Gender and Belonging in Undergraduate Computer Science: A Comparative Case Study of Student Experiences in Gateway Courses

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> If you look at movies where they highlight the awesomeness of engineers, any movie about NASA in the ’60s, right, it’s the same persona. The same pasty white guy with the thin black tie, white shirt at a desk doing something with a pencil and maybe there’s an oscilloscope somewhere, and we romanticize that…we say, “Oh, those guys are awesome. They put a man on the moon. I want to be like that.” Which is sort of excluding people. I mean, if you look at [the people] who are [leading technology] companies that we idolize? Mark Zuckerberg: pasty white guy. Bill Gates: pasty white guy. Dude who did Dropbox: not a pasty white guy, but he’s still a guy, you know? (White male, computer science gateway course instructor).

The peculiarity this computer science instructor describes—in which the popular image of the groundbreaking engineer, mathematician, or programmer subscribes to one specific set of racial and gendered characteristics over others—stems from a problem in science education that is at once obvious and perplexing. On the one hand, the cultural stereotype he mentions is recognizable because it is rooted in a long-acknowledged empirical reality: though women make up the majority of the student population in the United States, they are underrepresented in undergraduate science, technology, engineering, and mathematics (STEM) fields in general and computer science in particular (National Science Foundation [NSF], National Center for Science and Engineering Statistics [NCSES], 2015). In part, this disparity has led to reforms in undergraduate STEM education to offer higher quality learning experiences in the hopes of encouraging more women to persist to graduation (e.g., Bybee & Fuchs, 2006; Fox, Sonnert, & Nikiforova, 2009). Instructional change in introductory or “gateway” STEM courses, in particular, has been considered a critical part of these efforts (e.g., President’s Council of Advisors on Science and Technology [PCAST], 2012).

On the other hand, the instructor’s narrative highlights a paradox. While women’s overall participation across the sciences has been increasing, their participation in computer science has been decreasing. National data, for instance, show that the percentage of women graduating in computer science fell from 27% in 2002 to 18% in 2012, even as rising proportions of women received engineering, mathematics, and physics bachelor’s degrees (NSF, NCSES, 2015). Other studies indicate that women who initially choose undergraduate computer science programs have been switching out of them at much higher rates than men. For example, Ferrare and Lee (2014) found that more than 77% of women who declared computer science as their first major in college wound up leaving STEM before graduation, compared to 45% of men. These percentages represent their study’s highest attrition rate for women among the various STEM disciplines (Ferrare & Lee, 2014) and confirm continuing trends in undergraduate computer science (e.g., Cohoon 2001, 2002; Mann & DiPrete, 2013; National Science Board [NSB], 2004).

In this paper we qualitatively analyze local educational settings to better understand this disparity, focusing on student experiences in the kinds of gateway courses that have been shown to play such an important role in women's decisions to leave the sciences (e.g., PCAST, 2012; Seymour & Hewitt, 1997). By using a theoretical framework that emphasizes the influence of contextualized interactions on student feelings of belonging, we address the following questions in reference to two gateway computer science courses at two universities: First, which characteristics and interactions in each gateway course context—including local classroom, departmental, institutional, or disciplinary characteristics—influence whether students in general and women in particular feel they belong in computer science? Second, how do local gateway course settings compare and contrast, and how does this analysis help us better understand women's persistence[1] in computer science?

Deeper insight into women's experiences in local computer science contexts is valuable for a number of reasons, but most importantly because gender disparities lead to imbalances that reinforce stereotypes, limit opportunities for women, and, ultimately, undercut broader equity efforts (Ong, Wright, Espinosa, & Orfield, 2011; Roksa, 2011). In higher education, lower completion rates for women at the undergraduate level result in lower enrollments in higher-status master's and doctoral computer science degree programs, where cutting edge research is performed and degree recipients feed the ranks of university faculty across the country (Ceci, Williams, & Barnett, 2009; Sonnert, Fox, & Adkins, 2007). In the occupational sphere, though computer science represents a prestigious career choice with rising benefits (Carnevale, Smith, & Strohl, 2013; U.S. Bureau of Labor Statistics, 2015), lower female graduation rates in the field contribute to continued disparities in which women only account for 25% of the computer science workforce (NSB, 2014). These inequalities are not only self-perpetuating (Johnson, 2014; Murphy, Steele, & Gross, 2007; Scragg & Smith, 1998), they restrain student and worker ingenuity (Blickenstaff, 2005; Canetto & Byars-Winston, 2011; Page, 2008; Terenzini, Cabrera, Colbeck, Bjorklund, & Parente, 2001) and even national economic competitiveness (e.g., National Academies, 2010).

While influential, such utilitarian claims also tend to obscure the role that broad notions of "science" and "technology" play in unequally demarcating the social and cultural spaces in which we live and work (Cheryan, Plaut, Davies, & Steele, 2009; Cheryan, Plaut, Handron, & Hudson, 2013; Cheryan, Master, & Meltzoff, 2015; Ridgeway & Correll, 2004). Fox (2001), for instance, contends that science "reflects *and* reinforces gender stratification" through a value system in which attributes traditionally associated with men are granted higher status than those associated with women (Fox, 2001, p. 655, emphasis in original; also see Bourdieu, 1999; Gutmann, 1987; Herzig, 2004; Long & Fox, 1995). In this regard, others have considered scientific venues—including educational institutions, departments, and classrooms—as unique social and cultural spheres (what we will later call "social fields"), each with their own gendered customs and norms that influence the ways men and women relate to one another, the kinds of

[1] We define "persistence" as continuing on the path to complete an undergraduate degree in computer science. "Persistence" may also be described as *the absence of* switching to a non-STEM major.

roles they are assigned, and how valuable these roles are perceived to be (Acker, 1990; Bagilhole, 2002; P. Y. Martin, 2003). How, we should ask, do daily interactions in these gendered venues inform student experience and action? Indeed, a contextualized, theoretically informed emphasis on these issues not only helps us push past arguments linking gender equality to macro-economic strength, but also allows us to sharpen our focus on how broader hierarchies are experienced (and reinterpreted) in specific educational settings.

From this perspective, and following other studies looking at the influence of local contexts on STEM inequalities (Legewie & DiPrete, 2014; Ong et al., 2011; Palmer, Maramba, & Dancy, 2011), undergraduate education in computer science presents a valuable point of entry to qualitatively study how student experiences in a discipline marked by strong gender stratification may influence persistence decisions. Indeed, despite calls to change the culture of STEM education at research universities to foster increased inclusivity (Anderson et al., 2011; Wieman, Perkins, & Gilbert, 2010), there has been a dearth of recent scholarship holistically investigating how local experiences in postsecondary computer science contexts—exemplified by instructional methods, social interaction, gendered and disciplinary stereotypes, and students' sense of belonging (Garvin-Doxas & Barker, 2004; Margolis & Fisher, 2002)—might influence retention, especially within the gateway courses that are considered pivital to switching decisions in the sciences (Seymour & Hewitt, 1997; Stinebrickner & Stinebrickner, 2011). It is with these gaps in mind that we undertake the present study.

Background

Women's Underrepresentation across the Sciences

Located at an economic, cultural, social, psychological, and educational crossroads, women's underrepresentation in undergraduate STEM fields in general and computer science in particular has been the subject of much research over the last few decades from a variety of disciplinary and methodological perspectives. Though explanations for gender disparities are wide-ranging, a large body of work focusing on the different kinds of settings and interactions that influence women's educational experiences and academic decisions offers a springboard for our contextualized understanding of these disparities.[2]

Research looking across undergraduate STEM fields has been particularly revelatory. Studies have found, for instance, that a mismatch between the social and cultural characteristics of STEM fields and the preferences of women and students of color, sometimes referred to as

[2] Though we are focusing on computer science herein, scholars have suggested many explanations for gender disparities across STEM fields, including differences in self-efficacy between boys and girls and men and women (Heaverlo, Cooper, & Lannan, 2013; James & Smith, 1985; White, 1993), negative pre-collegiate science experiences (Blickenstaff, 2005; Legewie & DiPrete, 2014; Riegle-Crumb & King, 2011), women's strengths in other academic fields (Ceci et al., 2009; Mau, 2003; Ost, 2010; Sax, Jacobs, & Richards, 2010), the influence of parents and loved ones (Eccles, Jacobs, & Harold, 1990; Goode, Estrella, & Margolis, 2006; Sadker & Sadker, 1995), subconscious biases (Riegle-Crumb & Humphries, 2012; Shen, 2013), as well as wider cultural and social pressures for girls and women to conform to traditional gender roles (Keller, 1995; Linn & Hyde, 1989; Malcom, Hall, & Brown, 1976).

"cultural incongruity" (Gloria, Castellanos, & Orozco, 2005), is a significant factor in gender disparities across the sciences. For example, "chilly climates," described as local educational environments that convey the message that women are less capable than men, are likely to leave women feeling less confident than their male classmates (Hall & Sandler, 1982). The perception of unfair treatment from male peers (Cabrera, Colbeck, & Terenzini, 2001), negative interactions with faculty (Morris & Daniel, 2008), the dearth of female role models (Cotner, Ballen, Brooks, & Moore, 2011; Young, Rudman, Buettner, & McLean, 2013), as well as other more implicit gender biases in STEM classrooms and departments (Easterly & Ricard, 2011; Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012), generate chilly climates. These situations may not only discourage women from participating actively in classroom and advising settings, but also cause feelings of psychological alienation which lead to them leaving STEM fields altogether (Pascarella, Hagedorn, Whitt, Yeager, Edison, Terenzini, & Nora, 1997; Vogt, Hocevar, & Hagedorn, 2007).

Seymour and Hewitt's (1997) *Talking about Leaving: Why Undergraduates Leave the Sciences*, which also looked across STEM fields, speaks closely to the links between local educational experiences and gendered attrition as well. Exploring students' persistence and switching decisions in STEM courses at seven institutions of higher education, Seymour and Hewitt (1997) found that women who persist and those who switch face a similar set of challenges, including a common view that STEM courses are impersonal, large, and lecture-based, and a perception that science and math classes are more comfortable when women are not dramatically outnumbered by men. They also determined that switching decisions, particularly for women, were closely tied to their experiences in the large, introductory courses that are usually required to proceed in and graduate with STEM majors. Referred to as "introductory courses" (Eagan, Herrera, Sharkness, Hurtado, & Chang, 2011), "barrier courses" (Suresh, 2006), or "gateway courses" (Davies-Vollum & Greengrove, 2010), these include foundational classes such as Calculus 1, Introduction to Computer Programming, and General Chemistry that have been found to have high rates of failure as well as a reputation for "weeding out" those who perform poorly (Seymour & Hewitt, 1997).

Subsequent research has mostly supported Seymour and Hewitt's (1997) findings concerning the importance of introductory courses (Chen, 2013; Eagan et al., 2011; Stinebrickner & Stinebrickner, 2011) as well as to the kinds of pedagogical and curricular factors that are critical to women leaving STEM fields. With regard to instructional practice, recent studies have shown, for instance, that women often prefer small, interactive classes with hands-on demonstrations and group activities in which new material is contextualized within real-world situations (e.g., Knight, Mappen, & Knight, 2011). Research also suggests women can benefit from regular interaction with faculty members (Gayles & Ampaw, 2014).

Gender and Persistence in Computer Science

While some literature on persistence and gender is relevant across STEM, decades of rich research focused on computer science identifies challenges and opportunities specific to the field. Miura (1987), for instance, pointed to lower computer self-efficacy among women as a significant factor in the field's gender disparity, a finding later studies confirmed (Besana & Dettori, 2004; Fisher, Margolis, & Miller, 1997; Katz, Allbritton, Aronis, Wilson, & Soffa, 2006). Other research has pointed to the influence of mathematics-related self-confidence on women's interest in computer science (Lips & Temple, 1990; Powell, 2008; Wilson & Shrock, 2001). Studies through the 1990s and 2000s found multiple experiential factors influenced lower persistence rates by women, including different experiences with computers prior to entering college, mathematics- and programming-focused first-year computer science courses, the lack of departmental encouragement and support, the low number of women role models, a lack of collaborative work in the classroom, outright gender discrimination, and wider cultural stereotypes of computer science's heavy workload, social isolation, and gamer-mentality (Barker, McDowell, & Kalahar, 2009; Beyer, Rynes, Perrault, Hay, & Haller, 2003; Biggers, Brauer, & Yilmaz, 2008; Borg, 1998; Cheryan et al., 2009; Singh, Allen, Scheckler, & Darlington, 2007).

More recently, scholars have recognized that these wider stereotypes, or what Margolis and Fisher (2002) called "geek mythology," hold an especially significant sway over women's interest in the major. For example, Cheryan and colleagues (2009) discovered that simply altering objects in computer science classrooms from those stereotypical of the major (Star Trek or video game posters) to those less stereotypical (nature posters or phone books) could improve women's interest in computer science to a level comparable with their male peers. In another study, Cheryan, Drury, and Vichayapai (2013) applied a similar theory to male and female computer science role models, showing that women's interest and sense of belonging in computer science decreased when they were confronted with a stereotypical role model, regardless of the person's gender. Cheryan and colleagues also confronted the media's representation of the field, showing that while female college students' descriptions of computer scientists revealed characteristics usually thought of as incompatible with female gender roles, women who read articles that portrayed computer scientists without such stereotypes became more interested in the field (Cheryan et al., 2013).

While research points to the deconstruction of traditional computer science stereotypes as important to increasing women's interest and comfort in the field, promising practices for teaching and learning in classrooms have also been identified. In the 1990s, discipline-based education researchers pointed to team projects (Taylor, 1994) and participation-based modular learning (Carter & Jenkins, 1999), in particular, as ways to make computer science instruction more appealing to women, while more sophisticated methods, reaching beyond traditional lectures and lab-based learning, have been touted as possible equalizers in the field as well. "Media manipulation," centered on hands-on activities in which students create forms of media they view as relevant (Rich, Perry, & Guzdial, 2004), and "pair programming," in which a student "driver" and a student "navigator" work together on tasks, assignments, or tests (e.g., Salleh, Mendes, & Grundy, 2011), have been shown to increase academic performance and student satisfaction. "Peer instruction," a specific teaching protocol in which the instructor asks students to answer content-oriented questions individually then, after peer group work, guides a whole class discussion on the questions and related concepts (Alvarado, Lee, & Gillespie, 2014;

Porter, Guzdial, McDowell, & Simon, 2013; Porter & Simon, 2013; Zingaro & Porter, 2014), has been shown to be valued by students and effective in increasing student retention.

Though education research in computer science has much to add to our understanding of student experience in local educational environments, areas of the field need further development. Like the broader body of work on STEM persistence, the literature lacks theoretically informed qualitative analyses examining local computer science dynamics and student experience in colleges or universities, with two exceptions. Working in one research-intensive higher educational institution from 2000 to 2002, Garvin-Doxas and Barker (2004) used document analysis, student interviews, and hundreds of hours of classroom observations to study communicative behaviors and interactions in 13 introductory computer science classes. They found the classes they studied were primarily characterized by "defensive communication behaviors," or judgmental, dogmatic, and otherwise hierarchical social interactions, which lead to lower confidence and, eventually, attrition among women. While their results were consistent with previous research on STEM persistence, they recommended instructors create more supportive learning environments for women by learning students' names, acknowledging the content's difficulty, respecting questions, and using multiple instructional methods (Garvin-Doxas & Barker, 2004, pp. 16-17).

Based on data collected from 1995 to 1999, Margolis and Fisher's seminal *Unlocking the Clubhouse: Women in Computing* (2002) is another prime example of a qualitative analysis of such dynamics. The authors used classroom observations and interview data from students and instructors to investigate the complex, on-the-ground realities that factored into women's persistence decisions at Carnegie Mellon University, home of one of the country's premier computer science departments. Tracing postsecondary gender disparities in the field to lifelong socialization processes and male "claims on computing" starting in elementary school, the authors detailed a host of classroom and departmental climate-related issues at the university that contributed to women leaving the major. First, women's interests in computer science, which the authors described as pragmatically guided toward the use of computer knowledge outside the field, are not represented in teaching practices or curriculum. Second, men typically had more previous computing experience than women, which often led to women feeling less confident about their strength in computer science courses even if their abilities were as strong as those of their male peers. Third, the authors found that women felt a real, persistent sense of alienation from many of the stereotypical norms of (a male-centered) computer science culture, including its workload, single-minded focus on technology, and social isolation.

As exemplary case analyses of computer science courses, these two works underscore how the careful, holistic study of women's educational experiences—of gendered and disciplinary identities, instructional methods, and peer engagement, in particular—speak both to persistence and wider disparities in the field of computer science. At the same time, however, the studies highlight opportunities to strengthen the body of existing research on the topic. Because more than a decade has passed since data were collected for both studies, during which time gaps between women and men in the field have only intensified, the literature would benefit from the study of these phenomena in more contemporary settings. Each study, furthermore, focused on a single higher educational institution, which suggests that an in-depth, comparative examination of student experiences at multiple universities would provide insight into questions on the commonalities and differences embedded in local practices and experiences across cases. Additionally, neither work took an explicitly socio-cultural approach to their study of local teaching and learning dynamics, a limitation that seems especially conspicuous given recent calls to transform the culture of STEM disciplines to foster more effective undergraduate instruction (Anderson et al., 2011; Wieman et al., 2010)—an undertaking that will necessarily depend on a better understanding of the meaning students and instructors attach to local educational experiences (e.g., Ferrare, Benbow, & Vivyan, 2014). All in all, this state of affairs not only makes our analysis all the more timely and relevant, but points us toward the two distinct yet complementary theoretical frameworks that guide this paper: field theory and belonging.

Theoretical Framework

Field Theory

To comprehend social action in local computer science settings, one must develop a relational understanding of how multiple contexts, from narratives in the national media to one's educational role and past experiences, influence a student's daily experiences. Field theory, a framework that seeks to clarify the logic of human behavior with reference to social structure and individuality, proves useful, and intuitive, in this regard.

The concept of a "field," as the name suggests, is the framework's keystone. Conceived as a bounded, metaphorical plain of social relations, a field is a structured set of positions (e.g., roles in social or cultural hierarchies) in which individuals are drawn toward each other intentionally and unintentionally in the pursuit of similar resources (Bourdieu, 1999; J. L. Martin, 2003). Bourdieu, whose version of field theory is most widely known, envisioned social life as encompassing an almost endless number of such constellations, each with its own history, rules, and customs, and wrote about the fields of academia (Bourdieu, 1988), literature (Bourdieu, 1996), and the French state (Bourdieu, 1998), among others. Even with social life thus partitioned, an individual actor can be involved in any number of fields simultaneously, from those of her office or recreational bowling league to those of her family or university life, each in which she holds a different role. This role or position, in turn, shapes her perspective on the field as well as her perception of what kinds of actions are likely to lead to success within it (J. L. Martin, 2003).

Though fields operate according to their own specific social "gravity" (Bourdieu & Wacquant, 1992, p. 17), they are not completely autonomous. Not only are individuals acting in various social fields concurrently, but also at any given moment one field's internal relations depend on the broader fields in which it is nested and through which actors can gain or lose support in local struggles (Fligstein & McAdam, 2012). Referencing this "Russian doll" concept of smaller bundles of social relations nested within larger ones, then, we can conceive of a gateway undergraduate computer science course being socially located in a number of different ways. First, the course consists of specifically positioned students (at different stages in their degree programs, with varying experiences, etc.) and an instructor (who is adjunct, tenure-track, or tenured, with different racial and gendered characteristics, etc.) acting and interacting within a demarcated social field that is encased within the larger field of the university's computer science department, on which it depends for leadership, university resources, and other social and administrative assets (Figure 1).

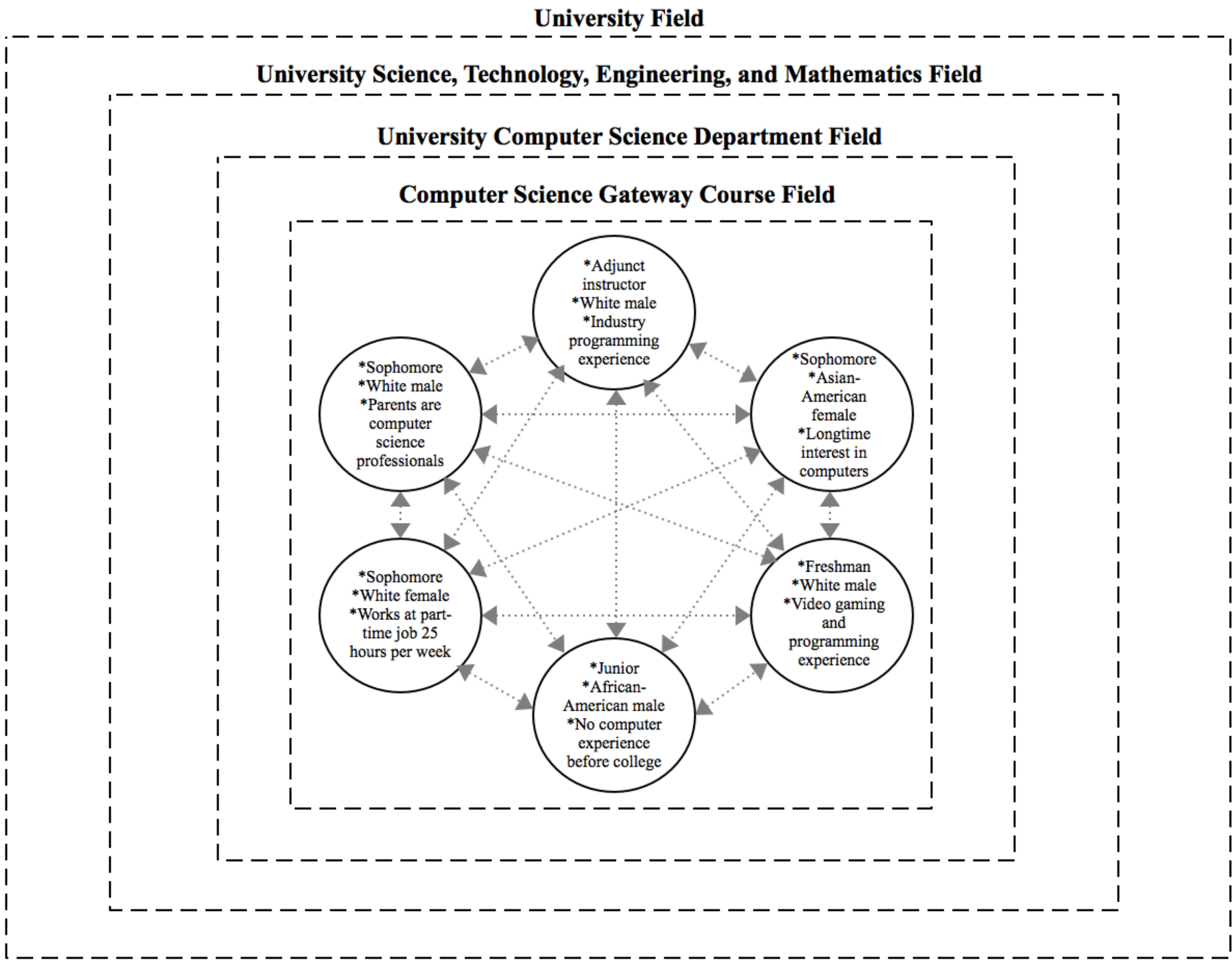

Figure 1. **Institutional Gateway Course Field Environment**

This departmental field comprises faculty members teaching various courses as well as undergraduate and graduate students enrolled in computer science degree programs. The department is encompassed within the institution's larger STEM field, which in turn is embedded within the university field, a still wider social sphere consisting of all other departments, schools or colleges, administrative divisions, and the institution's students, faculty, and staff. We can also envision the computer science departmental field as embedded within a wider field environment consisting of more extensive cultural and media representations of computer science, which itself is nested within a somewhat similar but still broader space of cultural representations of STEM culture, and so on (Figure 2).

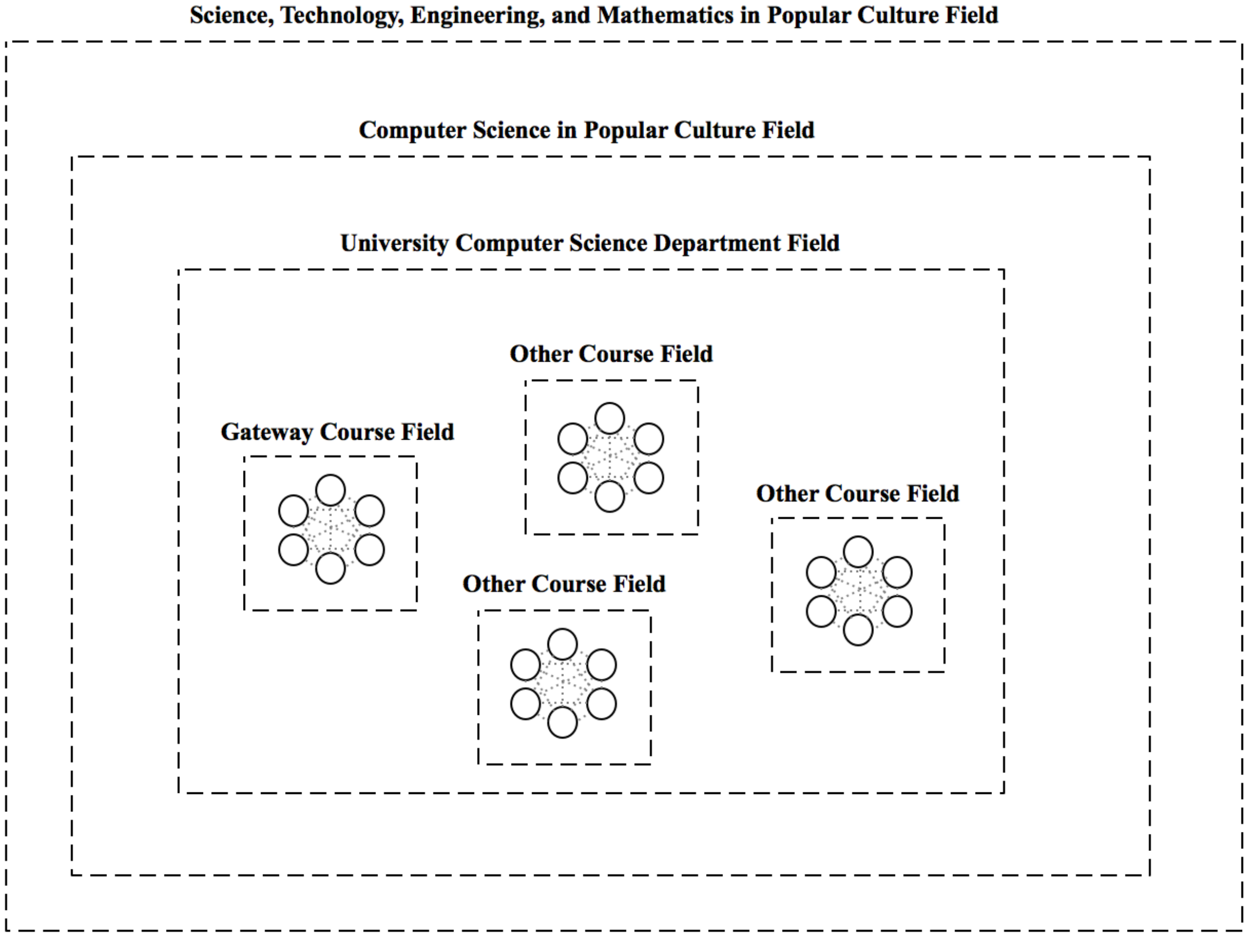

Figure 2. **Wider Computer Science Field Environment**

The main point in demarcating embedded fields is an important one: The relationships and dependencies of these multi-layered social arenas with and on one another are significant to their internal relations (Fligstein & McAdam, 2012). This key idea allows us to conceptualize how cultural values and norms in one field influence those in other subfields, and how individuals may simultaneously interpret the characteristics of the multiple (embedded) fields in which they live and work. In this way we can theorize how wider ideas about the gendered nature of technology—espoused through video game commercials or television sitcoms, for example—and the much more local advice or disapproval of a peer or a teacher can influence how women and men interact in a computer science classroom and whether they can see themselves as practitioners in the discipline.[3]

For all its strengths, field theory has often been criticized for its emphasis on social structure at the expense of day-to-day, individual experience, a shortcoming that has led theorists to

[3] We recognize numerous social fields may influence persistence decisions outside the educational setting including, say, a student's family, extra-institutional friendship circles, or religious affiliations. Still, a practical field analysis must be made subject to limitations in relation to what researchers consider most pertinent to the question at hand. Our analysis will therefore focus mostly on the local educational fields on which we gathered primary data, including each gateway course, its department, and its institution.

supplement the framework with concepts of motivation based on the work of the German Gestalt psychologists and James Gibson (Ferrare & Apple, 2015; J. L. Martin, 2003, 2011). Essentially, these social psychological elements open up the possibility that features of one's social field can themselves have "demand character" (Koffka, 1935; Lewin, 1933) or qualities which, when viewed from certain positions in the field, call for certain actions. If we consider a bed that beckons an exhausted traveler to sleep, to use one example, or a set of classroom interactions that compels a student to leave a major, to use another, we can therefore view the compulsion for a person to act as a function of her life experiences and the meaning she ascribes to aspects of her current field surroundings (J. L. Martin, 2011, pp. 166–169). This field theory of practice directs our attention to a locally attuned framework relating closely to each site's dynamics—in our case, the connections among gender, social position, instructional interactions, and individual perception in two gateway computer science courses—at the same time it shows how differences in local social patterns distinctly influence the way educational actors see the opportunities and challenges inherent in their unique settings (Ferrare & Apple, 2015). The study of precisely these kinds of perceptions, we contend, can help us better understand the phenomenon of women's persistence in computer science in a way that is intuitive and relatable to first-person experience (J. L. Martin, 2011, pp. 338-339).

The Theory of Belonging

With this framework in place we add one other concept to further specify our study: that of a specific environmental "demand character" in computer science gateway course fields—referred to as "belonging"—that students may perceive as inhering in local practices and interactions and that may lead them to stay in or switch out of the major. Described as the need to "form and maintain at least a minimum quantity of lasting, positive, and significant interpersonal relationships," psychologists Baumeister and Leary (1995, p. 497) posited that a sense of belonging is a fundamental, and universal, motivator to human action, at once shaped by an individual's reading of her social environment as well as the need to sustain psychological and physical well-being (Barden, Garber, Leiman, Ford, & Masters, 1985; Hale, Hannum, & Espelage, 2005). Fulfilling this need to belong, Baumeister and Leary (1995) argued, leads individuals to act in ways that will help them foster meaningful social connections, even if such actions preclude the attainment of other, less significant (in a motivational sense) goals or objectives. Indeed, when an individual feels his social environment is incompatible with his social needs—whether that environment represents an intermural floor hockey team, a group of researchers, or a computer science department—the theory of belonging indicates that he will seek out new environments in which he believes meaningful, lasting relationships can be more easily achieved. Social fit, in this way, stimulates people to take action and can therefore help us theorize how feelings of belonging in local computer science contexts relate to persistence decisions.

The concept of belonging has been used widely in educational research to help show the importance of interpersonal relationships, camaraderie, and a sense of community to student success across a variety of settings (Anderman, 2003; Battistich, Solomon, Kim, Watson, &

Schaps, 1995; Battistich, Solomon, Watson, & Schaps, 1997; Sánchez, Colón, & Esparza, 2005). The concept also has played an especially significant role in the study of student experience, perception, and success in postsecondary contexts. Indeed, as Hausmann, Schofield, and Woods (2007) argue, belonging is an implicit factor in many models of student persistence. “Academic and social integration” (Tinto, 1993), “institutional fit” (Bean, 1980), and “student involvement” (Astin, 1993), for instance, are all variables that relate to belonging. They are not only essential to influential college attrition models, they also are significant factors predicting the persistence of women, students of color, and students from lower socio-economic backgrounds in colleges and universities (Ostrove & Long, 2007). Others, still, have tried to explicitly model a sense of belonging. In their study of Latino and Latina student college persistence, for example, Hurtado and Carter (1997) constructed a belonging variable by gauging student participation in institution-oriented activities as well as discussions related to course content outside of class, while Ostrove and Long (2007) used a five-point scale to measure students’ perceptions of how they “fit” in their college of choice. Student feelings of belonging, as they reflect various mismatches between an individual’s sense of self and her perception of the social environment, also link to a number of other concepts used to explain persistence disparities in the literature, including cultural incongruity (Gloria et al., 2005), chilly and defensive climates (Garvin-Doxis & Barker, 2004; Hall & Sandler, 1982), stereotype threat (Spencer, Steele, & Quinn, 1999), and the masculine view of science (Schiebinger, 1991).

With this background in mind, the benefits of the additional belonging perspective become more apparent. If we think of a hypothetical computer science gateway course as a field, containing varied positions offering different perspectives on practices and interactions that compel students to act, the concept allows us to take the next step and investigate which specific aspects of this field might influence one universal motivation for action in particular: a sense of social and cultural belonging. In this way, and in the context of findings in the persistence literature, whether a student feels she *belongs in* computer science, characterized as it is by a field with varied interactions and practices that inhere with a welcoming or inhospitable character, offers valuable insight into her propensity to *persist in* computer science.

Ultimately, the theory of belonging provides a sound experiential foundation on which field theory’s focus on structure can rest. The theory allows us not only to center our attention on particularly meaningful facets of each field that foster or discourage feelings closely associated with persistence decisions, but also to buttress our analysis with several influential concepts that have been linked to attrition in the higher education and STEM persistence literature. Finally, it further enhances our field theory of practice by providing a lens through which identity-related issues, and their impact in local educational contexts, can be conceptualized (Solomon, 2007).

Methods

While the theoretical basis of this paper rests on field theory and belonging, our application uses a comparative case study approach characterized by the in-depth exploration of a specific bounded issue or concrete problem—here student experiences in gateway computer science courses that may influence persistence—using multiple cases based on multiple data sources

(Merriam, 1998; Stake, 2006). Because case studies are by definition rich, contextualized accounts of real-life phenomena, the method hews closely to our investigative aim, which seeks to better understand how local social contexts and experiences impel student action. The method also fits well with our theoretic framework, which conceives of multiple aspects of local field environments facilitating or inhibiting belongingness (and thus persistence) to local actors.

Sampling Strategy and Study Sites

Though case studies can employ different kinds of sampling procedures, ours depended on the purposeful sampling of two gateway computer science courses in two higher educational institutions. This research began as part of a wider project that visited six universities—chosen for their geographic, demographic, and institutional variety—to explore why undergraduates were leaving the sciences. Tasked with gathering qualitative data on instruction and practice in pivotal gateway courses from these institutions beginning in 2013, we started our sampling process by examining the course schedules of each of the study sites to identify introductory computer science classes required for students to advance in the major (Chen, 2013; Crisp, Nora, & Taggart, 2009; Davies-Vollum & Greengrove, 2010; Suresh, 2006). After cataloging these offerings, we sent resulting class lists to administrators and faculty members at each institution asking for feedback and then further edited or added to our course sample frame based on local recommendations.

Using these finalized gateway course lists, we next e-mailed each course's instructor asking for voluntary participation in our study, which entailed sitting for an interview, relaying a message from our team to his or her students, and allowing a researcher to observe two class sessions. Of the 33 computer science course instructors we contacted in these six institutions, five instructors from four universities self-selected into the study and ultimately participated during our site visits in 2013 and 2014 (a 15% response rate). These instructors forwarded the research team's e-mail solicitation on to their students asking for voluntary participation in the study, after which interested students were brought together in groups of up to nine individuals for focus group interviews.

Because our investigative and theoretical aims call for a much richer analysis of each case than a focus on all five of these gateway computer science courses would allow, we opted to center our analyses on only two of these five courses. We first reduced the sample by discarding two of the five courses that had only one student participant in their focus group interviews. Looking at the remaining three courses, we chose the final two cases for the contrasts in their institutional and classroom size, research and teaching foci, and geographic location—thus targeting a "diversity of contexts" (Stake, 2006, p. 24)—to give us two complementary yet distinct perspectives on student experience, gender, and interaction in introductory computer science courses. The first course case is from a medium-sized private Western university, hereafter referred to as "Harrison University," while the second is from a large, public, Midwestern university that we call "Grand Lakes University."[4] Data collected for each of these gateway computer science courses included one instructor interview (*n* = 2), focus group interviews with students (three focus groups in total, *n* =17 students), and two classroom observations (*n* = 4; see Table 1). All respondents also filled out a short survey, with students providing information on their gender, race/ethnicity, and major, and instructors providing information on their gender, race/ethnicity, and position title.

Table 1. Sample Characteristics

	Instructors				Students		
Course	Class Size	Position	Race/Ethnicity	Gender	Major(s)	Race/Ethnicity	Gender
Harrison University – Dr. Tisdale	25	Lecturer	White/ Caucasian	Male	Computer Science	Latino	Male
					Computer Science	White/Caucasian	Female
					Computer Science	White/Caucasian	Male
					Electrical Engineering	African-American	Male
					Computer Science	Asian-American	Female
					Computer Science	Asian-American	Male
					Computer Science and Mathematics	Asian-American	Female
					Computer Science	Asian-American	Female
Grand Lakes University – Mr. Metzler	280	Lecturer	Native American	Male	Computer Science	White/Caucasian	Male
					Computer Science	White/Caucasian	Male
					Computer Science	White/Caucasian	Female
					Computer Science	White/Caucasian	Male
					Computer Science	Asian-American	Male
					Computer Science	White/Caucasian	Male
					Computer Engineering	White/Caucasian	Male
					Computer Science	Latino	Male
					Computer Science	*Not reported*	Male

Data Collection

Semi-structured interviews. Instructor and student focus group interviews, which were digitally recorded and usually lasted 90 minutes, were based on semi-structured interview protocols with questions on a variety of course-specific topics including teaching and learning, classroom climate, and respondent views on student persistence and belonging. Interviews were transcribed and uploaded to NVivo 10 software. Though we focus our case descriptions below on these two courses, we supplement our comparative findings with patterns that emerged from the broader computer science data set from which these two cases were chosen. Researchers also conducted dozens of other gateway STEM instructor and student focus group interviews at each institution through the wider project of which this study is a part, data that we use to describe university-level field dynamics at Harrison University below. Likewise, we gathered further

[4] To protect the identities of our participants and their institutions, we assign pseudonyms to universities and instructors. We also use approximate figures, with qualifiers such as "almost," "about," and "over," to numerically describe programs and institutions in a few instances where we believe using exact figures would put our participants' confidentiality in jeopardy.

descriptive information on each institution from the U.S. Department of Education (2015), including enrollment figures, popular programs, and tuition expenses.

Classroom observations. Two observations of each gateway course were conducted using the Teaching Dimensions Observation Protocol (TDOP), an instrument that allows trained researchers to record the presence or absence of 41 specifically defined practices and interactions that might take place in a university classroom (Hora & Ferrare, 2013). Organized into five descriptive categories, these possible actions include 10 “instructional methods,” eight “pedagogical moves,” six “student/faculty interactions,” four “cognitive engagements,” and 13 “instructional technologies” (Table 2).

The four researchers who conducted the classroom observations in this study underwent several weeks of intensive group training on the TDOP, during which we familiarized ourselves with the instrument, engaged in detailed discussions of the coding definitions, tested and compared our coding skills using video-recorded STEM lectures, and established inter-rater reliability. Prior to entering the field in the spring of 2013, the team’s combined pairwise Cohen (1960) kappa average across the final four test observations was 0.70.[5] After data collection the TDOP codes for each course were entered into separate Excel spreadsheets, with rows representing consecutive two-minute intervals and columns representing the binary presence (“1”) or absence (“0”) of each of the 41 different codes across these 2-minute intervals.

[5] The combined pairwise Cohen (1960) kappa average scores across each major TDOP category for the final four observation tests were as follows: instructional methods, 0.90; pedagogical moves, 0.56; student/faculty interactions, 0.63; cognitive engagements, 0.56; instructional technologies, 0.85.

Table 2. Description of TDOP Categories and Codes

TDOP Category	Code	Description
Teaching methods		
Lecture	L	Instructor talking to the students and not using any visuals
Lecture with pre-made visuals	LPV	Instructor speaks with premade visual media (e.g., PowerPoint)
Lecture with handwritten visuals	LHV	Instructor speaks to students with hand-made visuals (e.g., writing on whiteboard)
Lecture with demonstration	LDEM	Instructor speaks while using demonstrations
Interactive lecture	LINT	Instructor talks to the students while asking successive questions
Small group work	SGW	Students form into groups of two or more for group work
Deskwork	DW	Students complete work alone at their seat
Whole class discussion	CD	Students are answering and asking questions amongst themselves
Multimedia	MM	Instructor plays a video or movie without speaking
Student presentation	SP	Students are giving presentations to the class
Pedagogical moves		
Moves into audience	MOV	Instructor enters the student seating area
Humor	HUM	Instructor tells joke or humorous anecdote
Reads	RDS	Instructor reads verbatim from prepared notes or slides
Illustration	IL	Instructor uses familiar example to which students can relate
Organization	ORG	Instructor directly indicates transition between topics
Emphasis	EMP	Instructor clearly states a topic is important
Assessment	A	Instructor gathers student learning data
Administrative task	AT	Instructor and/or student engage in logistical task
Instructor/student interactions		
Instructor rhetorical question	RQ	Instructor poses question without waiting for answer
Instructor display question	DQ	Instructor poses question seeking information
Instructor comprehension question	CQ	Instructor poses question about student understanding
Student question	SQ	Student asks original question
Student response	SR	Student responds to instructor question
Peer interactions	PI	Students interact with one another
Cognitive demands		
Recall and retain information	RRI	Students asked to define a term or recall basic facts
Problem solving	PS	Students asked to solve a close-ended problem
Creating	CR	Students are asked to solve an open-ended problem
Connections to real world	CN	Students are given examples linking material to experiences
Instructional technology		
Poster	PO	Instructor uses posters such as the periodic table or a map
Book	B	Instructor uses books during the class period
Notes	N	Instructor uses lecture notes
Pointer	P	Instructor uses laser or metal pointer
Chalkboard	CB	Instructor uses chalkboard or whiteboard
Overhead/transparencies	OP	Instructor uses machine to project images on screen
PowerPoint	PP	Instructor uses PowerPoint slides
Clickers	CL	Students use clickers to respond to instructor questions
Demonstration equipment	D	Instructor uses laboratory demonstration equipment
Digital tablet	DT	Instructor uses technology on which he or she can write on a document or graphic that is being projected
Movie	M	Instructor uses YouTube clips, documentary, or movie
Simulation	SI	Instructor uses digital applets or web-based simulation
Website	WEB	Instructor references online resource

Data Analysis

Thematic coding of interview transcripts. In line with our research questions and theoretical construct, our analytical methods followed an inductive coding framework meant to track the confluence of first-person accounts and various field attributes in instructor and student focus group interview transcripts. This process, undertaken by the first author, began with open coding at the manifest level (Charmaz, 2006) in which he used ideas from the text to create codes through multiple readings of a representative sample of computer science instructor and focus group transcripts, representing courses chosen for the case study analyses as well as those not chosen. The second round of coding used the constant comparative method (Glaser & Strauss, 1967) in which the first author compared each successive instance of a code to previous instances to confirm or alter code definitions. As the first author "codemapped," or regrouped this list of codes into more refined categories (Saldaña, 2013), he used field theory constructs to further organize codes representing multilayered facets of each position and social environment—from faculty availability ("instructor interactions") to classroom size ("department factors") or wider notions of computer science ("disciplinary culture")—which respondents linked to persistence decisions. The belonging construct was represented by "belonging" and "isolation," two "affective codes" (Saldaña, 2013) meant to represent the subjective qualities of reported student experiences. The first author used "belonging," the first, to mark participant phrases, stories, or anecdotes describing student feelings of social acceptance, while he used "isolation," the second, to mark participant phrases, stories, or anecdotes describing student feelings of social rejection or alienation.

With participant-generated and theoretical constructs thus combined, the first author applied the resulting codebook to all 12 computer science transcripts using simultaneous coding methods (Miles, Huberman, & Saldaña, 2014). Second cycle analytic techniques based on respondent repetition, the co-occurrence of codes, and the relationship of emergent meta-categories to our research questions followed (Namey, Guest, Thairu, & Johnson, 2008; Ryan & Bernard, 2003). These second cycle methods allowed us, first, to distill descriptive information for our two case studies detailing each local course context. This information makes up the case narratives answering the first research question below. Second, the techniques brought a few major, interconnected themes to the fore, both rooted in the case contexts and spanning the entire corpus. Through our comparative analysis, these themes in turn help answer our second research question.

Descriptive analysis of classroom observation data. TDOP-based classroom observation data in Excel were used to calculate the proportion of time each coded instructional practice or technique was used across all reported 2-minute intervals for each of the two case study courses (Hora, 2015; Hora & Ferrare, 2013; see Table 3). These data, which offer a rough estimate of the proportion of class time devoted to each practice, allow us to compare teaching methods and classroom interactions between the two cases.

Table 3. Gateway Classroom Data using TDOP Codes

TDOP Category	Code	Harrison University	Grand Lakes University
Teaching methods			
Lecture	L	.11	.01
Lecture with pre-made visuals	LPV	.02	.01
Lecture with handwritten visuals	LHV	.35	.87
Lecture with demonstration	LDEM	.65	.13
Interactive lecture	LINT	.33	.74
Small group work	SGW	.00	.04
Deskwork	DW	.00	.04
Whole class discussion	CD	.00	.00
Multimedia	MM	.00	.00
Student presentation	SP	.00	.00
Pedagogical moves			
Moves into audience	MOV	.01	.00
Humor	HUM	.21	.34
Reads	RDS	.00	.00
Illustration	IL	.76	.71
Organization	ORG	.00	.00
Emphasis	EMP	.13	.03
Assessment	A	.00	.00
Administrative task	AT	.05	.05
Instructor/student interactions			
Instructor rhetorical question	RQ	.32	.12
Instructor display question	DQ	.46	.89
Instructor comprehension question	CQ	.14	.25
Student question	SQ	.55	.16
Student response	SR	.80	.89
Peer interactions	PI	.41	.04
Cognitive demands			
Recall and retain information	RRI	.35	.55
Problem solving	PS	.51	.83
Creating	CR	.00	.01
Connections to real world	CN	.84	.74
Instructional technology			
Poster	PO	.00	.00
Book	B	.00	.00
Notes	N	.00	.00
Pointer	P	.00	.00
Chalkboard	CB	.34	.43
Overhead/transparencies	OP	.28	.00
PowerPoint	PP	.38	.03
Clickers	CL	.00	.00
Demonstration equipment	D	.63	.00
Digital tablet	DT	.00	.59
Movie	M	.00	.00
Simulation	SI	.00	.04
Website	WEB	.00	.00

Results

To answer our first research question, we begin with descriptions outlining specific course-related field contexts of our two gateway computer science course cases that respondents indicated influenced student belonging. From these case descriptions, we next answer our second research question by providing a comparative analysis of the case studies supplemented by data from the wider computer science sample. We close with conclusions and the implications of this study moving forward.

Gateway Course Field Characteristics Influencing Student Belonging

Harrison University. Harrison University is a medium-sized, private university with an undergraduate enrollment of about 5,000 students at the time of our visit in 2013, and a faculty to student ratio of 1 to 11. Tuition for undergraduate students is more than $40,000 per year at Harrison, which was known primarily for its business, social science, and performing and visual arts offerings (U.S. Department of Education, 2015).

According to students the reputation and resources of these three top programs, especially as compared to STEM disciplines, played a significant role in field dynamics at the university level. While the business program was housed in a large, new, centrally located building on campus, for example, the computer science department was set in an aged and comparatively out-of-the-way dormitory built in the 1950s. “You won’t even put me on campus, you give me this crap building,” one White female physics student reported. “I feel that they’re communicating, ‘We don’t care about you guys.’” Harrison University tours, another student joked, usually stayed far away from their part of campus, focusing instead on the performing arts or psychology buildings. From these students’ perspectives, the physical accommodations clearly represented a status imbalance not only between the university’s top programs and STEM departments, but also the students enrolled in them.

Several students said that this imbalance was reflected in other facets of campus life, including what time courses were scheduled, academic recognition, and the leisure time available to students at Harrison. “I don’t think that Harrison as a school encourages science majors,” the physics major told us. She had just twice described her department’s building as “awful,” and said she thought such differences discouraged STEM students. “My business major friends will cry ’cause all of a sudden they have…one class on a Friday.” She added that though she knew a number of business majors on Harrison’s honor roll, she didn’t have any science major friends on it. STEM classes, she believed, were too difficult. At the same time, while the workload associated with science classes seemed to isolate science majors socially from business or social science peers, it also had an upside. As one White female chemistry major explained, the adversity STEM students faced on campus brought them closer together. “I feel that us science kids are kinda like a family here, just because we’re all on the back end of campus, all hauled out together [on Friday mornings],” she said. “We watch the business majors, you know, frolic through the fields happily…so I think there’s a huge sense of community among science majors.”

In theoretic terms, these students suggested that their position as STEM majors in the broader institutional social field, with the position's requisite workload, remote buildings, more tiresome class meeting times, and overall lower status, segregated them from their peers. Still, the hardship pulled students together into a close-knit STEM "community," as some of the students called it, of shared struggle and sacrifice. As a smaller social field characterized by belongingness and inclusivity set within Harrison University's larger campus field, this STEM community served to offset at least some feelings of marginalization suggested by the wider institutional environment.

The home of our first gateway course case was yet another subfield therein: Harrison University's computer science department. Physically housed in its aging dormitory building, the department included more than a dozen faculty members, half of whom were tenure track and half of whom were non-tenure track instructors whose jobs focused on teaching. The gateway course's instructor, a White, non-tenure track male faculty member named Dr. Tisdale, described it as a department in which "everyone knows everyone else," a place with a "casual, laid back atmosphere" and small classes.

Dr. Tisdale's course, listed as an introduction to advanced concepts in computer science, was the last of a sequence of classes students in the major were required to take during their first year. As Dr. Tisdale said, the course was considered one of the more difficult of the first year, because of its heavier reliance on mathematics, its wide-ranging subject matter, as well as the levels of independence and competence the department expected from students. He had seen the course act as a stumbling block for many students, including those who needed to maintain a high grade point average in order to pay the institution's prohibitive tuition fees. "I've seen a fair number of students that quit because they're worried about their GPA, because of scholarships," he told us. "They'll drop just to avoid the possibility of getting anything less than an A."

Those who did not have to worry about financial constraints also had a tough time, the instructor reported. "It's a big switch of context," Dr. Tisdale explained. "You've been doing all these programming courses and then all of a sudden now you have to do basic proofs in math…they don't like that." While he tried to continually link the course's more advanced concepts to group work and real world, hands-on examples from his experience in industry, Dr. Tisdale said that students were often frustrated by the increased fluidity of tasks and topics they encountered.

> The assignments are different. They're a little more open-ended…I try to give them things that are less than perfect on purpose, you know, so that they'll learn to ask questions…it's hard for me to do it and it's hard for the students. Some students just cannot deal with that. They want everything to be, you know, specified, cut and dried. I've had students get angry.

The large number of topics covered in the course, which Dr. Tisdale suggested was partly the result of (more senior) department faculty relegating increasing amounts of content from upper level courses to the (adjunct- and TA-taught) introductory classes, was particularly problematic.

"There's been a tendency to sort of push things down…and some of us who have been teaching it lately have realized that that might not be the best way to go," he commented. "We're trying to teach too many different things." Dr. Tisdale's lower status position in the department field, in this way, had a potentially significant influence on his students' experience of the gateway course field.

For their part, the focus group students from Dr. Tisdale's course recognized the more complex demands of this gateway course as compared to previous classes in the sequence. Some students appreciated the increased independence, while others wanted a more firm set of guidelines to follow in completing coursework. One student, a Latino who was majoring in computer science, explained the sequence's progression similarly to his instructor. "As...the intro to Comp Sci series has gone on, they've kind of slowly moved us to have a more personal responsibility for what we can do with a little more freedom, ''cause that's how it is," he told us. "There are some guidelines, but we are working with other people, which is what we'll most likely do in the professional world." The course's assignments, many of the students noted, were wide ranging and fairly open-ended, which took time, practice, and instructor advice to master. Referencing this advice, one Asian American female, a video game graphics major in computer science, said Dr. Tisdale was often very helpful in alleviating some of the inevitable frustration that came with such difficult tasks. "There's many different ways to solve one problem, and many different 'right' styles," she explained, and "it's very good that he's able to look at your code, understand what your line of thinking [is], and help you get to the end of your question."

While the dynamics of the major's introductory sequence played an important role in what students experienced in this gateway course, our interview data also indicate that the size of the department, as well as its tight-knit relations, were significant factors as well. With two sections of about 25 students each, Dr. Tisdale's observed pedagogical practice in his afternoon class session centered on a variety of lecture methods, including lecturing in reference to PowerPoint slides ("LPV" with "PP" according to the TDOP coding scheme), lecturing while writing code or mathematical theorems on the white board (LHV and CB), and, most prominently, lecturing while demonstrating computing techniques (LDEM and D; see Table 3). He used illustrative techniques frequently (IL and CN), connecting the content to students' experiences through familiar, relatable examples, and peppered students with questions to which they offered regular responses as well as questions of their own (DQ, SR, and SQ). One White female computer science major described it as "a very collaborative experience." "Rather than writing the code himself," she said, "there's an interplay…he will offer suggestions, he'll write what we suggest to him, and we will actually come across errors in the code together, and any student will jump in and pose an issue or a solution." The instructor and students, most of whom had had interactions in similarly small introductory classes in Harrison's computer science department, also referred to one another by their first names. As we will discuss below, Dr. Tisdale believed his familiarity with each of these students gave him a good perspective from which to judge their comfort (or lack thereof) with the material, which allowed him to adjust his instruction and advising duties accordingly. It also had the added benefit, studies suggest, of communicating distinctiveness and social acceptance to each student (Garvin-Doxas & Barker, 2004).

Though instructor and students alluded to such familiarity being the case in both sections of the course, Dr. Tisdale pointed out that his two sections differed in a few important ways. The morning section, he said, which was composed almost entirely of young men, was consistently and painfully quiet. He told us that teaching these sessions entailed a lot of standing at the white board, trying to elicit student queries or responses, and hearing only an uncomfortable silence in return. As he put it, “they don’t ask as many questions. It’s almost as if they're afraid to exhibit ignorance.”

In contrast the afternoon section, to which the instructor invited our researchers to conduct the two classroom observations, not only had more students, but also included most of the course’s female enrollees. Dr. Tisdale described the section as brimming with kinetic energy, machine-gun type questioning from students, and a high level of student activity. He enjoyed it, he said, but it kept him on his toes. “Teaching that class is almost like controlled chaos,” he explained. “They’re asking things all the time to the point where I can’t even keep up with a lot of what’s going on. And it’s totally different than the other section, and I don't know why.” While he was uncertain as to how the sections turned out as they did (he suspected that many of the cohort’s women had purposefully registered for the same section the previous term), he said that the afternoon, female-majority class featured more questions and comments from women students than he had seen in any of his previous courses. “They’re completely unafraid,” he told us. It was a positive development, he thought, though he declared himself ignorant of its cause.

With these dynamics in mind, we find a multifaceted social field environment in this gateway course with interactions and practices that inhere with characteristics that students view as both welcoming and inhospitable. Like the wider Harrison University field, which suggested exclusion (through peripheral and aged STEM buildings, inconvenient course schedules, and higher workloads) and belonging (through an embattled yet united STEM field of struggle), and which Dr. Tisdale pointed out exerted financial pressures on scholarship students to drop difficult classes, women in particular could point to various facets of the introductory course that implied conflicting values. For example, while the jarring course curriculum caused many to feel frustrated and even “angry”—sentiments that students indicated might lead one to leave the major—the course also had an accessible instructor who emphasized hands-on classroom engagement and collaboration, methods that have been associated in the research literature with greater social cohesion and female persistence (Rich et al., 2004; Taylor, 1994). Instructor and student interview accounts also strongly suggest that the afternoon, female-majority session we observed offered more meaningful interaction and belonging in this regard, as well as an environment in which women could feel free to ask questions without worry.

Grand Lakes University. Grand Lakes University is a large, Midwestern university enrolling nearly 30,000 undergraduate students. As a public, flagship institution with a faculty to student ratio of 1 to 17, the university’s in-state resident students paid about $13,000 per year for tuition during the 2013-2014 academic year when we visited, while out of state students paid roughly $20,000.

The computer science department field was the home of around 40 tenure-track faculty and a handful of non-tenure track teaching-focused instructors teaching several dozen different courses. “Forty-some [faculty] are real and the five of us are kind of the cleanup squad,” said Mr. Metzler, the Native American male who taught this Grand Lakes University gateway computer science class. He was a teaching-focused, adjunct instructor who had been teaching introductory courses in the department for a few years. Now, after receiving a promotion to what he said was the highest non-tenure track position in the department, he was teaching the second course in the computer science major sequence, a gateway class of nearly 300 students centered on programming syntax. As had been the case in previous terms, the department organized the course to have two regular 75-minute lecture meetings per week in a large hall that fit all 280 students, and one smaller 50-minute lab meeting per week in which students would break into smaller groups and practice programming techniques under the supervision of teaching assistants.

These aspects of the course, Metzler later told us, were illustrative of the department’s culture. “Our buildings, course schedules, class rooms, et cetera, are set up around the idea of one person talking and hundreds listening,” he told us. “Perhaps non-computer science departments are different.” Such resources, he said, influenced how many students were allowed to enroll in a given class, how much laboratory time was available for coding practice, as well as the number of teaching assistants available, to name but a few factors that, as we explain below, influenced his students’ experience of the gateway course field.

Mr. Metzler believed he had a much different background, and therefore outlook, than most people in the department, which influenced his students’ experience in various ways. First, he came from what he called a long line of “janitors and truck drivers and no math people,” his way of saying that he had a predisposition toward the concrete or tangible. While computer science courses were often taught with close reference to mathematics, he abhorred what he saw as the abstract shorthand used in proofs and formulas, thinking it served to exclude potentially talented computer scientists from the discipline with an opaque shroud of symbols. He therefore purposefully tried to demystify math in his teaching, sticking to common themes that had helped him as a student. “If I have to use variable, I will use happy faces and stars and unicorns to emphasize that it’s not magical Greek, that it’s just stuff,” he said. “I tried to stick to things that are really concrete and very common. Things that they see every day.” Second, Mr. Metzler had an undergraduate background in the liberal arts, which he said made him look at computer science much differently than others in the field. His interest in computer science was based on his notion that the discipline was more similar in form to art than to mathematics, a perspective he would use to try to make programming more accessible to his students.

As he described it, Mr. Metzler’s social field position—concerning his anti-mathematics background, liberal arts experiences, and somewhat isolated status as a contingent instructor in a department focused on research—had multiple and direct influences on his teaching. Most generally, he believed these experiences had given him the mindset that every student could understand important (and often difficult) computer science concepts if those concepts were taught in the right way. As we will explain, because he saw himself as an individual who had come to understand and then master programming as something of an outsider, he tried to bring as many students as possible into computer science, especially those that traditionally had not been welcomed with open arms. For Mr. Metzler, women were of particular concern in this regard.

According to many of the course's focus group students, Mr. Metzler continually communicated a message of inclusion—for women, for those afraid to speak up, and for those not comfortable with mathematics—through multiple aspects of his instruction, though students' classroom experience was beset by a number of department-induced field factors that were beyond their instructor's control. Taking his place in front of a few hundred students in a 300-seat lecture hall, Mr. Metzler was mostly bound to the stage as he used the chalkboard (LHV and CB) and his digital tablet (LHV and DT) to perform the day's coding lessons in real time (Table 3). Despite the room's size, Mr. Metzler's observed teaching was defined by a quick and steady stream of commentary on the coding he was performing to clarify the day's lesson and why it mattered. Using humor (HUM), he interacted with students by asking questions about what he should include in his models or whether or not they understood the concepts, basing his coding progression on their feedback (LINT, DQ, CQ, and SR). Though students did not ask questions of Mr. Metzler often (SQ), focus group participants reported that a handful of individuals responded to his continual inquiries by shouting out answers through most of the observed class time.

Mr. Metzler also regularly offered a number of illustrative, authentic examples connecting his lessons to students' everyday experiences (IL and CN). One such example was a pilot dating website that he was building through the entire semester with student input. Mr. Metzler, pointing to the need to better include traditionally underrepresented students in computer science, said he purposefully formulated such example problems to make women feel more welcome. He commented, "When we do games in class, we almost always do games that are female-oriented." As he listed such "female-oriented" tasks, though, he revealed a somewhat formulaic perspective on female interests, combining common stereotypes of women with genres often associated with a technology-centered (and mostly male) subculture. "We do dating games, we do, um, we've done Pokémon because Pokémon's got a really good boy/girl ratio…we did Hello Kitty party pals, where you have to plan a party." Again, however, the sentiment was geared toward inclusion, and as Mr. Metzler told us,

> A large portion of [the men in the course] are kind of nerdy, antisocial, 'I love computers.' Which is great. I want them to be programmers, but I want other people to be programmers also. I always get this feeling that girls see the class, see who's in it, and they say, 'Okaaaaaay'… I don't want them to feel like, 'I don't belong here,' alright, because that's the easiest way to get to them to leave…if they're going to leave, then they're going to leave as an individual who can't do it.

Meant as they were to present authentic and welcoming example problems to students who needed to be drawn into computer science, Mr. Metzler's teaching illustrations were less effective than he hoped. Indeed, while students recognized his efforts to offer example problems that connected to their experiences, some said his illustrations exemplified the kind of larger cultural trends that turned women and underrepresented minorities off to computer science in the first place (also see Cheryan et al., 2015). One Latino computer science major, for instance, said he recognized undercurrents of what he called an "internet subculture" in the course that could feel exclusionary. "There's a lot of wacky, out-of-left-field references going on in there that some people might get, others won't get," he told us. "He does a lot of references to, say, anime for example, [or] he'll reference something like Naruto and he'll just start using a bunch of names." Another student, a White male, agreed, mentioning that when students did actually comment or ask questions in class (something respondents reported was rare), they usually seemed to share Mr. Metzler's cultural proclivities. "When people do talk, [it is] that culturally, stereotypical nerdery," he explained. He was a computer science major, but the topics seemed exotic to him. "I can feel that in the class…we've used, 'My Little Pony' in one of our things and different star chart references."

Students also spoke of a number of instances from class in which Mr. Metzler tried to invite participation and inclusion, but multiple social and physical aspects of the course made his efforts fruitless. Unquestionably, students were hesitant to speak up in such a large classroom with so many peers looking on. Less obviously, though, Metzler thought many were simply afraid of looking unknowledgeable, especially in front of peers who were more confident and experienced with computers in general as well as the "internet subculture" that Metzler had established as social currency in the classroom. The wide-ranging differences in students' pre-college experiences with computers, in particular, seemed to contribute to what Mr. Metzler characterized as a climate of fear and self-doubt that affected many students. "The biggest problem I see in the class is panic. I mean, flat out panic," he said. "They all talk to me one on one. But in front of their peers, no one says anything. And everyone that I've talked to is convinced that they are the only person in class that doesn't get it."

Importantly, this lack of self confidence in relation to practical computing experience also grew from frustrations the students had with the course's insufficient amount of supervised lab time. The lack of adequate lab time was somewhat puzzling for Mr. Metzler because faculty in the department agreed that the goal of this particular course was to teach students a new way of thinking that would allow them to, as he said, "problem solve using their computers." Hands-on learning, he told us, was key. "Teaching programming is teaching people how to do karate or swimming," he argued. "I stand up there and say, 'Watch! I'm swimming…now go home, and when I can't see you, and give you any feedback, just go do it.' It seems like a bad way to teach."

Still, while the course demanded substantial coding practice outside of class, department faculty had given short shrift to entreaties for more lab time and less lecture time, which Metzler and focus group participants agreed was necessary. The lack of regular coding practice, ultimately, diminished student understanding and retention of the material, which in turn made many feel confused and behind their peers. One Latino student, in particular, gave a harrowing description of how this felt. Although he appreciated Mr. Metzler's humor, real-life examples, and empathy, the class demanded more from the student than he thought he might be able to give. "This is almost another form of Java to me," he said, using the word "juxtapositional" to describe the see-saw like experience. "I can't quite relax, I can't quite be completely frightened…I don't quite know how to feel at the end, and that makes me a little nauseous."

As was the case in Dr. Tisdale's course, male and female students in Grand Lakes University's gateway class reported that they perceived field characteristics, at varying levels, as both welcoming and disaffecting. Dynamics at the departmental field level, which affected students' feelings of belonging through their instructor as well as through particular physical and structural aspects of the course, were especially influential. For example, despite Mr. Metzler's unique field positionality—including his outsider background as an "anti-math" liberal arts major and his focus on bringing as many students into computer science as possible—he believed his status as a contingent teacher in a research-focused department limited his effectiveness in lobbying for the lab time that he and his students thought necessary to meet the course's learning goals. Mr. Metzler and his students told us the resulting dearth of hands-on coding practice not only led to widespread anxiety, but also to feelings of technical inadequacy. Mr. Metzler's teaching practices in the classroom also sent mixed signals. On one hand, he encouraged inclusiveness in his classroom, seeking to connect the banal mechanics of syntax coding to student's real life experiences. But while his humor and eccentricity kept the class engaged, his subcultural references—which usually elicited remarks only from those "in the know"—were viewed by many students as remote and foreign. Such local reference to wider computer science stereotypes, as studies have shown, can be especially disaffecting to women (Cheryan et al., 2015; Margolis & Fisher, 2002).

Comparative Analysis of Local Gateway Course Contexts

"Brogrammers" and the broader disciplinary culture. The most significant theme emerging from our analysis was the pervasiveness of a distinct culture of computer science linking notions of gendered identity, previous experience with computers, and student perspectives to success in the field. "There's this term for the kinds of people who go into video game programming, and they're very macho and they're very 'I'm smarter than you,'" one White male gateway instructor said. "We call them 'brogrammers.'"

The term encapsulates what respondents described as a broad computer science field—referred to in Figure 2 as the "computer science in popular culture field"—that, at least tacitly, prizes the kind of exclusionary know-how often associated with men over the collaborative sensibility often associated with women (see, for instance, Herzig, 2004). It was a profoundly cultural aspect of the discipline, according to this instructor, that had a direct impact on students' sense of belonging in his introductory classes. "Maybe [brogrammers are] not explicit about it, but just by being assholes, they really repel people who aren't like them," he said, colorfully referring to the kinds of "defensive communication behaviors" that Garvin-Doxas and Barker

(2004) had observed in computer science classrooms more than a decade earlier. Dr. Tisdale at Harrison University, who mentioned a similar dynamic, also linked this male-centered atmosphere to women's feelings of marginalization. "The biggest challenge is just putting up with all the guys in the class," he concluded. "It's stereotypical, but we tend to get students, mostly male, that have had a lot of programming experience…I've noticed several times that it's hard for the women in the class to sort of overcome…the guys trying to get all the attention, showing that they know everything."

Mr. Metzler at Grand Lakes concurred, but offered a more nuanced take on the phenomenon. "We…get a lot of CS students that as a freshman are taking 20 hours [of classes]," he explained. "'Cause, 'I'm so smart. I was smart in high school, I can do this.'" Metzler described much of the outward confidence, however, as a defense mechanism. If computer science students, especially males, tended to grandstand in class, he surmised, it was mostly in an effort to appear knowledgeable in the eyes of the computer-focused peers with whom they felt some solidarity. In the terms of Baumeister and Leary's (1995) belonging theory, these students were acting to build socially meaningful relationships. Indeed, despite research showing computer science cultural norms' negative impacts on students occupying certain computer science field positions, namely women, these norms could also have a positive influence on feelings of belonging for students in other positions, as one Grand Lakes White male computer science major explained. When asked if his previous experience with computers made him feel more comfortable in the course or major, he answered, instead, that it was the social climate in Mr. Metzler's class that made him feel at home.

> What we're learning I kind of already know, so that's not really what's causing me to be in my major. It's kind of the culture of the class…that's more of an incentive for me to be a computer science major, because I see people who are more like me than there are in other fields. I could go to a math class and just sit there and just feel completely out of it, but if I'm in a programming class like this one, I say, 'Hey! Even if I'm bad at this I can, you know, hang out with people who will make me get better.

Still, Mr. Metzler argued that the wider culture's influence represented a double-edged sword. "We kind of built this neat bubble where all these people who maybe didn't get along before have a place, a safe place to be," he said. "But it tends to push other people away." Many female focus group participants across our wider computer science sample agreed. "It is different being a girl, especially with the confidence thing," one White female computer science major said. "Then you combine that with the whole Comp Sci mentality which is basically, 'I'm hot shit. I'm awesome.'" Altogether, she suggested, it often made for a lonely experience. "When you're surrounded by men who seem like they have it all together, you feel a little out of place."

As we have noted, the role such broader cultural fields play in women's interest, experience, and self-efficacy with computers (Beyer et al., 2003; Cheryan et al., 2015; Cheryan et al., 2009; Cheryan, Plaut et al., 2013; Katz et al., 2006), as well as broader STEM fields in general (Blickenstaff, 2005; Seymour & Hewitt, 1997), has been the subject of much research. Still, we can see here directly how wider cultural cues inhering in a local classroom field—through preening male peers or an instructor's references to "Bronies," (the name for boys and men interested in the "My Little Pony" franchise) to use but two examples—influence feelings of inclusion or exclusion and thus belonging in the computer science major, particularly for women.

Underrepresentation influences daily life. As a number of female respondents reported, exchanges in the classroom can be colored by these kinds of cultural forces in various ways, and the day-to-day social repercussions of being outnumbered can be complicated. One White female student, for instance, said being one of only a few women in class created an awkward tension with males who were interested in or intimidated by the possibility of an extra-curricular relationship. "It's hard to strike the friend balance with guys," she explained. "I always felt that either they thought I was hitting on them, they were trying to hit on me, or we were both really confused about what was going on…last semester, I just didn't talk to guys at all." She said that this awkward balance, in turn, led to what she thought was a general reluctance on the part of men to engage her in course work. "They help each other more than they would help me. So, I'm not sure if it's a 'me personally' thing or a 'me girl' thing." Another White woman in her focus group said she had had similar experiences, describing one such instance in which two male peers ignored her as she asked for help with a specific homework assignment. "I feel that, as a girl, I have to prove myself more," she said. Such interactions in computer science classrooms and departments, in turn, could affect a woman's broader social relationships and support networks. "All my friends are guys," another White female participant told us, mentioning that she usually didn't meet other women unless introduced to them by male friends in the major. "I don't feel like I know that many girls in computer science, so it's hard to come together and help each other out." As research on belonging has made clear, such feelings concerning the kind of meaningful relationships an individual can develop in her educational environment can have a profound influence on her choice to switch out of a major (Hurtado and Carter, 1997; Ostrove & Long, 2007).

Still, we also found a few instances in which these dynamics served to solidify, not diminish, female students' resolve to persist to graduation in computer science. While a number of women told us they were motivated to prove they could succeed in a male-dominated field, such underrepresentation increased their drive in the major in other ways as well. One White female in Dr. Tisdale's class, in particular, said her status as an underrepresented student was more of an incentive to continue in the field than anything else. "I was actually kind of curious if any of the girls had felt, 'Oh, I don't belong here,' because I definitely didn't [feel that way]," she told us. "My friends were all really worried sending me off to college to do computer science, they were saying, 'You're going to be harassed so often—no one's going to think you can do anything.' That's not true at all…it really empowers me personally to hear that surprise, 'Oh, you're a woman in computer science?'" In this student's case, the unusual field position of being one of only a handful of women in a major dominated by men not only increased her feelings of self-worth, but also made her more determined to obtain her computer science degree.

Teaching and learning. Pedagogical interactions are an important factor in determining whether students feel included or excluded in a particular educational field, and our findings in this regard confirm results from previous studies. Most significantly, students across our sample reported that working with real-world problems (Barker, Garvin-Doxas, & Roberts, 2005; Schilling & Klamma, 2010), as well as active instructor encouragement in light of student questions and peer collaboration (Salleh, Mendes, & Grundy, 2011; Taylor, 1994), made them feel more comfortable and more confident as computer science majors—often despite brogammer-oriented field norms. In light of these concerns, observation data can help us better understand the role these techniques played in each classroom (Table 3). Using the TDOP codes of "connections to real world" (CN) and "illustration" (IL) as a rough approximation of authenticity in teaching, we can see that Dr. Tisdale and Mr. Metzler frequently linked teaching content to familiar, relatable student experience in their classrooms (Dr. Tisdale used these techniques in 76% and 84% of intervals, respectively, while Mr. Metzler used them in 71% and 74%). Looking at the frequency of "student questions" (SQ) and "peer interaction" (PI) within each case, we can see that student questions were a larger part of Harrison University's gateway course than Grand Lakes University's (55% of intervals versus 16%), as was peer interaction (41% versus 4%), a finding that is unsurprising considering the considerable differences between Dr. Tisdale's more intimate classroom setting and Mr. Metzler's Grand Lakes lecture hall.

These observations, of course, remind us that departmental and institutional field dynamics influence course social fields, and therefore student feelings of belonging, in meaningful ways. The contrast between Harrison's gateway course, with two sections of 25 students held at a medium-sized private university, and Grand Lakes' course of almost 300 held at a large public institution, illuminates some of the limitations of instructor practice, especially when it comes to counterbalancing wider cultural and disciplinary norms. As Dr. Tisdale told us, for example, he knew many of the students in his small department from previous courses. "Our classes are quite small," he said, so "I have a pretty good idea of what [students] know and what they don't know." Reportedly, Dr. Tisdale was able to spend significant amounts of time with individual students assisting them with questions and problems, and most of the focus group students from this class believed he was giving them the support they needed to succeed. Students in Mr. Metzler's course, however, reported overcrowded teaching assistant sessions, long waiting lines at office hours, and the general inability to get help when it was needed, leading them to feel frustrated and, at times, deserted. Mr. Metzler, who told us he spent hours every semester trying to learn his students' names, admitted the class' size simply did not allow for individual attention. Some students, he concluded, would inevitably fall through the cracks. "Realistically, we've got a very large group of students and I know very little about them," he said. "I don't know where they came from, I don't know what their backgrounds are, I don't know where they're going."

Conclusions and Implications

Building from recent findings showing that undergraduate computer science continues to have the highest attrition rates proportionally for women within postsecondary STEM disciplines—a phenomenon that defies basic social equity goals in a high status field—our study adds to a growing body of literature seeking to better understand how local higher educational settings can influence student persistence decisions, particularly for women. Updating and extending important work in computer science, our study of gateway courses at Harrison University and Grand Lakes University contributes a nuanced interpretation of this wider problem in two important ways. First, we apply a field theory of practice that helps us more clearly conceptualize how varying social realms and positions influence student feelings of belonging and motivation. Second, we use an in-depth, comparative case study to detail how classroom, departmental, institutional, and extra-institutional characteristics, from instructional practices to popular stereotypes, shape experiences, meaning, and action for students in specific and contrasting higher educational contexts.

The results of this analysis point to multiple dynamics that influence belonging and persistence for female students in the field of computer science. While previous studies have highlighted the significance of broader computer science cultural values, self-efficacy beliefs, and experience with computers to female attrition, our findings demonstrate some of the complex ways these factors interconnect in the context of students' and instructors' daily lives. They also point to differences in local social interactions and positions that, from the perspective of students and instructors, can begin to mediate such factors, including opportunities to ask questions, collaborate, and work on "real world" examples in class, fuller access to instructors, and departmental and campus supports that contribute to a more meaningful sense of belonging in computer science.

While our work here confirms a number of previous findings, our application of a field theory of practice may provide guidance for others interested in formulating the ways that various micro-, meta-, and macro-level processes impel feelings, and thus persistence or attrition, in local higher educational contexts. Still, there are drawbacks to the framework. In general, field theory has been criticized for its limitations when it comes to empirically defining "field" boundaries, which can lead researchers to over-apply the concept to the point of theoretical irrelevance (Swartz, 1997).[6] The explanatory power of belonging, as a specific motivator for action, also had its limitations. As we found in our case studies, certain aspects of each social environment inhered with qualities that could suggest inclusion *and* exclusion, including Harrison University's institutional field (which discounted and united STEM students), the independence expected in Dr. Tisdale's course (which was intimidating and liberating for students), and Mr. Metzler's teaching illustrations (which linked lessons to examples relevant and irrelevant to students). Such simultaneous influences limit our ability to identify whether, on balance, a specific practice or field characteristic leads more to a sense of belonging or

[6] As Swartz (1997) argues, "Fields tend to proliferate. Subfields appear as well…conceptual inflation leads to its devaluation" (Swartz, 1997, p. 122).

alienation, which in turn complicates what should be the wider goal of educational research: to suggest possible solutions for problems.

With this point in mind, though our findings point to a few possible “one size fits all” remedies to improve women’s persistence in computer science—including the encouragement of more evidence-based instructional techniques as well as increased support for contingent faculty members who typically teach introductory courses in research universities (Jaeger & Eagan, 2011; Levin & Hernandez, 2014)—our contextualized analysis primarily underlines the need for interventions tailored to local educational settings. At Harrison, for example, computer science faculty could revisit their department’s course curricula to make sure no introductory class is covering too many disparate topics in one term, and that content more appropriate for upper-level, tenure-taught courses returns from whence it came. The Grand Lakes University computer science department could consider providing two or even three 50-minute labs per week for Mr. Metzler’s course as opposed to one, or breaking his enrollees into multiple sections so class sizes are smaller. Whatever the case, changes that increase female persistence, and decrease inequalities in the field, will most likely come from locally attuned reforms rather than national decrees.

In light of this work, as well as calls to focus research efforts on specific scientific disciplines instead of “STEM” writ large (Singer & Schweingruber, 2012), the literature would be well served by further studies seeking to better understand how local dynamics influence student experiences in other fields marked by gender, racial, and socio-economic disparities, including engineering and physics (Ferrare & Lee, 2014; Mann & DiPrete, 2013). How might other disciplines, especially those in which a previous familiarity with computers does not play such a critical role, inhere with characteristics that influence the persistence decisions of women, students of color, or first generation students, and how might such characteristics be shaped by local contexts?

Looking back to our opening qoute in which a gateway course instructor describes the popular but exclusionary image of engineers and computer scientists, we are reminded of the magnitude of the task at hand. As our findings indicate, alleviating such inequalities would require significant reforms at a number of different levels, from local classrooms, computer science departments, and institutions to the much wider and more deeply engrained sphere of popular culture. Still, we believe that theoretically and empirically informed scholarship not only raises awareness of the inequalities that continue to impede progress toward a more democratic educational system, but also marks a path forward for researchers and policymakers looking for working solutions to these challenges. As the information technology sector offers increasing numbers of skilled graduates a prestigious and lucrative place in the new economy, it is important that our efforts—continually organized, action-oriented, and engaged—keep pace with our technological innovations.

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