"I Don't Code All Day": Fitting in Computer Science When the Stereotypes Don't Fit

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ABSTRACT

Stereotypes of computer scientists are relevant to students' performance and feelings of belonging. While efforts exist to change these stereotypes, we argue that it may be possible to challenge a student's belief that stereotypes of computer scientists are relevant to whether they can become a computer scientist. In our previous work, we presented a model of five factors that influence students' decisions to major in computer science (CS). Data were collected from interviews with 31 students enrolled in introductory CS courses at two public universities in the United States. Here we elaborate on our grounded theory of one of these factors: how students assess their fit with CS. We describe how students measure their fit with CS in terms of the amount they see themselves as expressing the traits of singular focus, asocialness, competition, and maleness and how students make interpretations and decisions based upon these measurements. We found that students' interpretations were influenced by their attitudes toward the nature of stereotypes.

Keywords

Stereotypes; fit; major choice; grounded theory

1. INTRODUCTION

Enrollments in computer science (CS) are growing [29, 42], but as a field we have not made enough progress addressing the underrepresentation of women and minorities in CS [6, 24, 33]. Research to understand how students decide to major in CS [4, 5, 7, 21, 23, 26] can play an important role in identifying barriers students face and inform interventions.

This paper is an extension of our previous work [32] in which we interviewed 31 students who were enrolled in an introductory CS course at one of two large, public universities in the United States. In our previous work we developed a model of how students decided whether or not to pursue a major in CS based upon ability, fit, enjoyment, utility, and opportunity cost. The previous work developed a grounded theory [47] to model the processes by which students assessed their ability and how they used that to inform their decision about majoring in CS [32]. In the current paper, we present a grounded theory of how students assess their fit with CS. Students' assessment of their fit was nuanced, but consistently intertwined with the following stereotypes of computer scientists:

- **singularly focused** - CS requires an obsession with CS, necessarily at the exclusion of having other interests or meeting personal needs.
- **asocial** - computer scientists do not have social skills and CS requires working in isolation.
- **competitive** - CS courses (and thus potentially the field as a whole) are competitive and CS work is done individually as opposed to in collaboration with others.
- **male** - success in CS requires one to identify as male, or men are innately more talented in CS than women.

Research shows that students' stereotypes about individuals within a field and sense of belonging within that field are relevant to their interest, persistence, and performance [8, 10, 22, 30, 45, 49, 54]. While some efforts seek to change these stereotypes of computer scientists [14, 39], we recommend an additional strategy of helping students understand the stereotypes as not based upon the nature of the work in CS. This recommendation is based upon participants who expressed awareness of stereotypes that did not fit them, but were not dissuaded by these stereotypes. This is consistent with the recommendations of Ashcraft and Ashcraft [2] who recommend educating students about the ways in which the current stereotypes of computer scientists were constructed [17, 18, 19, 38].

In addition to concrete recommendations for educators (Section 8) we present a model of how students assess their fit with CS. This helps connect quantitative studies about how students decide whether or not to major in CS with education research regarding how students construct their identity and see that identity in relation to others [44]. Our work challenges the fatalism in studies showing that students who identify themselves as dissimilar to stereotypes of a field are correspondingly less interested in the field [30]. Based upon our model, it appears feasible to help students understand stereotypes as stereotypes and not as prescriptions for computer scientists.

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2. PREVIOUS RESEARCH

2.1 Research on CS Persistence and Attrition

While recent surges in enrollment [29, 42] may decrease the focus on students' decisions to major in CS, this research is still of crucial importance to making the field accessible to students who are underrepresented in CS. In the United States, it is well documented that people who identify as women, Black, Hispanic, American Indian, and/or Alaskan native are underrepresented in computing courses, degree programs, and careers [6, 24, 33]. This has motivated countless efforts to diversify computing (see [48, 56] for summaries) and research to understand barriers to students' access to computing [25, 33, 34].

Much of the research regarding students' interest in CS and how they select CS as a major has been quantitative [3, 4, 5, 7, 21, 23]. For example, a large-scale study of 1000 women found that these students' experience of social encouragement, self-perception, academic exposure, and career perception were the best predictors of their decision to pursue CS [23]. Kinnunen and Malmi identified lack of time and motivation, low comfort level in class, and prior commitment to a non-CS field as commonly cited reasons for students who dropped an introductory CS course [26]. Carter found that expectations of having to sit at a computer all day, prior interest in another major, and interest in a more "people-oriented" field were common reasons for disinterest in CS [7]. Barker and colleagues found that student-student interaction was the best predictor of students' plans to continue studying CS [3].

These findings motivate our current research to understand the mechanisms that shape these decisions. Qualitative research such as this can provide details to help educators apply the research within their own context. For example, Kinnunen and Simon [28] use grounded theory [27] to describe variation in the ways students interpret positive and negative programming experiences.

2.2 Research on Students' Belonging

Students' sense of belonging is widely recognized as relevant to persistence and engagement in academics [22, 46, 49]. The importance of belonging may be additionally influential for students who are underrepresented in the field and for students about whom negative stereotypes exist [45].

Research has consistently shown that stereotypes create barriers to access [12, 24, 45]. Stereotype threat [43, 45] describes the robust research finding that an individual's performance is depressed when poor performance on the task may be interpreted based upon a stereotype about some dimension of their identity. Cheryan and colleagues have done research on how students' interest in computing varies if they have interactions with people who fit stereotypes about computer scientists [10] or experiences within computer labs that look like stereotypical computer labs [8]. Master, Cheryan, and Meltzoff [35] argue that to increase girls' interest in CS, educational environments for CS should be redesigned to avoid current stereotypes of CS.

Ensmenger [17, 18, 19, 38] has documented the ways in which the stereotypical identity of a computer scientist has been constructed. While the work of computer scientists was originally feminized [38], it has been rebranded in ways that "reinforced the notion that there is a natural, historical, and inevitable connection between male forms of sociability and cognition and virtuoso computer programming ability." [19, p. 43]. In addition to this explicit masculine branding, Ensmenger identified that "the contemporary computer nerd is defined primarily by his consuming obsession with technology, his lack of conventional social skills, and inattention to his physical health and appearance." [19, p. 42].

Research suggests that even young children are aware of stereotypes [11], but researchers sometimes create a distinction between awareness of a stereotype and endorsement of that stereotype [12, 37, 45]. While research suggests that gaps between students' perception of themselves and scientists lead to decreased interest [30], we propose strategies that acknowledge those gaps, but encourage students to challenge the relevance of the stereotype.

2.3 Five Factors that Shape Decision to Major

In previous work [32], we identified five factors that appeared to shape students' decisions to major in CS or not:

- Their **ability** as related to CS: experience and expectations of success as CS majors
- Their **fit** between their identity and CS: the extent to which their own values and identity align with values and cultural expectations they associate with CS
- Their **enjoyment** of CS: how much they would enjoy majoring in CS
- The **utility** of CS: the extent to which CS would provide potential value to society or to them as individuals
- The **opportunity cost** associated with majoring in CS: practical constraints, as well as ways in which majoring in CS might restrict other plans

In this previous work [32], we selected a single factor, ability, and presented a grounded theory of how students assessed their ability within CS. In participants' discussion of their ability within CS, an important dimension of variability was whether or not students perceived ability within CS as innate or not. This dimension of variability aligned with Carol Dweck and colleagues' body of work that focuses extensively on students' beliefs about whether intelligence is innate [15, 55].

3. METHODS

3.1 Data Collection and Research Context

Interview data was collected in the U.S. at two large, public, research-focused universities. At University A, nine participants were recruited from UA-CS1 and eleven participants were recruited from UA-CS2. At University B, eleven participants were recruited from UB-CS1. All participants responded to a recruitment e-mail and were compensated \$15. Of these 31 students, about one third intended to major in CS, and an additional third were unsure or intended to minor, with the rest not intending to major or minor. Just over half of the students in the sample were women. At UA, women were oversampled among volunteers and at UB no screening was done. Within the paper, participants are referred to using identifiers including university and course level and a pseudonym that we attempted to match to the gender they indicated on a demographic survey.

The interviews used a semi-structured interview protocol, which affords the interviewer the flexibility to pursue unanticipated topics but does not guarantee that all participants are asked the same questions [47]. Topics included students' experiences in the current CS course, academic interests, and interest in and preconceptions of CS. Interviews lasted 30-60 minutes and were audio recorded and transcribed.

3.2 Data Analysis: Grounded Theory

We selected grounded theory as an analytic approach to understand and document our participants' process of deciding to major in CS. Previous research has used quantitative methodologies to identify patterns in students' process of deciding to major in CS [3, 4, 5, 7, 21, 23], but the patterns that can be identified in these research studies must be specified a priori. The grounded theory methodology seeks to highlight and value participants' individual experiences rather than testing a hypothesis or identifying the prevalence of a particular experience in a population. In conducting a grounded theory analysis we sought to capture the variation and themes that are present in our data and develop explanatory theories of our participants' processes of deciding to major in CS. The grounded theories developed in this project can be seen as hypotheses that attempt to explain how students decide whether or not to major in CS.

The analysis presented in this paper builds upon our original analyses [32]. We began by reading all interview transcripts and coding the transcript using open coding, which is a process of identifying noteworthy patterns and documenting instances of these patterns. Throughout the analysis we refined the operational definitions that identified what would and would not be identified as an example of each code. We clustered our approximately 75 codes into 25 categories that were then clustered to identify five factors that shaped participants' decision to major in CS: ability, fit, enjoyment, utility, and opportunity cost.

In our previous work [32], we developed a grounded theory of students' assessment of their CS ability and the process by which this shaped their decision to major in CS. We now extend this previous work to develop a complementary grounded theory of how students assess the fit between their identity and CS.

Of the codes initially believed to be relevant to students' evaluation of their fit with CS, we conducted an additional set of axial coding, with specific attention on students' assessment of their fit. In this process we identified four characteristics within the factor of fit: singular focus, asocial, competition, and male.

We generated dozens of diagrams in an effort to articulate how stereotypes, hearsay, and experiences shaped participants' assessment of their fit with CS. We evaluated the extent to which each diagram (1) captured important themes within the interviews, (2) provided an explanatory model for the process of assessing fit with CS that was consistent with our interview data, and (3) distilled this complex process of assessing fit with CS to be comprehensible outside of our research team.

Competing diagrams were refined to attempt to best capture the process present in our interview data. Our resulting model (see Figure 1) is analogous to our previous model for students' assessment of CS ability, which was despite our generation of divergent models and our initial assumption that an analogous diagram would not capture the salient themes and variation in students' assessment of their fit with CS. Both models are a variant of a traditional diagram used in some grounded theory research [47], customized to our data.

3.3 Overlap of Ability and Fit

We expect that the five factors of ability, fit, enjoyment, utility, and opportunity cost are interdependent. In particular, students' assessment of their ability likely influences their assessment of their fit with CS. For example, Linda described her assessment of whether she fits with the major as directly tied to her experience of how difficult the course was: *"I was a little bit discouraged from how difficult [inaudible] for me. It felt kind of lonesome, a little bit. I think maybe that's what I was feeling - a little bit of separation from the others, the other people. Because at end of [CS1], I was really excited and I felt like, 'Oh yeah, I can fit here.' And [CS2] is like the test: Can you really fit here? It's like another CS weed-out, and I felt like I was being weeded out and kind of thrown by the wayside." (UA_CS2_103).* This quotation provides a concrete example of how assessment of fit and ability are interdependent. We have not included ability as a fifth characteristic of fit because students' assessment of their ability has been thoroughly discussed in our previous paper [32].

3.4 Selection of Category Names

The characteristics of singularly focused, asocial, competitive, and male were selected because they were discussed throughout our interviews. In selecting the characteristic names we made the decision to have them align with our understanding of the stereotypes about computer scientists [19]. However, some of our participants identified collaboration as a requirement for CS as opposed to competition. We have decided to consistently label the characteristics with the stereotyped label (e.g., competition) rather than the non-stereotyped label (e.g., collaboration). Research has identified the ways in which stereotypes of computer scientists also include race, sexuality, and social class [2, 19]. Despite the vital importance of understanding these dimensions of the stereotypes we do not discuss them in our paper because our participants were not asked about these and did not mention them explicitly. We recognize that individuals have multiple identities and that stereotypes about different dimensions of their identities intersect and interact [1, 20].

4. THEORETICAL FRAMEWORK

In our analysis of students' assessment of their fit with CS, we did not begin with a guiding theoretical framework. The interviews illustrate a complex process by which students considered characteristics of themselves and the characteristics they perceived as being important in CS. Based on what emerged from the interviews, we found that Sfard and Prusak's narrative theory of identity [44] provides a framework and vocabulary for understanding and describing this process of assessing fit and how it relates to major choice. Within this process that our participants described, we found that whether students described particular characteristics of computer scientists as required was important. We integrate this idea with the theory from Sfard and Prusak [44] by building upon research from Dweck and Colleagues [15, 31, 35, 36].

Sfard and Prusak define identities as narratives or stories about self that an individual tells to themselves or others. Rather than being innate, these identity narratives are constructed and modified (sometimes unconsciously) through social interaction. With this narrative definition, Sfard and

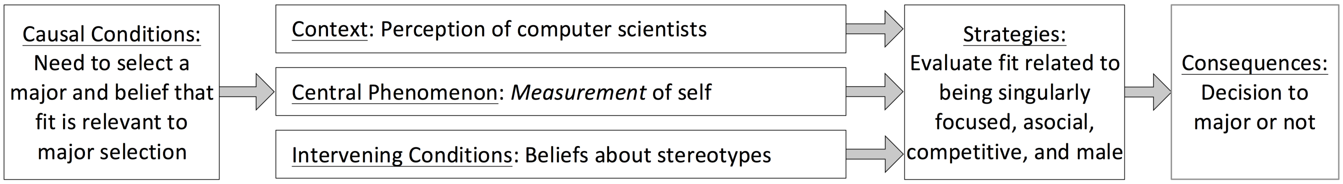

Figure 1: Diagram of grounded theory of students' assessment of fit with CS.

Prusak's theory describes how people form, modify, and express a variety of present and potential identities. Sfard and Prusak [44] also distinguish between two kinds of identities: actual and designated. An actual identity describes a person's present state, while a designated identity describes what could, at some point in the future, become part of their actual identity. Designated identities can be positive, in the sense that they reflect one's aspirations or sense of possible future selves, but they can also represent limitations on future selves or restrictions on what one can do or become. The language of "actual identity" may be misleading because it may be incorrectly interpreted as implying that there is a true identity. This would be a direct contradiction of the theory presented by Sfard and Prusak, which is that identities are socially constructed through narrative [44].

In terms of this framing, our interviews contain multiple narratives related to being or becoming a CS major or computer scientist. In the context of an interview about deciding to pursue CS, our participants' statements about the characteristics important to being a successful computer scientist can be seen as narratives about designated identities. In describing these CS designated identities, students often compared them explicitly or implicitly with their actual identities, providing some sense of the extent to which they see themselves fitting into CS.

The four characteristics of computer scientists that we highlight in this paper represent salient features of the CS designated identities described by our interviewees. Grounded in interview data, we not only detail student beliefs about these characteristics, but also propose a theory of how interest in the CS major is affected by actual and designated identities.

5. RESULTS

5.1 Overview of Model of Assessment of Fit

Figure 1 shows our grounded theory of how participants evaluated their fit with CS when deciding to major in CS or not. In the diagram we use the traditional grounded theory labels (underlined in Figure 1) [47]. Within the text below, we show these labels in parentheses. We identified the need to select a major and the belief that fit is relevant to major selection (Causal Conditions) as conditions that caused students to measure their self (Central Phenomenon, Section 5.2). The process of evaluating their fit (Strategies, Section 5.5) appeared to be shaped by three things:

- Students' assessment of self, i.e., what are the students' characteristics regarding being singularly focused, asocial, competitive, and male? (Central Phenomenon, Section 5.2)
- Students' beliefs about stereotypes, i.e., what is the relevance of stereotypes? (Intervening Conditions, Section 5.3)
- Students' perception of computer scientists, i.e., what are the characteristics of computer scientists regarding being singularly focused, asocial, competitive, and male? (Context, Section 5.4)

The outcome of students' evaluation of fit was their decision to major or not (Consequences, Section 5.6).

5.2 Central Phenomenon: Measuring Self

In this work, the central phenomenon is the student's narrative of themselves with respect to the four characteristics: singularly focused, asocial, competitive, and male. Students' narratives about themselves enable them to evaluate if they fit with their perception of the characteristics of computer scientists. We asked students to complete a demographic questionnaire, which asked them to identify their gender, but in designing the interviews did not seek to collect narratives about their actual identities related to being singularly focused, asocial, or competitive. The focus on these characteristics came out of the data analysis. Despite this, participants shared stories that included actual identities related to the four characteristics. For example, Ellie described herself as a *"people person" (UB_CS1_11).*

5.3 Intervening Conditions: Beliefs about Stereotypes

Through open coding we found that an important dimension of variation was whether or not students thought particular personal characteristics were required of computer scientists. This finding connected to the work of Dweck and colleagues (e.g., [15]), which describes students as either entity or incremental theorists. Entity theorists endorse the idea that intelligence is fixed, while incremental theorists endorse the idea that intelligence is malleable. Levy, Stroessner, and Dweck [31] generalize entity and incremental theorists as endorsing that a person's traits, and not just intelligence, are either fixed or malleable. Based upon this generalization, Levy, Stroessner, and Dweck evaluated the extent to which children with each theory engaged in social stereotyping. The researchers hypothesize that entity theorists may "believe that traits can be reliably inferred from small samples of behavior." [31, p. 1422]. This distinction between an individual's knowledge of stereotypes and their endorsement of those stereotypes is a common distinction [11, 13, 37]. The primary implication of this research is that educators should work to challenge the notion that characteristics of the CS stereotype are required by the field.

5.4 Context: Sources of Stereotypes

While students' perceptions of computer scientists are likely shaped by cultural stereotypes of computer scientists [19], we infer that participants made measurements of computer scientists through observations, information provided by others, and personal experience. The following details about the research contexts illuminates ways in which institutional structures can reinforce or dispel stereotypes.

5.4.1 Singularly Focused

Participants' appeared to measure the characteristic of computer scientists as singularly focused through observations, personal experience, and statements from friends and advisors.

- Melissa described observations of her close friends as *"doing the same thing every day, every night, and without sleep. And without eating anything." (UA_CS2_104).*
- Vanessa reported that *"And now I see why people are in lab all day" (UB_CS1_02).*
- Christine described that she heard *"Like 'oh we don't sleep' or they're like 'oh yeah we just sit in front of the computer all day.'" (UB_CS1_09).*
- In contrast, Isabella reported that the seminar leader: *"showed us that there are a lot of people who like CS, but they don't do it 24 hours, you know". (UA_CS1_009).*

Class time provided opportunities for students to interact with other students who might reinforce or challenge the stereotype of computer scientists being singularly focused. The workload expectations of the students' course or other courses within the major could also shape perception of whether being singularly focused is required.

5.4.2 Asocial

Participants measured the characteristic of asocial through observations of computer scientists and peers.

- Linda described her observation that her CS1 class is *"a very silent class"* and that there were *"not a lot of sociable people. There's definitely, there's definitely a few" (UA_CS2_103).*
- Jana characterized her family members working at a large software company by saying that *"all of them are introverts" (UA_CS2_101).*
- In contrast, Christine described the need for social and collaboration skills: *"you have to learn to work with other people because I mean the huge projects it's never like done by one person." (UB_CS1_09).*

Students' perceptions of whether CS requires being asocial may relate to the extent to which students interact within the course. At University A, students in CS1 and CS2 observe their peers during the three large lecture sessions, the one or two weekly quiz sections, and while working in the programming lab dedicated to the course. There is minimal interaction between students during the three weekly large lecture meetings. Assignments in the course are done individually and there is a strict anti-collaboration policy around submitted assignments. Students may ask questions of course staff in the programming lab and during quiz section. Students from UB had six hours of closed lab and a single hour of lecture a week. Graduate or undergraduate teaching assistants in the lab were told to encourage students to collaborate and students were allowed to pair program [51] on lab exercises, homework, and projects.

5.4.3 Competitive

Participants' measurements of the characteristic of competitive related to the structures of competition within classes and whether individuals were competitive.

- Linda expressed that the environment is *"definitely extremely competitive" (UA_CS2_103).*
- Dennis reported, *"I know that the admission rate is low for the CS dept." (UA_CS1_004).*
- Jana reported that students described her CS2 class as *"a weedout class" (UA_CS2_101).*
- In contrast, Gregory observed that his CS1 class *"always felt like the class was trying to kind of foster that interest in CS rather than - you know - weed people out of the class." (UA_CS1_007).*

Admission to the CS major is competitive at UA. Less than 25% of majors are accepted directly out of high school. Most prospective majors apply after two years of prerequisite coursework, and at the time of these interviews approximately 40% were accepted. At UB, there are two CS-related majors. One major is populated by students directly out of high school. The other major has had a competitive admissions process, but at the time of these interviews did not. When Linda discussed her difficulty finding students in her class to work with or talk to she said: *"it was either the students or it's just sort of the–the course, how it discourages collaboration on assignments ... everyone's scared of that; they won't really say what they do for their assignments. They really won't talk about it" (UA_CS2_103).* When asked how big of an impact this had on the amount of collaboration in the course, Linda said: *"I felt that was one of the main problems, ... I think it's good to make sure students aren't copying, but if those are the only assignments we get—one big one per week—and we can't work with each other really, because sharing ideas means kind of sharing code ideas, so code kind of comes up. It's just kind of scary. You don't really want to share ideas" (UA_CS2_103).* This suggests that perhaps course structure or policies could affect the perception that CS lacks collaboration.

5.4.4 Male

In our sample, only students who identified as female made comments about either the proportion of females in CS or whether one must be masculine to fit with CS.

- Xenia observed that *"there are a lot more guys" (UB_CS1_04)* in the CS major.
- Melissa observed that *"guys do perform better than girls in the CSE courses. At least [CS1] and [CS2]. And you can see that there are more guy TAs than the girl TAs. So - I think like in [CS2], I think, like more than 70%, at least that show up in the class, there are like 70% of guys." (UA_CS2_104).*

Melissa's observations were accurate that about 80% of the TAs and the students in her CS2 class were men. While participants may have been told about the gender make-up within the field or CS courses, they only reported observing the gender make-up and did not report personal experiences beyond observations of the gender make-up.

5.5 Strategies: Evaluating Fit

Students examined their fit with CS by interpreting their self-assessment of how much they reflected the characteristics of singular focus, asocial, competitive, and male relative to what they perceived as the requirements of the field of CS for these characteristics. These interpretations were shaped by students' internal beliefs about stereotypes as well as their context, such as observations in their CS courses and the experiences of their peers. To show the potential for these stereotypes to discourage participation we present examples where students assume these characteristics are required. To show narratives that may be helpful for supporting and encouraging students who perceive themselves as different from the stereotypes we present examples where students challenge or reject the requirement of these characteristics.

5.5.1 Singularly Focused

Explicit in a number of the participants' descriptions is that they believe that CS requires a singular focus. For example, Anthony, described computer scientists as needing to be *"disconnected"* from the world. Anthony expressed that there could be exceptions to this, but attributed these exceptions to differences in the difficulty of the work. He said: *"I can imagine people who are like successful in CS and they still can do good in this world. They can take care of their family and their health and lots of stuff. Just depends on how difficult the task is." (Anthony, UA_CS1_001).* Although he identified exceptions, these exceptions do not challenge the underlying requirement of being *"disconnected"* from the world when facing difficult CS tasks. Another participant, Kendra, used language such as *"can't"* and *"have to"* to describe that computer scientists *"have to be able to make it their lifestyle; can't just do it as a side thing, have to be thinking about it all the time." (UA_CS2_102).* For Anthony and Kendra, who describe the nature of the work as requiring a singular focus, the designated identity of a computer scientist was tied to being singularly focused.

In a few instances, individuals challenged the stereotypes or directly rejected them. Charles mentioned some of the stereotypes of computer scientists being singularly focused, but later he said: *"you also have to step back and just not be too stressed from it. I guess you have to be, to a degree, easy going ... You have to be able to detach yourself from your work." (UA_CS1_003).* Isabella reported that her friends questioned her: *"'CS, really? I mean isn't that you just sit down and you code for hours'"(UA_CS1_009).* She explicitly identifies this as a stereotype and says it does not describe her: *"That is kind of the stereotype of CS. They just code all day and work very hard. But you know I like working hard. But I am not, you know there are the stereotypical CS programmers. But I am not one of them. And you know I have fun, and go out and do other things. I don't code all day" (Isabella, UA_CS1_009).* Orion described how he plans to be an exception to the stereotype of a singularly-focused computer scientist: *"I don't plan on becoming the recluse that stays in the basement with high-end technology. I'm going to be the guy with the high-end technology that still goes outdoors" (UA_CS2_106).* The first set of cases (Anthony & Kendra) presented designated identities that included a singular focus as a necessary component. The second set of cases included a competing narrative to the singular focus (Charles) and two students who present a designated identity that does not conform to the stereotype (Isabella & Orion).

5.5.2 Asocial

Students connected the nature of the work of CS with being asocial or requiring a lack of a social life. Patrick said that one of the characteristics of a computer scientist is *"not having a social life so you can think about your programs all day" (UA_CS2_107).* Jana expressed that not everyone can become a computer scientist because CS requires a particular *"mental outlook" (UA_CS2_101).* She said: *"maybe that mental outlook includes them being introverts, because CS is very abstract, so maybe it's connected somehow." (Jana, UA_CS2_101).* Similarly, Linda connected the nature of CS work to being asocial: *"[CS] takes a mind that likes being with themselves sort of, because it is pretty impersonal – or very you and the computer"(UA_CS2_103).*

A few students' described concrete examples of exceptions to the stereotype of computer scientists as asocial. Brian described his CS lab as *"pretty loud" (UB_CS1_08).* When asked if he liked this, he responded: *"I really like it cause it's just more fun that way. - cause then you're talking with everybody - you know - comparing programs and stuff" (UB_CS1_08).* While Linda had expressed that the nature of CS work required being asocial, she sometimes defended the level of social interaction in CS. She reports that her roommates discouraged her from going into CS: *"they say I'm too sociable for this" (UA_CS2_103)*, but she contended that CS is *"what you make of it, based upon your personality and what you prefer" (Linda, UA_CS2_103).*

5.5.3 Competitive

Several students felt that one would need to be competitive to thrive in CS. When asked if there was anything he found unappealing about the CS major, Gregory explains his belief that as you go into higher-level CS and mathematics classes there is more competition, *"I'm sure this is a misrepresentation, but my estimation is that people are less social and a little bit more competitive. They are - that there is less that spirit of collaboration than you might find in kind of a lower level of the class. And I guess that turns me off." (UA_CS1_007).* Linda described that you can *"overcome the competition and challenge" (UA_CS2_103)*, which both endorses the expectation of competition and expresses a belief in her ability to operate within it.

Participants also described the requirement of collaboration in CS, which challenges the expectation that CS requires competition. For example, multiple students identified that a successful computer scientist must have *"communication skills" (Dennis, UA_CS1_004 and Emily, UA_CS1_005).* Noah said that a successful computer scientist has to be *"able to work in a team and communicate with people" (UA_CS2_105).* Christine expressed that a successful computer scientist needs to work with people: *"you have to learn to work with other people because I mean the huge projects it's never like done by one person." (UB_CS1_09).* Heather described CS as *"individual" (UA_CS1_008)*, but her description of a successful computer scientist shows that she recognizes the value of collaborative work in CS: *"I could see someone who is successful being able to interact with a group of people, like lead a meeting, for example. Have good ideas. Be able to communicate, be open to other ideas. Teamwork." (Heather, UA_CS1_008).*

5.5.4 Male

In our interviews, only female students mentioned how being male related to being successful in CS. Melissa was the most unambiguous in stating that it was an advantage for computer scientists to be male: *"I think just like the girls and guys have different kind of system of thinking, just like, I just think that guys are more used to thinking the way that the programming language is thinking. Like girls may like more* *of like English literature or like the other like music. And the guys more like those applications stuff like engineering, CS, or like stuff like EE. I think that is inherited. Like you are born with those characteristics." (UA_CS2_104).*

Three students at UA made statements that showed they clearly rejected the stereotype that you must be male to be successful in CS. For example: *"even though it is a male-dominated field, I feel like I have been getting along with people in that class. Most of my friends are guys in that class. (laughs) It is o.k." (Heather, UA_CS1_008).* Xenia noticed that there are more guys than girls in her class but she feels comfortable in the classroom and does not view that as a deterrent: *"my friend and I laugh about it, that's about it." (UB_CS1_04)*

5.6 Consequences: Decision to Major or Not

5.6.1 Singularly Focused

Participants connected the stereotypes of CS requiring a singular focus to their decisions to major in CS. For example, Andrew explained that CS was unappealing because *"I don't want to spend the whole day just sitting in the lab." (UB_CS1_07).* Similarly, Melissa explained: *"I am an outsider, so I think oh why are you just doing the same thing every day, every night, and without sleep. And without eating anything. It is kind of crazy." (UA_CS2_104).* Christine described how the stereotype of a singular focus and asocialness shaped her decision: *"I just think like maybe I don't get to see the sun too much and all I do is sit there and code. I'm just like doing it all on my own. That's kind of unappealing." (UB_CS1_09).*

5.6.2 Asocial

Participants linked the requirement of asocialness to their decisions to major in CS. For example, Jana had described being an introvert as part of the required *"mental outlook" (UA_CS2_101)* for a computer scientist. She explained that *"I'm not that much of an introvert"* and described that this made another major a *"much better fit" (UA_CS2_101).* Similarly, Tiffany expressed concern about the potential for social interaction: *"I don't know how much I would love working with computers exclusively or computers and a small group of people for a job. I would rather be working with more people rather than computers' (UA_CS2_111).* Ellie described CS as unappealing: *"it lacks more of that social aspect that I like a lot." (UB_CS1_11).* The stereotype was not universally discouraging, Heather described: *"Sometimes I just like working on my own, like without talking to other people, and I just get work done a lot faster." (UA_CS1_008).*

5.6.3 Competitive

Competition impacted students' interest in majoring in CS in multiple ways. When asked if there was anything he found unappealing about the CS major, Gregory explained that he expects more competition in higher level CS courses: *"And I guess that turns me off." (UA_CS1_007).* At UA the difficulty of getting into the CS major is something most students are aware of and dissuades some from applying to the major: *"After taking the course [UA CS2] and hearing about how competitive applications are and getting into the school is, I was like, 'oh okay, we know what I'm not majoring in' (laughs)" (Rachel, UA_CS2_108).*

5.6.4 Male

When asked if there were things about the CS major that did not appeal to her, Heather cited stereotypes as one negative: *"I'm not a fan of the stereotypes that people make about women in CS" (UA_CS1_008).* Heather felt that people often mentioned that she did not fit the stereotype: *"I mean every single person I have told that I am trying to major in CS has made some kind of comment about the way that they see me, and it kind of puts me off a little bit. (laughs)" (UA_CS1_008).* Despite this, Heather is planning on taking CS2 and applying to the CS major. Melissa went on at length about why *"guys do perform better than girls in the CSE courses"* and added that *"So, uh, I think if (CS2) was not in the requirements of my major, I think I won't consider to take these two courses." (UA_CS2_104).*

6. DISCUSSION

Our research reinforces previous research about the importance of students' feelings of belonging [8, 10, 22, 30, 45, 49, 50, 54]. This is particularly important for students about whom negative stereotypes exist [45] and any students who are underrepresented in CS based upon one or more dimensions of their identity. We reject assumptions that differences between a student's identities (i.e., actual identities [44]) and the stereotyped identities of computer scientists (i.e., designated identities [44]) must diminish students' interest.

Previous research [2] recommends teaching students about the development of the identity of a computer scientist, to show it is constructed rather than essential, "unmasking and raising awareness about the historical evolution of specific occupational identities." [2, p. 153].

At UA, a one-credit seminar exploring women in CS seeks to accomplish this. The course is offered to students taking CS1 or CS2 and provides an opportunity for students to visit local companies, attend research presentations, and meet current student CS majors and alumnae [16, 52]. One of the goals of the course was to: "Encourage a broad, accurate view of computer science and related fields." [53] The seminar made a point of dispelling common stereotypes about CS: "With every research visit we emphasized that computer science is more than just sitting in front of a computer all day. We felt that it was important to highlight the interactive, creative side of the computing field." [16, p. 10.905.5]

Four of our participants (Linda, Emily, Heather & Isabella) were enrolled in this seminar. Several of them mentioned it specifically when discussing stereotypes about CS.

Isabella attributed her rejection of the stereotype of singular focus as coming from information she gained in the seminar: *"This is where the seminar came in, at first I thought that wow. CS really isn't for me because all the kids that are in my [CS1] they have been programming since they were 7, they have programmed all of their lives. And like, they even do it as a hobby. And I mean I find CS fun, but I don't do it on the weekends you know. And that is o.k. And when I hit the seminar that was what I was afraid of going into CS, that I was competing against all of these people who programmed as a hobby you know. But the seminar, [the leader] showed us that there are a lot of people who like CS, but they don't do it 24 hours, you know. And they do other things and they are successful at it. It is o.k. to have other interests, and that is often a bonus to have other interests, because it opens your eyes to different things." (UA_CS1_009).* Isabella explicitly stated that the seminar has made her more interested in majoring in CS.

Heather was planning on majoring in CS and found the seminar helpful in terms of allowing her to meet more women interested in CS and to have some of her doubts about whether women can do CS addressed. People are surprised when she says she wants to major in CS and tell her that she does not fit the CS stereotype - telling her she should major in dance instead. Heather said she found the seminar useful *"because those were some of the doubts that I had myself. And it was nice to hear that other people had the same experiences, and have other people tell them that they could not be a CS major or that they would get in just because they were a woman. But when [the leaders] said 'that is not true, we do not consider that at all' that was good confirmation." (UA_CS1_008)*. When asked if the seminar had influenced her interest in majoring in CS, she replied: *"I think that has confirmed it a lot because I have seen people like myself in that class. Who are interested in, but not completely sure they want to do this. And again, they are women." (UA_CS1_008)*.

7. VALIDITY AND LIMITATIONS

Subjectivity is inherent in the process of interpretive qualitative research, but we attempted to address validity concerns in our study's analysis and presentation. All three researchers have experience teaching introductory CS courses and background in education research in CS. This meant that we were familiar with the language of CS, as well as the pedagogical context, which guided follow-up questions during interviews and aided data interpretation.

Interpretations presented here were the result of negotiations by at least two researchers who examined transcript data. In keeping with qualitative traditions, we offer the reader context and numerous quotes for our claims, allowing them to make judgments of validity. As is common with grounded theory work, our goal was not universal theory, so we make limited claims about the generalizability of our findings and the prevalence of observed phenomena. We do, however, expect that many of the complex relationships our theory describes apply to other settings.

One potential limitation was that participants were self-selected volunteers. However, the sample included roughly equal numbers of students intending to major, considering majoring or minoring, and not intending to major in CS, suggesting limited relevance of self-selection bias. A clearer limitation stems from our sole focus on the self-perceptions of students. Important as they are, we expect there are other influences on interest in majoring in CS that students are not conscious of or do not self-report for some other reason.

Finally, it should be noted that we only interviewed students who were currently taking a CS1 or CS2 course. Research has found that women who had not taken a CS course were more likely to mention a stereotype than women who had taken a CS course [9]. Thus we might expect the influence of stereotypes to be even more pronounced among that group, suggesting the importance of encouraging women to take CS courses.

8. CONCLUSION

Our previous work [32] identified five factors that students considered when deciding whether to major in CS: ability, fit, enjoyment, utility, and opportunity cost. In this paper we elaborate on how students determine their fit with CS. We identified four characteristics some students felt were required for one to have in order to fit in CS: singularly focused on CS, asocial, competitive, and male. We found that some students were able to reject stereotypes about what was required to be a computer scientist, particularly when provided examples of computer scientists who themselves did not match these stereotypes. One intervention we observed having an impact on our interviewees was the women in CS seminar [16, 52] at UA. This course was successful in showing students that stereotypes they had about CS were not requirements of the field. While this seminar was offered as a separate course, elements of the course (e.g. explicit discussion of stereotypes, outside speakers) could be integrated into introductory CS courses. CS educators may also consider modifying aspects of their course to be sure they are sending accurate messages about what is required to be in CS. Having course staff describe outside interests can dispel the image that someone who does CS has no time for or interest in anything else. Providing opportunities during class or lab for students to interact with their peers and drawing a connection to interaction in the CS workplace can show that interaction and collaboration are a part of CS. Students' experience of competition at UA could be influenced by both the competitive admissions policies and restrictive collaboration policies. This pattern, while observed within a small sample, warrants departments using caution when implementing competitive admission requirements in response to over-enrollment [29, 41, 42]. Recruiting female TAs or female guest speakers could help challenge all students' association of computer scientists as men.

Although not discussed in this paper, in our previous work [32] we found enjoyment, utility, and opportunity cost also shaped students' decision to major in CS or not (see Section 2.3). The amount each of these factors affects each person's decision will vary and interact. For example, it seems likely that the amount someone expects they would enjoy majoring in CS is impacted by both their assessment of their ability and how well they fit with their notion of who a computer scientist is. For some students, the extent to which they see CS as providing potential value to society or to themselves (i.e., utility) will be an overwhelming factor in their decision to major in CS. Exposure to CS before college and multiple pathways into the CS major are critical to assuring that the opportunity cost associated with majoring in CS is not so high to dissuade students. At Stanford, research shows that women tended to take CS late in their college career [40], suggesting that it is important to get students who are underrepresented in CS to try it early.

One future direction would be to use our findings to inform a quantitative study to further validate causal relationships and document the prevalence of various beliefs and experiences. Our hope is that our work will directly inform the design and validation of interventions to help potential CS students make informed major choices.

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10. REFERENCES

[1] J. Acker. Inequality regimes gender, class, and race in organizations. *Gender & society*, 20(4):441–464, 2006.

[2] K. L. Ashcraft and C. Ashcraft. Breaking the "glass slipper": What diversity interventions can learn from the historical evolution of occupational identity in ICT and commercial aviation. In *Connecting women*, pages 137–155. Springer, 2015.

[3] L. J. Barker, C. McDowell, and K. Kalahar. Exploring factors that influence computer science introductory course students to persist in the major. In *ACM SIGCSE Bulletin*, volume 41, pages 153–157. ACM, 2009.

[4] S. Beyer, K. Rynes, and S. Haller. Deterrents to women taking computer science courses. *Technology and Society Magazine, IEEE*, 23(1):21–28, 2004.

[5] R. Boyle, J. Carter, and M. Clark. What makes them succeed? Entry, progression and graduation in computer science. *Journal of Further and Higher Education*, 26(1):3–18, 2002.

[6] T. Camp. Computing, we have a problem.... *ACM Inroads*, 3(4):34–40, 2012.

[7] L. Carter. Why students with an apparent aptitude for computer science don't choose to major in computer science. *ACM SIGCSE Bulletin*, 38(1):27–31, 2006.

[8] S. Cheryan, V. C. Plaut, P. G. Davies, and C. M. Steele. Ambient belonging: how stereotypical cues impact gender participation in computer science. *Journal of personality and social psychology*, 97(6):1045, 2009.

[9] S. Cheryan, V. C. Plaut, C. Handron, and L. Hudson. The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women. *Sex roles*, 69(1-2):58–71, 2013.

[10] S. Cheryan, J. O. Siy, M. Vichayapai, B. J. Drury, and S. Kim. Do female and male role models who embody stem stereotypes hinder women's anticipated success in stem? *Social Psychological and Personality Science*, 2(6):656–664, 2011.

[11] D. Cvencek, A. N. Meltzoff, and A. G. Greenwald. Math–gender stereotypes in elementary school children. *Child development*, 82(3):766–779, 2011.

[12] D. Cvencek, N. S. Nasir, K. O'Connor, S. Wischnia, and A. N. Meltzoff. The development of math–race stereotypes:"they say chinese people are the best at math". *Journal of Research on Adolescence*, 25(4):630–637, 2015.

[13] P. G. Devine. Stereotypes and prejudice: their automatic and controlled components. *Journal of personality and social psychology*, 56(1):5, 1989.

[14] J. D'Onfro. *How this Googler is trying to shake up Hollywood's idea of who an 'engineer' is*, 2015. http://www.businessinsider.com/julie-ann-crommett-cs-in-the-media-2015-10.

[15] C. S. Dweck and E. L. Leggett. A social-cognitive approach to motivation and personality. *Psychological review*, 95(2):256, 1988.

[16] C. Eney and C. Hoyer. Making a difference on $10 a day: Creating a 'women in cse' seminar linked to cs1. In *Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition*, pages 10.905.1–10.905.10. ASEE, 2005.

[17] N. L. Ensmenger. Letting the "computer boys" take over: Technology and the politics of organizational transformation. *International Review of Social History*, 48(S11):153–180, 2003.

[18] N. L. Ensmenger. *The computer boys take over: Computers, programmers, and the politics of technical expertise*. Mit Press, 2012.

[19] N. L. Ensmenger. Beards, sandals, and other signs of rugged individualism: Masculine culture within the computing professions. *Osiris*, 30(1):38–65, 2015.

[20] S. Fenstermaker and C. West. *Doing gender, doing difference: Inequality, power, and institutional change*. Psychology Press, 2002.

[21] J. Gal-Ezer, D. Shahak, and E. Zur. Computer science issues in high school: gender and more.... In *ACM SIGCSE Bulletin*, volume 41, pages 278–282. ACM, 2009.

[22] C. Goodenow. Classroom belonging among early adolescent students: relationships to motivation and achievement. *The Journal of Early Adolescence*, 13(1):21–43, 1993.

[23] Google for Education. *Women Who Choose Computer Science - What Really Matters*, 2014. https://docs.google.com/file/d/0B-E2rcvhnlQ_a1Q4VUxWQ2dtTHM/edit.

[24] Google for Education. *Images of Computer Science: Perceptions Among Students, Parents and Educators in the U.S.*, 2015. https://services.google.com/fh/files/misc/images-of-computer-science-report.pdf.

[25] Google for Education. *Searching for Computer Science: Access and Barriers in U.S. K-12 Education*, 2015. https://services.google.com/fh/files/misc/searching-for-computer-science_report.pdf.

[26] P. Kinnunen and L. Malmi. Why students drop out cs1 course? In *Proceedings of the second international workshop on Computing education research*, pages 97–108. ACM, 2006.

[27] P. Kinnunen and B. Simon. Building theory about computing education phenomena: a discussion of grounded theory. In *Proceedings of the 10th Koli Calling International Conference on Computing Education Research*, pages 37–42. ACM, 2010.

[28] P. Kinnunen and B. Simon. My program is ok–am i? computing freshmen's experiences of doing programming assignments. *Computer Science Education*, 22(1):1–28, 2012.

[29] J. Kurose. Booming undergraduate enrollments: a wave or a sea change? *ACM Inroads*, 6(4):105–106, 2015.

[30] J. D. Lee. Which kids can "become" scientists? Effects of gender, self-concepts, and perceptions of scientists. *Social Psychology Quarterly*, pages 199–219, 1998.

[31] S. R. Levy, S. J. Stroessner, and C. S. Dweck. Stereotype formation and endorsement: The role of implicit theories. *Journal of Personality and Social Psychology*, 74(6):1421, 1998.

[32] C. M. Lewis, K. Yasuhara, and R. E. Anderson. Deciding to major in computer science: A grounded theory of students' self-assessment of ability. In *Proceedings of the Seventh International Workshop on Computing Education Research*, ICER '11, pages 3–10, New York, NY, USA, 2011. ACM.

[33] J. Margolis, R. Estrella, J. Goode, J. J. Holme, and K. Nao. *Stuck in the shallow end: Education, race, and computing*. MIT Press, 2010.

[34] J. Margolis and A. Fisher. *Unlocking the clubhouse: Women in computing*. MIT press, 2003.

[35] A. Master, S. Cheryan, and A. N. Meltzoff. Computing whether she belongs: Stereotypes undermine girls' interest and sense of belonging in computer science. *Journal of Educational Psychology*, 108(3):424–437, 2016.

[36] A. Master, E. M. Markman, and C. S. Dweck. Thinking in categories or along a continuum: Consequences for children's social judgments. *Child development*, 83(4):1145–1163, 2012.

[37] C. McKown and M. J. Strambler. Developmental antecedents and social and academic consequences of stereotype-consciousness in middle childhood. *Child Development*, 80(6):1643–1659, 2009.

[38] T. J. Misa. *Gender codes: Why women are leaving computing*. John Wiley & Sons, 2011.

[39] National Center for Women and Information Technology and Televisa Foundation. *TECHNOLOchicas*, 2015. technolochicas.org.

[40] K. Redmond, S. Evans, and M. Sahami. A large-scale quantitative study of women in computer science at Stanford University. In *Proceeding of the 44th ACM Technical Symposium on Computer Science Education*, SIGCSE '13, pages 439–444, New York, NY, USA, 2013. ACM.

[41] E. Roberts. *A History of Capacity Challenges in Computer Science*, 2016. http://cs.stanford.edu/people/eroberts/CSCapacity.pdf.

[42] E. S. Roberts. Meeting the challenges of rising enrollments. *ACM Inroads*, 2(3):4–6, 2011.

[43] T. Schmader, M. Johns, and C. Forbes. An integrated process model of stereotype threat effects on performance. *Psychological review*, 115(2):336, 2008.

[44] A. Sfard and A. Prusak. Telling identities: In search of an analytic tool for investigating learning as a culturally shaped activity. *Educational researcher*, 34(4):14–22, 2005.

[45] C. M. Steele. A threat in the air: How stereotypes shape intellectual identity and performance. *American psychologist*, 52(6):613, 1997.

[46] J. Stout and B. Tamer. Collaborative learning eliminates the negative impact of gender stereotypes on women's self-concept. In *Proceedings for the Annual Meeting of the American Society for Engineering Education.*, 2016.

[47] A. Strauss, J. Corbin, et al. *Basics of qualitative research*, volume 15. Newbury Park, CA: Sage, 1990.

[48] The Coalition to Diversify Computing. *Resources*. http://www.cdc-computing.org/resources/.

[49] V. Tinto. *Leaving college: Rethinking the causes and cures of student attrition*. ERIC, 1987.

[50] N. Veilleux, R. Bates, C. Allendoerfer, D. Jones, J. Crawford, and T. Floyd Smith. The relationship between belonging and ability in computer science. In *Proceeding of the 44th ACM Technical Symposium on Computer Science Education*, SIGCSE '13, pages 65–70, New York, NY, USA, 2013. ACM.

[51] L. Williams, R. R. Kessler, W. Cunningham, and R. Jeffries. Strengthening the case for pair programming. *IEEE software*, 17(4):19, 2000.

[52] *Women In Computing Seminar*. http://courses.cs.washington.edu/courses/cse190a/.

[53] *Women In Computing Seminar Syllabus*, 2009. http://courses.cs.washington.edu/education/courses/cse190a/09au/190a_syllabus_au09.doc.

[54] D. Yeager, G. Walton, and G. L. Cohen. Addressing achievement gaps with psychological interventions. *Phi Delta Kappan*, 94(5):62–65, 2013.

[55] D. S. Yeager, R. Johnson, B. J. Spitzer, K. H. Trzesniewski, J. Powers, and C. S. Dweck. The far-reaching effects of believing people can change: Implicit theories of personality shape stress, health, and achievement during adolescence. *Journal of Personality and Social Psychology*, 106(6):867, 2014.

[56] *YesWeCode*, 2014. http://www.yeswecode.org/.