional researchers may wish to focus specifically on a number of aspects of the STEM climate:

- *Pedagogy and classroom climate.* To what extent does STEM pedagogy involve lecture versus collaborative learning? To what extent are real-world applications emphasized in instruction? To what extent do grading practices promote competition among students? What is the nature of student-faculty interaction? To what extent are students exposed to female STEM professionals and to professionals who have successfully combined scientific work and family responsibilities? When considering the STEM climate, gather a variety of perspectives, as there may be important perceptual differences between students and faculty, between women and men, and so on. Also consider the extent to which the STEM climate is distinct from other academic climates on campus.

- *Interactions with peers.* What is the nature of the academic and social interactions among peers in STEM? To what extent do peer interactions reflect competition versus collaboration? To what extent are women included in the formation of study groups? What are the gender dynamics of study groups? Are there social support groups for women in STEM?
- *Science identity.* Assess gender differences in students' interest and confidence in STEM. Regularly survey students to allow tracking STEM-related confidence over time.
- *Portrayal of science.* Assess how STEM fields are portrayed on your campus. To what extent do marketing materials and STEM departmental websites appeal to both male and female students?

Ultimately, in addition to documenting the participation of women in STEM on their campus, institutional research offices should assess the conditions for women in STEM. Through research and assessment, institutional researchers can serve as agents of change in advancing opportunities for women in STEM. Naturally, to be most effective such work requires coordination between, and collaboration among, other campus units, ranging from academic to student affairs, and directly involving faculty and students from specific STEM departments.

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