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Citation: Cech, E. et al. "Professional Role Confidence and Gendered Persistence in Engineering." *American Sociological Review* 76.5 (2011): 641–666. Web. 27 Apr. 2012.

As Published: <http://dx.doi.org/10.1177/0003122411420815>

Publisher: Sage Publications

Persistent URL: <http://hdl.handle.net/1721.1/70471>

Version: Author's final manuscript: final author's manuscript post peer review, without publisher's formatting or copy editing

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Professional Role Confidence and Gendered Persistence in Engineering

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6/8/2011

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American Sociological Review, Volume 75, (5), pp. 641-666, October 2011.

Total Word Count: 12,146

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Author Biographies

Erin Cech is a doctoral candidate in sociology at UC San Diego. Her research examines individual-level, cultural mechanisms that reproduce inequality, especially those pertaining to sex segregation in science and engineering fields. Her dissertation investigates the “self-expressive edge of sex segregation,” analyzing how gender schemas and self-conceptions influence career decisions of college students over time. She also studies the role of professional culture in wage inequality, cross-national beliefs about work time for mothers (with Maria Charles), and, in a *Social Problems* article, perceptions of inequality among high-level professional women (with Mary Blair-Loy). She earned Electrical Engineering and Sociology degrees from Montana State University.

Brian Rubineau is an Assistant Professor of Organizational Behavior at Cornell University's School of Industrial and Labor Relations. He completed his dissertation "Gendering professions: An analysis of peer effects" in 2007 at the MIT Sloan School of Management, concentrating in Organization Studies and Economic Sociology. His research focuses on elucidating how informal social dynamics generate and perpetuate inequalities in organizations.

Susan Silbey is Leon and Anne Goldberg Professor of Sociology and Anthropology and department head at the Massachusetts Institute of Technology. Her current research focuses on the legal regulation of scientific laboratories, environmental health and safety systems, and the education of engineers. Her most recent publications include, “Taming Prometheus: Talk About Safety and Culture” (*Annual Review of Sociology* 2009); “The Dialectic Between Expert Knowledge and Professional Discretion: Accreditation, Social Control and the Limits of Instrumental Logic” (*Engineering Studies*, 2009); “The Sociological Citizen: Pragmatic and Relational Regulation in Law and Organizations,” (*Regulation and Governance* March 2011).; and, *Law and Science I, II* (Aldershot, 2008).

Carroll Seron is a Professor in the Department of Criminology, Law and Society; she also holds appointments in the Department of Sociology and the School of Law at the University of California, Irvine. Building on her earlier work in the sociology of the legal professions, her current research, with Susan Silbey, seeks to explain the persistent under-representation of women in engineering. She has published in *Law & Society Review*, *Work & Occupations*, the *Annual Review of Sociology*, *Criminology* among other journals. She is the former Editor of *Law & Society Review*.

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Professional Role Confidence and Gendered Persistence in Engineering

ABSTRACT

Social-psychological research on gendered persistence in science, technology, engineering and mathematics (STEM) fields is dominated by two explanations: women leave because they perceive their future family plans to be at odds with the demands of STEM careers, and women's low self-assessment of their skills in the intellectual tasks of STEM, net of their performance, leads to their attrition. This article uses original quantitative panel data to examine *behavioral* and *intentional* persistence among students who enter an engineering major in college. Surprisingly, family plans do not contribute to women's attrition during college, but are negatively associated with men's intentions to pursue an engineering career. Additionally, math self-assessment does not predict behavioral or intentional persistence once students have enrolled in a STEM major. This article introduces *professional role confidence*—one's confidence in his or her ability to successfully fulfill the roles, competencies, and identity features of his or her profession—and argues that women's lack of this confidence, compared to men, reduces their likelihood of remaining in engineering majors and careers. The authors find that professional role confidence predicts behavioral and intentional persistence, and that women's relative lack of this confidence contributes to their attrition.

Professional Role Confidence and Gendered Persistence in Engineering

I. INTRODUCTION

Who persists in professional occupations? Nearly as many women “revolve” out of male-dominated fields as the number who enter (e.g. Jacobs 1989). Researchers have shown that this gendered persistence is driven by structural, cultural and social-psychological processes. While discriminatory and cultural factors such as biased hiring (e.g. Reskin 2003) and chilly climates (e.g. Sandler, Silverberg, and Hall 1996) contribute to gender segregation in male-dominated fields, social-psychological factors, encompassing individually-held beliefs about one’s abilities, competencies, anticipated roles, and personal fit, begin early in the professional education process and continue throughout one’s career (Cech 2007, Xie and Shauman 2003). Because much of the gender differential in persistence emerges out of seemingly “voluntary” individual decisions to stay or leave (Correll 2001), social-psychological determinants are an important part of occupational sex segregation.¹

This article focuses specifically on the factors influencing gendered persistence in professional careers during the process of credential acquisition. Credential acquisition refers to the education and training processes required to obtain the requisite certifications (MD, Ph.D., B.S., etc.) that allow prospective professionals to enter practice in the workforce.

We test two prominent social-psychological explanations of persistence (family plans and self-assessment), and introduce a third, professional role confidence, likely to be salient during credential acquisition. We ask whether family plans and self-assessments, shown to be important in decisions to take advanced math and science courses in high school and selection of STEM majors in college, continue to affect persistence once students enroll in an engineering major. We

then investigate the importance of professional role confidence on men's and women's persistence.

The *family plans* explanation suggests that common expectations for women to assume primary responsibility for family care encourage them to abandon their ambitions in male-dominated fields for more family-friendly female-typed occupations (Eccles 1987; Frome, Alfeld, Eccles, and Barber 2006; Fiorentine 1987, 1988). We find no evidence that women's family plans lead to their attrition from engineering once they have entered engineering training. Family plans may have a later effect on women's career plans (as shown by copious literature on work/family balance), but do not deter women from an engineering credential. We do find, unexpectedly, that men with strong family plans seeking an engineering degree are less likely to pursue a career in engineering.

The *self-assessment* explanation argues that women's low self-assessment of the skills required for the core intellectual tasks of a profession (e.g. mathematics in the case of engineering), net of their actual performance, leaves them less confident in these skills and thus less likely to pursue and persist in male-dominated fields (Correll 2001; 2004). Although the women in our sample succeeded in overcoming the mathematics hurdles in high school and entering an undergraduate engineering program, they nonetheless express significantly lower math self-assessment than the men. However, we find that math self-assessment does not significantly predict persistence in an engineering major. Once students have matriculated into this math-intensive field, more complex, profession-specific self-assessments such as career-fit and expertise confidence appear to replace math self-assessment as the driving social-psychological reasons for attrition.

To explain gendered persistence in engineering education and gendered intentions to pursue a career in engineering, this paper introduces a third explanation: professional role confidence. *Professional role confidence* refers to one's confidence in his or her ability to fulfill the expected roles, competencies and identity features of a successful professional in her or his field. Becoming a successful professional involves not just the mastery of the core intellectual skills of the profession (e.g. mathematics), but also the cultivation of confidence in, identification with, and commitment to the profession. We argue that women and men develop different levels of professional role confidence in heavily sex-typed fields and therefore are differentially likely to persist. We examine two dimensions of professional role confidence: "expertise confidence," or confidence in one's ability to wield the competencies and skills required of practice in the profession, and "career-fit confidence," or confidence that the profession's career path is consonant with one's individual interests and values. We find that professional role confidence is cultivated more successfully in men than in women engineering students, leaving women less likely to plan to complete the engineering major or pursue a career in engineering. This additional factor—professional role confidence—helps to explain differential persistence unexplained by other social-psychological theories.

We test these three explanations of persistence with a longitudinal sample of engineering students. Engineering is an ideal laboratory to test these theories. Because practice in engineering requires only a bachelor's degree, the decision-making timeframe is more condensed for prospective engineers than for students interested in professions that require additional years of post-baccalaureate education. On the other hand, college is a time of great career decision-making flexibility with little cost of time or training for switching career tracks, relative to the costs of making such changes once in the workforce. These truncated yet comparatively flexible

decision-making conditions should sharply focus the effects of these determinants of persistence. Additionally, engineering is the most sex-segregated non-military profession in the United States (National Science Foundation 2008) and among industrialized societies more generally (Charles and Bradley 2009). The young men and women who select engineering as a field of study have already weathered the pervasive effects of gendered stereotyping of early adolescence (Leslie, McClure, and Oaxaca 1998; Xie and Shauman 2003), allowing us to focus our attention on issues of persistence rather than recruitment.

We use original panel data of engineering students from four schools (MIT, Franklin Olin College of Engineering, Smith College, and the University of Massachusetts Amherst) at two time periods: Year 1 (freshman year) and Year 4 (senior year).² These data are appropriate for our analysis because they trace students' commitment to engineering careers from the beginning to the end of their undergraduate years. Further, our data come from institutions illustrative of the range of engineering educational programs in the United States: a land-grant college typical of the public institutions where 80% of American engineers are educated (UMass); the highest-ranked engineering school in the nation (MIT); and two small innovative programs developed to challenge the standard engineering education offered at both the elite and conventional engineering schools (Olin College and Smith College). In the next section, we discuss our conceptualization of persistence, the existing explanation of supply-side effects on persistence, and describe our professional role confidence explanation in detail.

II. THEORETICAL FRAMEWORK

Our conceptualization of persistence captures two theoretically important dimensions: students' persistence in engineering majors from freshman to senior year (behavioral persistence) and their future career plans (intentional persistence). We seek to explain these two dimensions

of persistence as functions of students' family plans, self-assessment and professional role confidence; see Figure 1 for our conceptual model.

[Insert Figure 1 about here]

Persistence

Persistence in a professional field requires both the development of requisite skills, which are certified through credentials, and a commitment to stay the course. We conceptualize the achievement of the requisite credential (in this case, an undergraduate engineering degree) as *behavioral persistence*. In contrast to studies that employ a dichotomous conceptualization of persistence (stay/leave), we conceptualize behavioral persistence as a trichotomous process by differentiating three paths: (1) leaving engineering majors for *other* STEM fields (biological and physical sciences, math and other technology-related majors), (2) leaving engineering for non-STEM fields (arts, humanities, business, education, social sciences, and other non-STEM related professional degrees such as nursing) or (3) persisting in an engineering major and earning a degree. If students move from engineering into another STEM field, the switch could reflect features of the structure and culture of the engineering profession specifically, while the decision to leave STEM altogether suggests factors that perpetuate gender segregation across STEM fields.

Majoring in engineering is a necessary but not a sufficient condition to explain career choice and career plans. Once a college student has declared an engineering major, she must begin to think about whether she will leverage her degree to secure employment in an engineering field. We conceptualize the development of a commitment to enter the field and work as an engineer in the near future as *intentional persistence*. Whereas behavioral persistence captures the more objective prerequisites of persistence, intentional persistence taps into its

subjective dimensions. We measure intentional persistence at the end of respondents' college years. It is, therefore, a projection of whether students will pursue a career in engineering.

Family Plans

Women and men make major life decisions in the context of multiple social forces, with pressures that pull them in directions tangential—or even opposite—to their career goals. The choice of a college major, social-psychologists argue, depends on the extent to which students perceive majors as consistent with their anticipated future roles. The family plans explanation posits that women who strongly value their future parenting and spousal support roles are likely to resolve current or future work-family conflicts in favor of those roles (Eccles 1987; Eccles, Adler, and Meece 1984; Farmer 1997; Feather 1988).³ Researchers have found, for instance, that women who place a high priority on their future families were less likely to enter science majors than their female peers with weaker commitments to family roles (Burge 2006; Ware and Lee 1988). Women's desires for a family-flexible field were also negatively associated with their intentions to persist in a male-dominated career (Frome et al 2006, 2008).

These analyses suggest that women's considerations of their future family roles could be causally related to their exit from a STEM career path (see Frehill [1997] and Seymour and Hewett [1997] for cogent counter-arguments). Consistent with the family plans explanation, we expect that students' family plans at college entry will influence both their behavioral and intentional persistence. We hypothesize these relationships separately for women and men, as the family plans literature largely ignores the effects of men's family plans on their persistence in male-dominated fields.

H1a: The importance of women's family plans (having a long-term committed relationship and raising children) is negatively related to intentional persistence in engineering.

H1b: The importance of women's family plans is positively related to their attrition from engineering majors into non-STEM fields.

This literature is inconclusive as to how family plans are related to women's attrition into another STEM major. Because engineering is typically reputed to be even more conducive to work-family conflict for women than science or math fields (Eccles 1987; 1994), we expect that women with strong family plans would leave engineering for other STEM majors:

H1c: Importance of women's family plans is positively related to switching into another STEM major.

The relationship between family plans and persistence is unclear for men. Seymour and Hewett (1997) suggest that family plans may have a positive effect on persistence for men, inducing them to intend to persist in highly-paid STEM careers. It is an open question whether men with strong family plans are more likely to persist in engineering rather than switch to another STEM major.

H2a: The importance of men's family plans is positively related to their intentional persistence in engineering.

H2b: The importance of men's family plans is positively related to their behavioral persistence in engineering.

Self-Assessment

Self-assessments are self-referenced evaluations that individuals have of themselves. In this article, we are interested in assessments of one's professionally associated abilities rather

than, for example, students' assessments of their basketball skills or physical attractiveness (Owens et al. 2010). Most research examining the effects of self-assessments studies the influence of gendered math self-assessment on persistence in male-dominated career paths (e.g., Correll 2001; Seegers and Boekaerts 1996). Although gender differences in math *performance* are nonexistent once math preparation is controlled (Hyde et al. 1990),⁴ research has repeatedly found differences in men's and women's *self-assessment* of their math abilities (Correll 2001, 2004). Whether the result of young men's and women's internalization of gender stereotypic views of math or their belief that others may hold them accountable to such stereotypes, the gender-typing of certain tasks means that men, *ceteris paribus*, assess their math skills more highly than women assess their own math skills (Correll 2001, 2004; Ma and Johnson 2008).⁵

Self-assessment differentials are produced by gendered experiences within the math discipline itself (Correll 2001; Ridgeway 1997) and can accumulate over time (Hyde et al. 1990), even controlling for comparable preparation and performance (Correll 2001; Seymour and Hewett 1997). Additionally, low math grades have a more negative effect on women's persistence than on men's at the point of transition from high school to college (Correll 2001).

These math self-assessments affect students' selection of college majors: "maladaptive cognitions regarding math-related capabilities may be at least as important as math ability per se in influencing major choices" (Betz and Hackett 1983: 332). Correspondingly, Correll (2001) found that math self-assessment was significantly associated with the likelihood of choosing a quantitative major after high school among both men and women. The importance of math self-assessments, paired with the documented gender differences in such self-assessments, contributes to gender disparities in the decision to choose a quantitative major (Correll 2001: 1721).

Research on these self-assessment dynamics has been conducted on or across the high school-college juncture. The students in our sample have, however, entered college as high achievers in math and have higher-than-average math self-assessment.⁶ Whether math self-assessment remains a salient factor once students have selected math-intensive majors is an empirical question we seek to answer.

H3a: High math self-assessment at college entry is positively related to intentional persistence for men and women.

H3b: High math self-assessment at college entry is negatively related to switching out of engineering for a non-STEM field for men and for women.

Consistent with theories of self-assessment, we hypothesize enduring gender differences in mathematical self-assessment during the credential acquisition.

H3c: Even among these mathematically high achieving women, women enter college with significantly lower levels of math self-assessment than men.

Such differences may contribute to gender disparities in the decision to persist in an engineering career.

Professional Role Confidence

Most research on social-psychological impediments to women's persistence in male-dominated fields examines the consequences of women's internalization of commonly circulating cultural beliefs about gendered skills and competencies. Such research pays insufficient attention to the factors that emerge from men's and women's direct exposure to and immediate experiences with the profession itself. We argue that, in addition to widespread normative gender beliefs influencing career choices (e.g. Eccles 1994), interactive, cognitive,

and embodied experiences during professional training lead women and men to form different levels of confidence in their abilities to fulfill the role of a successful professional in their field.

We begin from the understanding that becoming—and being—a successful professional is more than the mastery of technical skills or expert knowledge (Becker et al. 1961; Schleef 2006). Professional socialization involves the development of hands-on and tacit understandings of a diverse range of situations, especially where ambiguous or messy problems call for discretionary expert judgment (Hughes 1971). In addition, socialization promotes identification with and affinity for the profession's sentiments, values, and commitments to the collectively espoused and enforced norms (Merton et al. 1982; Sullivan et al. 2007). Thus, in order to complete the requisite training, foster appropriate commitment and identity, and pursue a professional career, prospective professionals need to develop *confidence* in their ability to enact the expected role performances.

We call this concept *professional role confidence*. It involves both confidence in wielding the practical competencies of day-to-day professional work; and identification with the professional role and belief that one will enjoy this role, with all the complexity, uncertainty, and responsibility that accompany its fulfillment.

The development of professional role confidence is an important part of successful professional socialization and begins in earnest upon entry into the profession's credentialing process. During credentialing, men and women have their first experiences as profession members rather than aspirants. Through interaction with faculty, mentors, and peers both inside and outside the classroom, students engage in anticipatory professional behavior as they begin to master technical knowledge and practical competencies, identify with valued symbols, enact

expected norms, espouse professional truisms and learn to project a confident, capable image to others (Becker et al. 1961; Dryburgh 1999; Granfield 1992; Schleef 2006).

Professional role confidence is likely to be salient for persisting in credential acquisition because this is the first time young men and women are expected to perform the actions that define a professional (Dryburgh 1999; Schleef 2006). Those who develop confidence in their ability to perform the professional role should be more likely to persist in their pursuit of that professional career; those who have little professional role confidence should be weeded out through self-selection or through the various (informal and formal) sorting processes of their credentialing programs.

We expect that men and women develop different levels of professional role confidence. This variation in confidence likely emerges from two sources: from gendered cultural beliefs about the appropriate professions for men and women, and from factors specific to the profession in question. First, women are more likely to have a difficult time developing professional role confidence in male-dominated fields because such confidence has to overcome prevalent popular beliefs about the different kinds of activities that men and women are “naturally” fit for and good at, and therefore should pursue (Charles and Bradley 2009; Ridgeway 2009).

Second, women are less likely to develop professional role confidence in fields where the socialization processes and work cultures are historically gendered masculine. Women in male-dominated fields have a harder time than men internalizing and confidently performing the professional role that is nurtured primarily through group socialization rather than specific task instruction (Dryburgh 1999: 670; also see Haas and Shaffir 1991 and McIlwee and Robinson 1992). Furthermore, faculty and fellow students often deem as unfit those whom they see as deviating from the conventional embodiment or model of a professional—an event more likely

for women in male-dominated field than men (McIlwee and Robinson 1992; Trice 1993). For these reasons, women likely express less professional role confidence than men in fields such as engineering, which are culturally coded as male and where group socialization is salient. In fields where the professional role aligns more with female-typed tasks and competencies (e.g. nursing), men may have less professional role confidence than women.

We conceptualize two dimensions of professional role confidence active while students are in the process of acquiring their professional credential: (1) “expertise confidence,” or confidence in the tasks and competencies required of this kind of professional and (2) “career-fit confidence,” or confidence that the professional role of the practitioner will suit their particular interests, needs, values and sense of “self.”⁷

As professionals gain more experience in their field, their understanding of the professional role is likely to become more complex or nuanced. Thus, the salience of these or other dimensions of professional confidence may vary as professionals progress through their careers. We return to this point in the discussion and suggest an additional dimension of professional role confidence that is likely to be salient once men and women complete their credential and enter the workforce. Here, we investigate the expertise and career-fit dimensions of professional role confidence as it develops during the credentialing process.

“Expertise confidence” refers to the confidence students have in the set of techniques, logics and competencies required to successfully participate in their chosen profession. Importantly, expertise confidence is distinct from a single task-specific measure such as math self-assessment because it encompasses the broad range of cognitive orientations and problem-solving tasks associated with a profession, rather than a single task category. Expertise confidence should be particularly important to persistence during credential acquisition because

that is when neophytes become aware of and begin to practice field-specific competencies as they rehearse their future professional roles.

At least two factors challenge women's development of expertise confidence in male-dominated fields such as engineering. First, on top of navigating an often grueling and emotionally-charged professional socialization process, women face the additional challenge of negotiating a hegemonic culture of engineering that often valorizes displays of masculinity (Dryburgh 1999). Most engineering role competencies are male-typed within this culture, and women bear the burden of proving to others that, despite gendered expectations, they are skilled engineers. In contrast, men's expertise confidence is consistent with cultural ideologies that stereotype technical engineering skills as masculine domains (Faulkner 2000).

Second, men are more likely than women to have participated in informal tinkering and gaming activities as adolescents (McIlwee and Robinson 1992). These kinds of activities can serve as a form of anticipatory socialization (Merton 1968; Schleef 2006) to the competencies considered relevant in engineering. For women entering engineering with disproportionately less exposure to such anticipatory socialization, the necessary levels of expertise confidence for success may be more difficult to develop, or to display.

Without adequate confidence that they have the appropriate level of expertise to be a successful professional, women will be less likely than men to persist in engineering majors and to see themselves as engineers in the future:

H4a: Expertise confidence is a significant and positive predictor of intentional and behavioral persistence in engineering.

H4b: Women have significantly less expertise confidence than men.

The second component, “career-fit confidence,” captures students’ confidence that their chosen field is appropriate for them and will provide them with interesting and worthwhile employment over time. It encompasses both students’ beliefs that their chosen field will lead to a fulfilling career and their certainty that the professional identity involved in such a career is consonant with their self-perceptions. Career-fit confidence is less about the students’ assessment of their own abilities and competencies, which is captured by expertise confidence, than about students’ assessments of their alignment with the profession’s ethos and culture.⁸

Career-fit confidence is likely to be an important component of persistence in professional fields. For most contemporary American students, the purpose of higher education is to develop expertise through academic disciplines and experiences that align with an existing, distinct self in preparation for a career that, in turn, fosters self-expression and self-realization (Charles and Bradley 2009; Schoon 2001). Those with confidence in their career choice believe that their selected field fits their individual interests and values. If students are unsure that their professional credential can provide them with a satisfying career or if they question the organizational routines, professional relations, or person they will be expected to become, they may be more likely to leave.

Like expertise confidence, career-fit confidence is partly contingent on successful professional socialization processes. Professional training and education programs must convince students that the profession is deserving of their commitment and that it serves interests and goals with which they can identify. Intensive marketing by faculty and administrators occurs early in the credentialing process, as programs work to enroll students. These efforts to persuade students of the virtues of the field, and the desirable status accorded practitioners in that field,

continues throughout the training and credentialing process in an effort to retain as many students as possible (see e.g. Lichtenstein et al. 2009).

Students who express confidence in their fit with the engineering profession will be more likely to persist in an engineering major and intend to persist in an engineering career:

H5a: Career-fit confidence is a significant and positive predictor of intentional and behavioral persistence in engineering.

The processes of professional socialization, especially developing a conventional engineering identity, may leave women in engineering with less career-fit confidence than men. As men and women proceed through the process of acquiring a professional credential, they try on “provisional selves” corresponding to their understandings of the professional role (Ibarra 1999). Experimenting with these profession-specific provisional selves gradually leads to the internalization of a corresponding professional identity. Provisional selves that are congruent with individuals’ “self-schemas” (organized generalizations about one’s self-defining and personal attributes) are likely to increase students’ confidence that engineering fits them; provisional selves that are discordant with self-schemas are likely to undermine students’ confidence that they have made the correct career decision (Howard 2000; Rosenthal et al. 2011).

Self-schemas are, of course, deeply gendered (Markus et al. 1982). Women’s self-schemas are likely to be less consistent with professional identities in engineering than men’s, increasing the potential for discord between women’s self-schemas and the “provisional selves” they try on in the process of developing a professional identity. Furthermore, the perception of engineering as “gender inauthentic” for women (Faulkner 2009) may foster in them a felt

incongruence between their gender and their developing professional identities—an incongruence that likely hinders their confidence in their fit with the profession.

Professional identity development, as with the development of more general conceptions of identity, depends upon the positive reactions of others (Cooley 1902; Huntington 1957). Thus, developing a professional identity rests, in part, on verification from relevant others in one's social milieu (Burke 2004; Rosenthal et al. 2011). If these others hold gendered views about the appropriateness of certain identities (e.g. professional identities), then men and women will have different amounts of the resources necessary for professional identity development (e.g., Seron et al. 2011).

Thus, we expect that women and men develop different levels of career confidence in engineering:

H5b: In engineering, women have significantly less career-fit confidence than the men. Such differences may lead to gendered intentional and behavioral persistence.

The gendered persistence literature does not lend itself to clear hypotheses about the effects of expertise and career-fit confidence on switching into other STEM versus a non-STEM field.

Institutional Settings

The success of professional socialization in facilitating students' professional role confidence may depend on the institutional setting. Our sample represents diverse institutional arrangements. Although MIT, the gold standard of engineering education has been committed to increasing the number of women engineers for four decades, Smith and Olin have made formal commitments to do a better job of improving the success rate of women engineering students. UMass, is a large state land-grant university with significant resource constraints relative to the

more resource-rich MIT. These and other factors may entail institutional effects on persistence behaviors, or even gendered persistence. On the other hand, there is much evidence to suggest that pressures to conform to external standards and credentialing trump differences in educational missions and goals (DiMaggio and Powell 1983; Sauder and Espeland 2009; Seron and Silbey 2009). We control for institution to identify whether these different approaches to engineering education significantly affect behavioral or intentional persistence.

III. DATA AND METHODS

Data

We use unique longitudinal panel data to analyze gender differences in persistence in engineering. Our sample consists of 288 students who entered engineering programs in 2003 at four institutions of higher education: Massachusetts Institute of Technology (MIT), the University of Massachusetts at Amherst (UMass), the Franklin W. Olin College of Engineering (Olin)⁹ and Smith College (Smith). Our analysis draws from the 2003 and 2007 waves of our longitudinal survey data. The entire freshman classes at MIT, Olin, and Smith, along with 332 randomly-selected UMass freshman, were invited to participate in the study (overall response rate: 35.8%).¹⁰ Response bias analyses run between the sample and the 2003 population data at each school show that the sample marginally over-represents Asian students at MIT ($p=.08$) and marginally under-represents African-American students at UMass ($p=.09$). No other gender or race/ethnicity differences were found.

Survey data were collected through online surveys administered to the students via e-mail. Although the full sample includes students from many different majors, only students enrolled in--or intending to enroll in--an engineering major in year 1 were included in the analysis presented here. We tracked students from freshman to senior year whether they

remained in engineering, changed to another major, or left college altogether. The year 1 to year 4 retention rate of the subsample we use in this analysis is 73%.

Dependent Variables

We test two measures of persistence: Behavioral persistence (students' completion of an engineering major, year 1 to year 4) and intentional persistence (students' year 4 belief that they will be an engineer in five years). Behavioral persistence is an ordinal variable with three values corresponding to three theoretically important possible outcomes: (1) respondents remained in an engineering major, (2) respondents left engineering for another STEM major, (3) or respondents left engineering for a non-STEM major.

We created intentional persistence from a question in year 4 that asked students to identify the likelihood they will "be an engineer in five years" (1=very unlikely to 4=very likely). The operationalization of all variables and factors can be found in Table 1.

Independent Variables

To measure family plans, we average the centered responses to the following two questions asked in Year 1: "Importance to me: building a family" and "Importance to me: building a satisfying, long-term intimate relationship" to create an "importance of family plans" variable ($\alpha=.721$). We include measurements for math self-assessment, a year 1 variable asking respondents to rate their math ability compared to an average person their age: 1=Lowest 10%, 2=Below Average, 3=Average, 4=Above Average, 5=Highest 10%.

We test our professional role confidence hypotheses with two scale measures that ask about students' confidence as a result of their initial exposure to engineering (i.e., during the spring semester of their first year in college).¹¹ All questions making up the professional role confidence scale measures began with, "As a result of your engineering courses..." prompting

students to respond in the context of their initial experiences with the profession. The expertise confidence measure is a scale variable ($\alpha=.809$) combining Likert-scale responses where students were asked to rate their confidence on the following indicators as a result of their engineering courses: “Developing useful skills,” “Advance to the next level in engineering,” and “my *ability* to be successful in my career.”¹² The “career-fit confidence” measure is a scale variable ($\alpha=.751$) combining Likert-scale responses where students were asked to rate their confidence on the following indicators as a result of their engineering courses: “Engineering is the right profession for me,” “Selecting the right field of engineering for me,” “Finding a satisfying job” and “My commitment to engineering, compared to my engineering classmates.”

To measure potential institutional and environmental differences at each school, we include dummy variables for Olin, Smith and UMass where appropriate (MIT is the reference category). From supplemental analyses using interaction terms between gender and school (not shown), we found that none of the school influences on persistence were gendered. Table 1 lists the operationalization of the other individual-level controls in our model.

[Insert Table 1 about here]

Analytic Strategy

We use separate modes of analysis for the two dependent variables: Multinomial Logistic Regression (MLR) for behavioral persistence and Ordinal Logistic Regression (ordered logit) for intentional persistence.¹³ The sets of independent variables and controls are identical across the two types of regression models. Our first estimated model includes only gender and relevant controls. Our second model adds the family plans and self-assessment measures, and in our third model, we add the professional role confidence variables. Our final model adds an

interaction term between family plans and gender. Appendix Table A presents the correlations among the variables included in our analyses.

IV. RESULTS

Table 2 presents the univariate and bivariate statistics for our dependent and independent variables, for all respondents and separately for men and women. The final column indicates whether the values are significantly different between men and women. Consistent with the persistence literature described above, men have higher levels of behavioral persistence than women. While women are twice as likely as men to switch to *other* STEM fields; when men switch out of engineering, they are more likely to switch to non-STEM majors than women. Men report higher levels of intentional persistence; that is, they are more likely than women to intend to be an engineer in five years. This school-to-work juncture is critical and, according to some (e.g. Xie and Shauman 2003), has the highest attrition rate of any point in a STEM career. We find attrition from engineering during credential acquisition (the mean is slightly below “somewhat likely” to be an engineer in 5 years), and women are more likely than men to leave.

[Insert Table 2 about here]

Men and women find raising a family and developing a long-term intimate relationship equally important: there are no significant gender differences in the “importance of family plans” measure. These similarities speak to the importance of considering both women’s and men’s experiences as they try to reconcile their professional and personal goals.

Table 2 also presents the descriptive statistics for respondents’ math self-assessment and their career and expertise confidence. As expected, the men in our sample rate their math skills significantly higher than the women rate their own math skills (*H3c*). However, women and men

do not earn significantly different grade point averages in college; their end of high school SAT math and verbal scores, although well above average, were also statistically similar.

Consistent with the hypotheses about professional role confidence, the men in our sample have significantly more expertise confidence (*H4b*) and career-fit confidence (*H5b*) than women. If these measures of self-assessment and confidence are significantly related to persistence, then these differentials could contribute to gendered persistence.

We found a few differences by race/ethnicity on our key variables. Hispanic and Latino students have stronger traditional family plans than other students (2.65 vs. 2.31, $p < .05$). White respondents also have significantly higher math self-assessment than non-white respondents (4.21 vs. 4.01, $p < .05$). However, there are no significant differences in expertise or career-fit confidence by race or ethnicity.

Turning to the multivariate results, columns I and II of each model in Table 3 represent the MLR behavioral persistence models (Column I represents the likelihood of persisting in engineering versus switching to another STEM major and column II represents the likelihood of persisting in engineering versus leaving STEM entirely). Each column in Table 4 presents results from the corresponding ordered logistic regression models for intentional persistence.¹⁴ Model 1 in both Tables 3 and 4 include the gender coefficient (female=1) plus controls for parents' education, SAT math and verbal scores, GPA, and institution. Consistent with the bivariate statistics, women are more likely than men to leave engineering for another STEM major (Model 1 in Table 3: $B = -1.46$, $p < .05$) and less likely to intend to persist in engineering in five years (Model 1 in Table 4: $B = -.878$, $p < .05$).

Interestingly, we find no strong differences in the schools' nurturance of intentional persistence, even for the elite private schools.¹⁵ We also find no significant differences in mean

expertise and career-fit confidence by school (analysis not shown), suggesting that any institutional differences matter little for the development of students' professional role confidence. African-Americans are significantly more likely than white respondents to intend to persist in engineering. This is an interesting finding that requires further research with larger samples.¹⁶

Model 2 adds the family plans and self-assessment measures. Family plans are a weakly negative predictor of behavioral persistence, versus leaving STEM entirely (Model 2_{II} of Table 3: $B=-0.701$, $p<0.10$). We return to the family plans explanations below with Model 4, which includes an interaction term between family plans and female to accounts for the gendered effects of family plans on persistence. Contrary to hypotheses based on the self-assessment literature (H3a and H3b), math self-assessment is *not* a significant predictor of behavioral or intentional persistence at the stage of credential acquisition. Interaction terms (estimated in separate analyses and available on request) between gender and the self-assessment variables were also insignificant.

[Insert Table 3 about here]

[Insert Table 4 about here]

The inclusion of the family plans and self-assessment measures in the model does not reduce the importance of gender as a predictor of persistence: the gender coefficient remains significant in Model 2 for both dependent variables (Table 3). Controlling for family plans actually makes the gender coefficient in B_{II} fully significant, suggesting that family plans may moderate the relationship between gender and behavioral persistence (versus leaving STEM entirely). We explore this further in Model 4. The gender differences in persistence remain, net of respondents' family plans and gender differences in math self-assessment.

Model 3 adds professional role confidence effects along with family plans, self-assessments, and relevant controls. As shown in Table 3, expertise confidence is a significant and positive predictor of persisting in an engineering major, compared with switching to another STEM major (supporting H4a). The more confident students are in their professional expertise, the more likely they are to persist in engineering. However, women have significantly less of this expertise confidence than men (see Table 2). *Ceteris paribus*, a woman with expertise confidence of 3.4 (the mean expertise confidence for men) rather than 3.1 (the mean expertise confidence for women) would be 9.3% more likely to persist in an engineering major rather than switching to another STEM major. Similarly, a man with expertise confidence of 3.1 instead of 3.4 would be 8.1% less likely to persist in an engineering major.

As shown in Table 4, career-fit confidence is also a significant and positive predictor of persistence: the higher students' confidence that that they will find engineering work personally satisfying and congruent with their interests and values, the greater their intentions to remain in engineering five years after graduation. As table 2 shows, women's career-fit confidence in their first year is significantly weaker than men's confidence. *Ceteris paribus*, a woman with career-fit confidence of 3.0 (the mean career-fit confidence for men) rather than 2.7 (the mean career-fit confidence for women) would be 9.2% more likely to intend to persist in engineering. Similarly, a man with expertise confidence of 2.7 instead of 3.0 would be 8.6% less likely to intend to persist in engineering.

Gender is no longer a significant predictor of persistence once the professional role confidence measures are included. The gender coefficient is reduced by 31.8 percent (between 2₁ and 3₁ in Table 3) and 35.3 percent (between Models 2 and 3 in Table 4) and is no longer significant in either of these models. Gender remains significant for one persistence option in

Model 3 of Table 3: men are more likely than women to leave STEM entirely. Accounting for professional role confidence helps explain gendered persistence that is unexplained by family plans and self-assessment differences.

Expertise and career-fit confidence work similarly for men and women (as interaction terms with gender were insignificant), but we find some interesting differences in the effectiveness of these types of confidence by race/ethnicity. Expertise and career-fit confidence are significant predictors of persistence for white students (the reference group). For Hispanic and Asian/Asian-American students, the effects of these professional role confidence measures on persistence are significantly stronger. (Interactions between expertise confidence and the Hispanic identification measure in intentional persistence regressions and interactions between career-fit confidence and the Asian/Asian-American indicator in engineering major persistence were significant and positive; results available by request.) The effects of expertise and career-fit confidence on persistence for other racial/ethnic groups did not differ significantly from the reference category. As noted above, there are no significant differences in expertise and career-fit confidence by race/ethnicity, so these interaction terms suggest different degrees of importance of professional role confidence across racial/ethnic groups. Expertise confidence, for example, may be particularly important for Hispanic students, who may face additional stereotypes that they are less technically inclined than white or Asian students (Eglash 2003). We hope these racial/ethnic differences in the effectiveness of professional role confidence to promote persistence will be explored in larger samples.

Model 4 adds an interaction term between family plans and female. For both persistence measures, we see an opposite trend than that expected from H1a. For men (whom the family plans coefficient now represents), the importance of family plans has a *negative* impact on their

persistence in an engineering major versus switching to another STEM field (4_{II} in Table 3: $B = -1.362, p < .05$) and on their intentions to be an engineer in 5 years (Table 4: $B = -1.167; p < .01$). The significant family plans * female interaction term ($B = 1.554, p < 0.01$) in Table 4 means that the effect for women's family plans is much closer to zero ($B = 0.387, p > 0.1$) than that for men, and with the opposite sign.

To better understand the nature of this interaction effect, we plot the predicted intentional persistence values from our Model 4 estimates in Table 4 by sex and high or low levels of traditional family plans (determined by a median split) in Figure 2. As Figure 2 illustrates, the gender differences in family plans effects result from persistence differences between men and women with low levels of traditional family plans. Men with low levels of traditional family plans have higher levels of intentional persistence, and women with low levels of traditional family plans have lower levels of intentional persistence. Men and women with high levels of traditional family plans do not differ in their intentional persistence. For behavioral persistence, although no coefficients are significant, they follow the same pattern as that for intentional persistence. This pattern is the opposite what was predicted by H1b. We discuss these results in the next section.

V. DISCUSSION

This paper examines two predominant social-psychological explanations of gendered persistence, family plans and math self-assessment, and contributes professional role confidence to current explanations of occupational gender segregation. We find no evidence to support the theory that women's traditional family plans lead to their attrition during credential acquisition. Similarly, we find no evidence supporting an association between math self-assessment and persistence in an engineering major. Instead, we find that professional role confidence is

significantly associated with engineering persistence, and that its differential distribution between men and women contributes to gender segregation in engineering.

We began this investigation by asking whether the explanations for the differential persistence of men and women in male-dominated professions derived from research on high school students or students transitioning from high school to college similarly apply during credential acquisition. There is little consideration in the social-psychology literature of how these factors may be contingent on career stages—the sequence of phases in a standard career trajectory (e.g. secondary education, credential acquisition, workforce entry, promotion).¹⁷ Our findings point to the importance of considering how determinants of gender segregation vary by career stage. Factors that significantly segregate at one stage (e.g., math self-assessments during the high school-college transition) may not have strong effects at other stages. Likewise, the determinants we identify as important for persistence through credential acquisition may turn out to be less salient at later career stages.

Family Plans

Although family plans likely influence women's careers plans (as copious literature on work/family balance shows), we find no such effects during engineering credential acquisition. Conceivably, young women's early family plans may have already filtered them out of the pipeline before college entrance (c.f. Burge 2006). Our data call this explanation into question, however, as family plans at college entry are not significantly different for women who began college as engineering majors and those who began college as non-engineering majors.¹⁸ It is possible, however, that the effects of family plans for women may emerge at a later career stage. The women in our sample have yet to face the challenges of motherhood or professional work, and thus may remain optimistic about their ability to effectively balance both.

In contrast, family plans appear salient at the stage of credential acquisition for *men*: we find that family plans are negatively associated with men's intentions to persist in engineering. Perhaps placing a lower importance on longer-term relationship and family concerns allows men to focus more fully on their engineering studies. It is also possible that men with traditional family plans expect to bear the financial burden of their household and intend to leave engineering for lucrative fields (e.g. law or finance). This surprising finding requires more research.

Prior research has certainly suggested that the work-family balancing act weighs more heavily on women than men (Epstein, Seron, Oglensky, and Saute 1999; Presser 1994). Our research suggests that the weight of this balancing act may hit at different career stages for men and women. More speculatively, our family plans findings may corroborate an historical shift in how men and women weigh the importance of work-family balance; men may now be thinking harder about work-family balance issues than in previous generations (Gerson 2010). We recommend that the family plans literature move from examining how women's family plans influence their persistence in male-dominated fields to understanding how family plans affect women's *and* men's persistence in male-dominated fields.

Math Self-Assessments

Our findings modify the math self-assessment explanation in important ways. Even after enrolling in an undergraduate engineering program, the women in our sample have significantly lower math self-assessment than men (see Table 1); nonetheless, math self-assessment does not predict persistence in engineering at the credential acquisition stage. The lack of effect of math self-assessment is not necessarily surprising, given the importance of math self-assessment for choosing STEM majors in the first place. Indeed, the finding that math self-assessment is

significantly and positively related to whether or not students enter college as engineering majors (e.g., Correll 2001) is present in our data as well.¹⁹ However, once students have matriculated into a math-intensive field, more complex, profession-specific assessments, such as career-fit and expertise confidence which this research conceptualizes, seem to replace math self-assessment as driving social-psychological reasons for attrition. The findings reported here may foreshadow students' evolving understanding of the demands of work in a professional field.

Professional Role Confidence

We identify professional role confidence, and its components of expertise and career-fit confidence, as important to students' behavioral and intentional persistence during credential acquisition. Confidence in their ability to successfully perform the professional role and confidence in their ability to enjoy and find fulfillment in that role significantly predict students' behavioral and intentional persistence in engineering, respectively. We find that professional role confidence is cultivated more successfully among men than women, leaving women less likely than men to continue in an engineering career. We find no difference in levels of expertise and career-fit confidence by race and ethnicity for either men or women, but expertise confidence may be particularly important for the intentional persistence of Hispanic students and career-fit confidence for the behavioral persistence of Asian and Asian-American students.

The concept of professional role confidence has implications for explaining gendered persistence in engineering more generally. Research has shown that, once credentialed in engineering, women are nonetheless significantly more likely to leave compared to their male counterparts (Jacobs 1989; Xie and Shauman 2003). As men and women with engineering credentials transition from school to work, the findings reported here suggest that their

differential expertise and career-fit confidence developed through formal education and training experiences may help explain this pattern.

Consistent with our finding that persistence is affected by more profession-specific knowledge and experiences than were important (or available) at earlier career stages, we speculate that professional role confidence may take on additional dimensions as men and women progress along the professional career trajectory, and is unlikely limited to engineering. Although more research is required, the development of professional role confidence may influence differential credential acquisition and persistence in other professional fields as well.

For example, men and women have been entering medical school at relatively equal rates for some time (Institute of Education Sciences 2009); nonetheless, the distribution of men and women by medical specialty remains highly gendered. Women tend to cluster in what are seen as “softer,” more nurturing areas of practice (e.g. pediatrics and family care) and are under-represented in others (e.g. surgery) (Boulis and Jacobs 2008). Similarly, women tend to cluster in certain basic science fields (e.g., biology and chemistry) and are under-represented in others (e.g., physics) (Xie and Shauman 2003). Professional role confidence presents an opportunity to help explain these gendered patterns.

Research on the professional socialization of physicians suggests another potential dimension of professional role confidence that also may be important at later career stages. Fox (1957) and Light (1979) suggest that learning to cope with uncertainty is an important part of professional socialization. Considering the ability to cope with uncertainty as a form of confidence, several types of uncertainties Light (1979:313) identifies among medical students map onto our expertise and career-confidence constructs.²⁰ Notably, however, two types of uncertainty do not: uncertainties in interacting with instructors and patients.

Although professions vary in their degree and nature of interactions with clients, instructors and other professionals, we suggest that *relational confidence* is likely to be an important additional dimension of professional role confidence. This relational confidence may have sub-components depending on whether the interaction is with other members of the profession (e.g., in informal intra-professional joking [Faulkner 2000] or formal medical patient hand-offs [Kellogg 2009]), with its clients (e.g., physician's "bedside manner" [Becker et al. 1961]; a lawyer's 'personal touch' [Seron 1996]), or with the general public (e.g., Cahill's [1999] discussion of the "emotional capital" of morticians). Relational confidence may also include role-appropriate mannerisms, demeanor, dress, etc. that are expected in professional settings (e.g. cursing and masculine norms of dress on oil rigs [Miller 2003]). The confidence a professional has in navigating across these role interactions, and being able to present oneself in a role-appropriate manner, may be a critical confidence needed to continue and succeed in a professional career.

If a profession's intra-professional interaction norms are highly masculine or perhaps even anti-feminine (as Turco [2010] documents among professionals in the leveraged buy-out industry), it may be more difficult for women to gain this type of confidence. The finding that male engineering students can develop their engineering identity via interactions with another randomly-selected same-sex engineering student while female engineering students cannot (Rubineau 2007) could indicate that relational confidence contributes to gendered engineering persistence even during credential acquisition. Just as the relational dimensions of professional role confidence may become more important at later stages of the career trajectory, expertise confidence and career-fit confidence may become less important. Exploration of professional

role confidence, its constituent dimensions, and whether, when and how these dimensions develop and affect persistence is an area of much needed additional research.

Engineering Persistence

A strength of this study's analytical approach is its multi-faceted measures of engineering persistence. By examining both behavioral and intentional measures of persistence, we can be more certain of whether, when and how theorized antecedents of persistence actually influence decisions to stay or leave. In addition, our use of a tripartite measure of behavioral persistence presents a refinement for explaining the gendering of STEM fields and shows that the destinations of students exiting one major and transferring to another are important beyond their decision to leave. We find a gendered pattern in students' attrition from engineering majors: women who leave engineering majors are more likely to end up in another STEM field than to leave STEM entirely. Men are less likely to leave engineering than women, but when they leave, they are more likely to leave STEM fields entirely than to switch over to another STEM field. These gendered patterns in exiting students' destinations present an important site for future research.

VI. CONCLUSION

This article contributes to our understanding of gendered persistence in male-dominated, math- and science-intensive fields by introducing the concept of professional role confidence. Through their professional education, students are expected to develop views of themselves as competent, skilled, successful professionals and to become committed to and enthusiastic about their future careers. Our findings show that early professional role confidence predicts persistence measured three years later. If women develop less confidence about their abilities to

be successful professionals and express more ambiguity about their fit or comfort within the discipline—then women remain in engineering at lower rates than men.²¹

Our approach shows that different social-psychological factors matter for different measures of persistence; factors are not similarly salient for short-term decisions (persistence in a major) as they are for decisions about career launch (intent to persist in a professional field in five years). Expertise confidence matters for persistence in an engineering major rather than leaving for another STEM major, but has little impact on plans for a future career in engineering. In contrast, career-fit confidence is strongly and positively related to future career plans. It appears that concerns about how one expects to fit with conventional occupational norms is a strong determinant of career plans, more so than students' confidence in their engineering competencies, and seems more important than expertise confidence in crossing the critical college-workforce juncture in an engineering career.

The findings reported here suggest important implications for policy. How might professional role confidence be fostered in young women (and men)? The professional socialization available through class lectures, lab exercises, and group activities alone seems unlikely to help students develop adequate professional role confidence, and, as discussed previously, likely aggravate the gender discrepancies in this confidence. Engineering programs may more effectively develop professional role confidence through direct discussion about professional roles, expertise and career fit.

One approach might be to offer a kind of “directed internship” seminar that involves working engineers and a real-world engineering project. This experience would integrate explicit learning objectives related to advancement to the next level in the engineering career as well as a broader range of skills required for success as an engineer. This form of practical integrated

learning experience, designed in part by educators who are familiar with gender biases in the profession, could help to broaden students' conceptions of the "engineering role," which is usually defined in labs and classrooms as too narrowly technical and mathematical, to include the full breadth of competencies (e.g. communication and teamwork) that are actually part of professional expertise. By having students experience a range of such directed internship projects, the spectrum of careers available under the umbrella of engineering could be broadened, allowing more students to find their fit within the profession.

In concluding, we note important caveats: The results presented here are based on a midsize, longitudinal sample of students at four U.S. institutions. Although our sample allows us to examine the effects of family plans, math self-assessment and professional role confidence on persistence with an appropriate time lag, there are several limitations to our study. First, our sample is not representative of all institutions of higher education in the U.S. We hope questions capturing professional role confidence will be included in future nationally representative samples to ensure that these trends are generalizable. Second, due to time constraints in survey administration, we were not able to ask respondents about their professional role confidence and family plans at multiple points, making it difficult to track whether and to what extent their views changed over time. Finally, we would have liked to have a multi-dimensional scale for math self-assessment to enhance construct validity (see e.g. Correll 2004).

We hope others will continue this research with larger samples and extend it to other fields, taking seriously the way the structure of normative career trajectories and institutionalized decision points influences the social-psychological deterrents in play. Attention to stage-specific processes may not only help research more accurately capture determinants of persistence, but

could also be key to developing outreach and policy initiatives tailored to specific stages in gendered professional careers.

ENDNOTES

¹ A rich literature addresses the perpetuation of gendered career interests throughout childhood, secondary and higher education, and careers (Charles and Bradley 2009; Eccles 1994; Kilborne, England, Farkas, Berton, and Weir 1994). We examine issues that emerge *after* men and women express interest in a STEM field.

² Per our IRB approvals at each institution, we have permission to use the names of each school.

³ This explanation has roots in neoclassical economics and psychology (e.g. Becker 1964; Ceci and Williams 2011; see England 1984 for a cogent critique). We focus here on the recent social-psychological scholarship that emphasizes the cultural foundations of these choices rather than the rational calculation of long-term costs and benefits.

⁴ Women in STEM majors often outperform men: women take fewer math and science courses in high school, on average, but they have done better in these courses, and have higher high school GPAs than men (Xie and Shauman 2003).

⁵ Women often internalize the fear that others judge their math abilities along popular misconceptions of gender (Steele 1997). This “stereotype threat” encourages women to *disidentify* with math-related realms, reconceptualizing their values so as to remove math-related areas as domains for self-evaluation (Spencer, Steele, and Quinn 1999).

⁶ The sub-sample of students in our study who entered college as engineering majors had significantly higher math self-assessment at college entry ($p < .05$) than the subsample of non-engineering majors.

⁷ The decomposition of our professional role confidence construct into an expertise/competence component and a fit/normative component is consistent with and similar to a convention from the large and related literature on self-concept, esteem, and identity (Owens et al. 2010; Cerulo 1997). In this literature, confidence-related concepts such as self-esteem (here, more similar to specific self-esteem than global self-esteem [Rosenberg et al. 1995]) are often decomposed into competence and worth dimensions (Cast and Burke 2002:1042).

⁸ The psychological concepts of “intrinsic value,” “utility value,” and “attainment value” appear to capture similar aspects of confidence as our notion of career-fit confidence, but these measures are conceptualized and empirically studied at the task-level (e.g. Watt 2008).

⁹ Olin is an engineering-only college, so students may not switch to a non-engineering major and remain enrolled in the institution. Olin students are therefore excluded when testing for behavioral persistence.

¹⁰ Students entered the panel in a two-step process: first, students were invited to participate, and then the survey was distributed. Students who took the first survey were included in the panel. At UMass, we oversampled students who indicated an interest in engineering. The response rate at each institution is as follows: 29.2% at MIT, 39.6% at Smith, 73.3% at Olin, and 40.1% at UMass. The high response rate at Olin was advantageous, given the small size of each cohort.

¹¹ Engineering and pre-engineering students at all four schools take at least one introductory engineering course in their first year.

¹² Although “my ability to be successful in my career” references students’ “career,” this question captures students’ confidence that they have the requisite skills to succeed in an engineering career (a component of expertise confidence) rather than their confidence that they personally ‘fit’ in engineering.

¹³ We performed a stratified analysis by sex to identify terms that differ substantially by gender. For those terms, we included interaction variables with gender to estimate the difference.

¹⁴ Tolerance values are not directly calculated for MLR, so we ran diagnostic OLS models to check for possible multicollinearity. For each behavioral persistence model, we ran OLS regression models representing the right-hand and left-hand column of each behavioral persistence model. We also found tolerance statistics for the intentional persistence logits. For all models, VIF values for non-interacted independent variables did not exceed 3 and VIF values for interacted variables were within the standard tolerance cutoff of 10 (Robinson and Schumacker 2009).

¹⁵ Our previous research using this sample found that which school students attended impacted persistence only if students came into the program unsure of their commitment to engineering (see Rubineau et al. 2008).

¹⁶ While a larger and more representative sample is required, we speculate that this result may be driven by socio-economic status differences between African-American and white respondents. Although not a significant difference, the mean family income of African-American students is about \$20,000 less than that of white students. Consistent with Ma's (2009) finding that lower-income students are more likely to select undergraduate majors that lead directly to high-income, economically secure employment, the African-American students in our sample may be more inclined to persist in an engineering career, where stable, well-paying jobs are relatively abundant. Why this effect occurs only for intentional but not behavioral persistence is a question for future research.

¹⁷ We do not intend to invoke here a lock-step career path similar to the "pipeline" analogy. Rather, we define stages by the credentials and experience required to advance. One must have a

high school degree (or GED) to advance to college, a college degree to go to professional school, a credential to advance to the workforce, and workplace experience to advance in the professional hierarchy.

¹⁸ Importance of family plans among women who entered college as engineering majors (mean=2.39) is not significantly different from the importance of family plans for women who entered college as non-engineering majors (mean=2.31). The same is true for men: mean traditional family score for men entering as engineering majors: 2.31; mean traditional family score for men entering as non-engineering majors: 2.21.

¹⁹ Year 1 math self-assessment is significantly and positively associated with year 1 engineering enrollment (0=no, 1=yes) in a logistic regression model (results available by request) with the relevant control variables (gender, SAT math and verbal scores, school, and parents' education).

²⁰ Diagnosis and treatment uncertainty involve the technical knowledge and expertise needed in the profession. The resolution of these types of uncertainties (either by tolerance of uncertainty or by its reduction) corresponds to the development of expertise confidence. Professional knowledge uncertainty, which is resolved by gaining sufficient knowledge about the profession to allow students to identify the medical specialty that is the best fit for them personally (Light 1979), is analogous to our career-fit confidence component.

²¹ In developing these policies it is important to underscore that the women in this study are at the far end of the high achievement continuum. We would speculate a similar study design at less elite institutions would reveal even greater differences between men's and women's professional role confidence.

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Figure 1: Theoretical Model and Expected Direction of Relationships

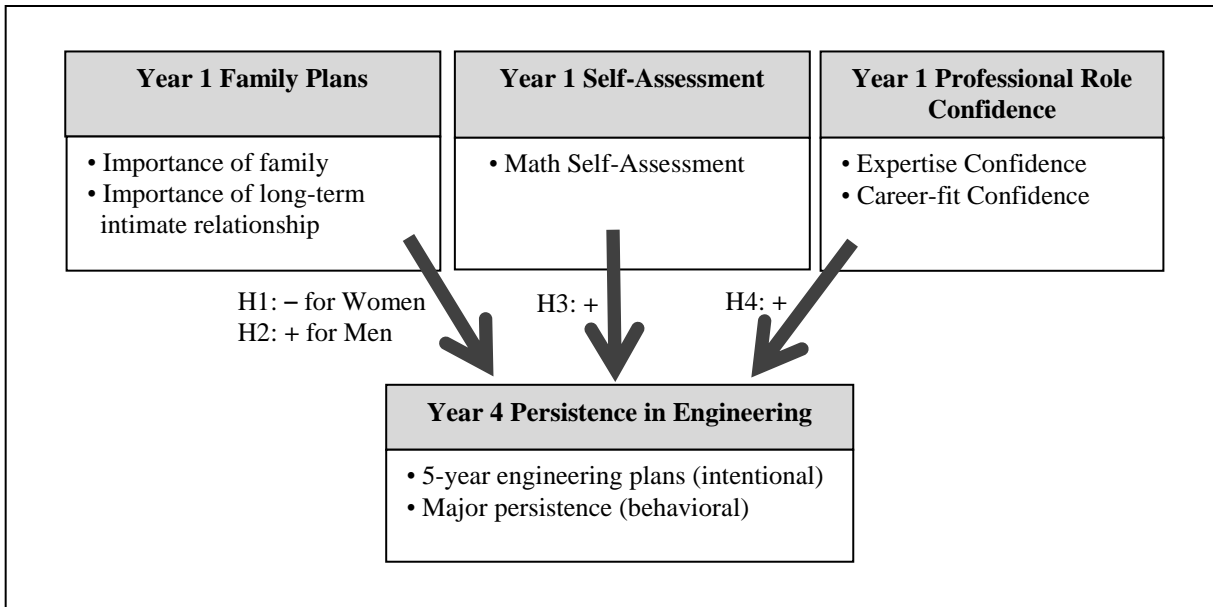


Figure 2: Intentional persistence and the interaction between sex and traditional family plans (predictions estimated using Model 4 in Table 4).

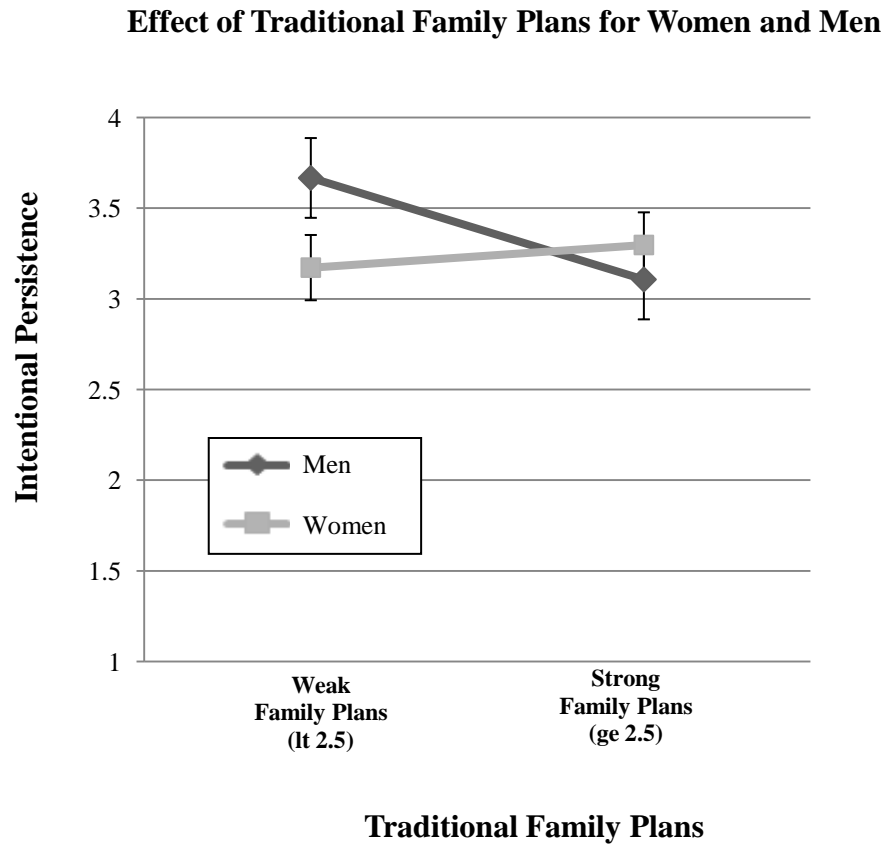


Table 1: Operationalization and Measurement of Study Variables

KEY INDEPENDENT VARIABLES

Importance of Family Plans (alpha=.721)

Importance to me:

(0=very unimportant to 3=very important)

- Building a Satisfying, Long-Term Intimate Relationship
- Building a Family

Math Self-Assessment

Rate your math ability compared to an average person your age:

(1=lowest 10%, 2=Below Average, 3=Average, 4=Above Average, 5=Highest 10%)

Professional Role Confidence: Expertise Confidence (alpha=.809)

As a result of my engineering courses:

(1=not confident at all to 4=very confident)

- Developing Useful Skills
- Advancing to the Next Level in Engineering
- My Ability to be Successful in my Career

Professional Role Confidence: Career-fit Confidence (alpha=.751)

As a result of my engineering courses:

(1=not confident at all to 4=very confident)

- Engineering is the Right Profession for Me
- Selecting the Right Field of Engineering for Me
- Finding a Satisfying Job
- My Commitment to Engineering

BEHAVIORAL PERSISTENCE (DV)

Persisted as an engineering major=0 (Year 1--4)

Left engineering for another STEM major=1 (Year 1--4)

Left engineering for a non-STEM major=2 (Year 1--4)

INTENTIONAL PERSISTENCE (DV)

“How likely is it that you will be an engineer in 5 years?”

(1=very unlikely to 4=very likely)

INSTITUTIONAL VARIABLES

Attends Smith College (1=yes)

Attends Olin College (1=yes)

Attends UMass (1=yes)

MIT is the comparison category

INDIVIDUAL-LEVEL CONTROL VARIABLES

Gender (women=1)

Hispanic or Latino (yes=1)

African American (yes=1)

Asian or Asian-American (yes=1)

Cumulative GPA (year 4)

Mother’s Education

(3=some elementary or grammar school; 10=graduate degree)

Father’s Education

(3=some elementary or grammar school; 10=graduate degree)

SAT Math Score (self-reported)

SAT Verbal Score (self-reported)

Writing Self-Assessment

Rate your writing ability compared to an average person your age:

(1=lowest 10%, 2=Below Average, 3=Average, 4=Above Average, 5=Highest 10%)

Table 2: Means and Standard Deviations

	All (N=288)		Women (N=125)		Men (N=163)		T-test
	Mean	Std dev.	Mean	Std dev.	Mean	Std dev.	
Percent women	.437						
Percent Hispanic or Latino	.083		.058		.109		
Percent African-American	.044		.079		.020		*
Percent Asian-American	.245		.315		.198		*
Intentional Persistence, year 4	2.795	1.129	2.716	1.164	2.929	1.064	*
Behavioral Persistence, year 4	.796		.772		.825		*
Switched to another STEM major ^a	.108		.167		.063		*
Switched to non-STEM major	.096		.061		.112		*
GPA	3.383	.447	3.412	.395	3.357	.490	
SAT Math	738.127	64.590	733.149	62.612	742.730	68.777	
SAT Verbal	697.001	84.837	698.043	78.911	696.024	93.221	
Mom's Education	8.150	1.871	8.104	1.898	8.271	1.800	
Dad's Education	8.525	1.999	8.540	1.923	8.526	2.050	
Importance of Family score	2.349	.823	2.393	.812	2.313	.833	
Importance of raising a family	2.175	.962	2.185	.998	2.167	.936	
Importance of a long-term relationship	2.524	.788	2.603	.745	2.460	.816	
Math Self-Assessment, year 1	4.142	.786	4.044	.762	4.220	.799	*
Writing Self-Assessment, year 1	3.603	.910	3.580	.979	3.619	.979	
Expertise Confidence, year 1	3.285	.507	3.093	.482	3.441	.474	***
Career-fit Confidence, year 1	2.861	.598	2.667	.559	3.013	.586	***

Notes: * $p < .05$, ** $p < .01$, *** $p < .000$, based on two-tailed test.

^aOther STEM majors include biological sciences, physical sciences, and other technology-related majors. Non-STEM majors include those in the arts and humanities, business, education, social sciences, and other non-STEM professional degrees such as nursing.

Table 3: Behavioral Persistence in Year 4 by Family Plans, Self-Assessment, and Professional Role Confidence

	Model 1		Model 2		Model 3		Model 4	
	1 _I	1 _{II}	2 _I	2 _{II}	3 _I	3 _{II}	4 _I	4 _{II}
	+ =Persist - =Other STEM	+ =Persist - =Leave STEM	+ =Persist - =Other STEM	+ =Persist - =Leave STEM	+ =Persist - =Other STEM	+ =Persist - =Leave STEM	+ =Persist - =Other STEM	+ =Persist - =Leave STEM
Female	-1.460*	1.047	-1.357*	1.452*	-.926	2.057*	-3.358	-1.691
Family Plans								
Importance of Family Plans (Family + Relationship)			-.128	-.701†	-.205	-.946†	-.914	-1.362*
Family Plans * Female							.982	1.440
Self-Assessment								
Math Self-Assessment			.014	.643	-.116	.575	-.160	.670
Writing Self-Assessment			-.275	-.508	-.365	-.235	.394	-.272
Professional Role Confidence								
Expertise Confidence					1.781*	-.263	1.849 *	-.311
Career-fit Confidence					-.625	-.624	.652	-.750
Institutional Effects (MIT is reference category)								
UMass	-.266	-.041	-.211	-.027	-.123	-.006	-.034	-.059
Smith	.128	-.288	.083	-.417	.045	-.947	.102	-1.015
Olin								
Individual Controls								
Hispanic or Latino	.263	-.345	.245	-.659	.588	-.362	-.555	-.313
African-American	-.884	-1.172	-.777	-.666	-.731	-1.154	-.698	-1.144
Asian	-.912	.526	-.812	.292	-.822	.336	-.888	.272
GPA	.237	.836	.348	.747	.315	1.161†	.486	1.240†
SAT Math	.003	-.001	.002	-.004	.002	-.003	-.003	-.004
SAT Verbal	.007†	.007	.009†	.011*	.010†	.008	.011	.009
Mother's Education	-.183	.144	-.237	.165	-.181	.343	-.146	.385
Father's Education	-.284	-.271	-.236	-.322	-.282	-.348	-.311	-.372
Intercepts	1.236	2.607	.889	1.863	2.827	4.772	2.610	5.099
Pseudo R-Squared	.212		.258		.314		.332	

Models:

1: Controls only

2: Model 1 + family plans and self-assessment measures

3: Model 2 + professional role confidence measures

4: Model 3 + interaction term between family plans and female.

N= 205; † p < 0.10 * p < .05 ** p < .01 *** p < .001, based on two-tailed tests. The results on math self-assessment and family plans remain the same whether they are included in the model separately or together. The expertise confidence and career-fit confidence measures retain the same significance levels even if they are included in the models separately and when self-assessment and family plans measures are removed.

Table 4: Intentional Persistence in Year 4 by Family Plans, Self-Assessment, and Professional Role Confidence

	Model 1	Model 2	Model 3	Model 4
Female	-.878**	-.834*	-.540	-3.787**
Family Plans				
Importance of Family Plans (Family + Relationship)		-.136	-.276	-1.167**
Family Plans * Female				1.554 **
Self-Assessment				
Math Self-Assessment		.155	.145	.343
Writing Self-Assessment		-.176	-.061	-.150
Professional Role Confidence				
Expertise Confidence			.060	.139
Career-fit Confidence			1.063*	1.196 **
Institutional Effects (MIT is reference category)				
UMass	-.397	-.186	-.605	-1.224
Smith	-.461	-.299	-1.069	-1.004
Olin	-.684	-.607	-.594	-.295
Individual Controls				
Hispanic or Latino	-.159	-.315	-.486	-.021
African-American	20.623***	20.578***	19.564***	19.769***
Asian	-.095	-.158	-.158	-1.000*
GPA	.218	.106	.093	.612
SAT Math	-.009*	-.009*	-.008†	-.004
SAT Verbal	.000	.001	-.002	-.002
Mother's Education	-.035	-.055	-.019	.114
Father's Education	.006	.023	-.048	-.139
Thresholds: 1	-9.873	-9.927	-8.686	-4.341
2	-8.467	-8.856	-7.306	-3.039
3	-7.155	-7.211	-5.870	-1.824
Pseudo R-Squared	.151	.159	.238	.262

Models:

- 1: Controls only
- 2: Model 1 + family plans and self-assessment measures
- 3: Model 2 + professional role confidence measures
- 4: Model 3 + interaction term between family plans and female.

N= 288; † p < 0.10 * p < .05 ** p < .01 *** p < .001, based on two-tailed tests. We also performed versions of this analysis stratified by sex, to investigate whether there were any significant differences in the effects of the variables between men and women. The only significant difference we identified was that for the importance of traditional family plans. As a result, we include that interaction term in the model presented, but not other interaction terms. The results on math self-assessment and family plans remain the same whether they are included in the model separately or together. The expertise confidence and career-fit confidence measures retain the same significance levels even if they are included in the models separately and when self-assessment and family plans measures are removed.

Appendix Table A: Pearson Correlations (N=288)

	1. Behav Persist.	2. Intentl Persis.	3. Impt. of Family	4. Math Self- Assess	5. Writing Self- Assess	6. Female	7. MIT	8. Umass	9. Olin	10. Smith	11. GPA	12. SAT Math	13. SAT Verbal	14. Mom Edu	15. Dad Edu	16. Expert. Conf	17. Career -fit Conf	18. Hisp or Latino	19. African -Amer	20. Asian -Amer
1.	NA																			
2.	-.310***																			
3.	-.005	.027																		
4.	-.032	.041	.103																	
5.	-.016	-.085	.004	.200**																
6.	.013	-.095	.048	-.113	-.020															
7.	-.060	.001	.068	.119	.010	-.051														
8.	-.004	-.027	-.058	-.135*	-.061	-.224***	NA													
9.	-.016	.001	-.086	.005	.087	-.053	NA	NA												
10.	.006	.036	.082	-.047	-.069	NA	NA	NA	NA											
11.	-.086	.069	.025	.231**	.052	.061	.096	-.190*	.013	.063										
12.	-.139	-.068	-.003	.331***	.092	-.073	.407***	-.574***	.188**	-.276***	.282**									
13.	-.156*	-.094	-.024	.274***	.374***	.012	.285***	-.468***	.243**	-.278***	.283**	.566***								
14.	-.018	-.073	.133*	.206***	.105	-.027	.086	-.198**	.068	-.005	.055	.262***	.271***							
15.	.026	-.100	.167*	.228***	.210***	.002	.145*	-.198***	.028	-.048	.027	.272***	.328***	.637***						
16.	.006	.207**	.109	.357**	.188**	-.342***	.002	-.034	.057	-.048	-.055	.032	.151	.131	.162*					
17.	-.049	.360**	.065	.055	.067	-.287**	.045	.039	-.062	-.043	-.123	-.105	-.018	-.039	-.004	.633***				
18.	-.070	-.087	-.069	.200**	.182**	.042	-.121	.066	.131*	-.060	.197*	.118	.255**	.077	.056	-.039	-.162*			
19.	.105	.018	.022	-.035	-.035	.087	.075	-.084	-.039	.033	-.059	-.109	-.064**	-.040	-.077	-.003	.065	.055		
20.	-.058	-.122	-.050	.042	-.064	.126	.288***	-.182**	-.094	-.157**	.075	.379***	.197**	.029	.149*	-.076	-.096	.157*	.080	NA

* p<.05 ** p<.01 *** p<.000