"I Wish that I Belonged More in this Whole Engineering Group:" Achieving Individual Diversity

CYNTHIA E. FOOR
Research Institute for STEM Education
University of Oklahoma

SUSAN E. WALDEN
Research Institute for STEM Education
University of Oklahoma

DEBORAH A. TRYTTEN
School of Computer Science
University of Oklahoma

ABSTRACT

Engineers need a breadth of experience to enrich the gene pool of ideas from which elegant engineering solutions can be drawn, called "individual diversity." While performing large ethnographic research studies where hundreds of engineering students were interviewed, we interviewed Inez, a student that epitomizes individual diversity. Inez is unlike most engineers: she is female, multi-minority, and from a socio-economically disadvantaged background. Inez's story is told here using "ethnography of the particular," where the story of a single individual is explored. Inez has persevered through challenges posed by her lack of familiarity with the culture of engineering, her weak high school preparation, and her feelings of being an outsider in engineering. Inez's story demonstrates that the playing field in engineering is still not level, particularly for socio-economically disadvantaged students. Her story provides a poignant example of the impact of five of Conefrey's cultural myths of science.

Keywords: culture of engineering, inclusion, individual diversity

I. INTRODUCTION

William A. Wulf, President of the National Academy of Engineering, recently called for diversity in engineering in broad terms:

> When I speak of diversity, I mean the kind of inclusion you probably thought of instantly, that is, appropriate representation of women and underrepresented minorities. But my idea of diversity also includes the notion of *individual diversity*, that is, the breadth of experience of a single individual [1].

He goes on to frame an eloquent and impassioned argument for inclusion. He equates different life experiences as the gene pool out of which the most creative and elegant engineering solutions are born. He sees the quality of engineering as directly affected by the diversity of this gene pool.

In spite of efforts to broaden participation in science, technology, engineering, and mathematics (STEM), these fields are still very much the domain of the entitled [2]. Students who arrive at college ready to take calculus, or better yet, with some experience with calculus, have much higher retention rates in engineering [3]. Students who arrive at college without this advantage start out behind in curricula packed with required and sequenced courses that cannot be started until the student has begun calculus. In addition to academic preparation, students come to college with attitudes and expectations developed as a result of their experiences in the contexts of their families, communities, and economic situations. Simply put, a student who comes from an economically disadvantaged background outside the dominant culture and who attended a resource-poor high school does not have the same odds of contributing to the gene pool in engineering as a student from a family within the dominant culture of median or above median means, and attended a resource-rich school district. Because of this, engineering suffers the loss of individual diversity as defined by Wulf.

Since 2003, we have interviewed college students majoring in engineering, compiling and analyzing the stories of many successful engineering students, including Inez (not her real name). Inez is unlike the majority of engineering students. If the historical, mythical norm of engineering is that of the high-achieving, elite, white male, then an average-achieving, first generation college attending, economically-disadvantaged, multi-minority female is truly different. In short, she is one representation of the individual diversity of experience. Additionally, she tells an inspiring story of the strength, determination, and courage that she has called upon to persevere to become an engineer. Despite the progress of the last 30 years, her story demonstrates that success in engineering is still not pursued on a level field.

Inez speaks from the margins of that engineering playing field. As an outsider, she offers a view that can be painful for those inside to hear. According to LeCompte [4], the words of the silenced shine a sometimes unflattering light on existing social and institutional structures and hierarchies of power that are invisible to those in the mainstream. Her voice, and others like her, can be muted by the disenfranchisement that comes from inexperience with the culture of academia. At the end of the interview, on the verge of tears, Inez reflected on her experience in engineering education.

> Interviewer: Is there anything else that you want to add about your experiences here? …

Inez: I just wish that I belonged more in this whole engineering group, with the students and the teachers. I never got that feeling. It might be me, I don't know.

Inez offers us powerful insight into the experience of the other. Her story deserves to be told and engineering educators and school administrators need to hear her.

II. Research Methodology

As part of investigating factors contributing to undergraduate engineering student and program success, hundreds of undergraduate engineering and physics majors were interviewed. The one- to two-hour semi-structured interviews included engineering majors (chemical engineering, computer engineering, computer science, electrical engineering, engineering physics, and industrial engineering) and physics majors attending four large, comprehensive research institutions in the United States. The semi-structured interview protocol allowed the interviewer to augment standardized questions with additional probes as needed. Students were asked questions which encouraged them to describe their educational background, family life, and experiences in college. Interviews were transcribed and reviewed for accuracy and removal of identifying information. In most of the research coming from this project, the transcripts were coded using NVivo qualitative analysis software [5] and the patterns of response were aggregated to examine traditional research questions [6–11].

This work is different. It is not constrained by the original research questions, but rather exploits the power of qualitative research. An advantage of qualitative research is having the design flexibility to respond to patterns or experiences that arise from the data as part of the discovery process [12]. The primary source of data for this paper is a single interview or what Plummer [13], refers to as a "human document," an account of a single individual's experiences, which reveals the individual's actions as a participant in a society. From this human document, we will construct a narrative portrait to tell the story of this individual and her experiences within the engineering education system. In turn, her experiences provide a lens through which we examine the broader impact of STEM culture on individual diversity.

Narrative is a means through which those who have been historically marginalized can be heard [4]. By extracting a single individual from a large ethnographic study similar to those used in seminal works on attrition from STEM fields [14, 15], we create "an ethnography of the particular" [16]. This approach does not examine the institutional politics for themselves but rather the effects of these politics on everyday life and the ways power is experienced by an individual. This "intimate view" [17] allows us to see the larger social and cultural forces operating in the society through the eyes of one individual [18].

Narrative as a research methodology has not been used extensively in engineering education; however, it has firm roots in the social sciences [12, 19, 20]. A precedent for using narrative composites in engineering education research exists in Felder's work [21–26]. His work differs from ours in that his students are fictionalized composites, instead of real individuals with concealed identities like Inez.

Using surveys with large sample sizes, null hypotheses, and the expectation of statistical significance cannot meaningfully describe marginalized individual's experiences. In fact, the preference for statistical data over research techniques like narrative can be a marginalizing factor on its own accord [27]. For example, many schools measure retention by the number of first-time, full-time students that graduate from the institution within six years. This definition of retention is used in some published institutional rankings, which contribute to institutional prestige. Using this definition encourages institutions that want to improve their prestige to focus on the needs of first-time, full-time students. This way of measuring retention and university programs designed to increase retention statistics can be instruments of marginalization for non-traditional students with different needs. In other words, while statistics may be unbiased in the mathematical sense, they may not be unbiased in the human sense.

It may seem uncomfortable to focus attention on someone who is undeniably an outlier, rather than focusing on the majority. Mathematicians designed robust statistics, after all, in such a way that a single outlier cannot alter the final conclusion. Outliers like Inez, however, are the very people that we need to attract and retain in engineering if we want to diversify our intellectual gene pool. We cannot wait for the accumulation of a statistically significant sample of people like Inez to learn from her experiences. First, we are unlikely to attract and retain a substantial cadre of these students without understanding their experiences. Second, as Wulf points out, engineering needs the contributions these students will bring now [1]. Instead, we must listen to these hidden and experientially diverse people one story at a time using research methodologies that are appropriate to the task.

The conventions used in quoting participants and the interviewer in this document are as follows. Quotes from Inez and comparator students are presented prefixed by the student designation and a colon. When the interviewer's question is necessary for comprehension, it is prefixed by "Interviewer:". Words in square brackets are added by the researchers to clarify context. Words in curly brackets are used to conceal information which might diminish participant anonymity, for example, {high school} would replace the name of a specific high school. Words in parentheses represent non-verbal participant responses, such as laughter or a pause. Ellipses are used to indicate that irrelevant words or sentences have been removed.

III. Critical Cultural Theory

Critical cultural theory views culture as a historically generated human process not a given. Cultural reproduction theories are a type of critical cultural theory that view educational institutions as a major force in the construction and transmission of gender, race, and class stratification [20, 28]. Other major forces include family, religion, and the state. One of the leading theorists of inequality in education is Pierre Bourdieu. Bourdieu [29, 30] suggests that educational success includes a whole range of cultural behaviors that extend beyond the cognitive to the ability to play the game of social interaction within a specific social space. The cultural rules which govern social spaces reflect and sustain the ideologies and sensibilities of the dominant class. In the U.S., those sensibilities are white, male, Christian, heterosexual, married, and middle-class [2]. Distinctive cultural knowledge of each social class, such as skills, manners, norms, dress, style of interaction, and linguistic facility, is transmitted to younger generations by their families. While each

person obtains their own class' cultural knowledge, it is the cultural knowledge of the dominant class that prevails and frames the terms of interaction within educational settings. For example, many assumptions about a person are made based on dialect. A person who speaks a southern U.S. dialect of English is treated differently than one that speaks a northeastern U.S. dialect of English. It is not an accident that the anchors for the national television news all speak the same dialect of English, independent of their place of origin.

Bourdieu defines social classes as "sets of agents" who occupy similar positions, and "who being placed in similar conditions and subjected to similar conditionings, have every likelihood of having similar dispositions and interests and adopting similar stances" [30]. Class involves one's behavior, basic assumptions about life, one's experiences which validate assumptions and expectations [31, 32]. For Bourdieu then, class becomes the way you see the world and your place in it [29, 30].

As McIlwee and Robinson [33] suggest, to be an engineer is to look like an engineer, talk like an engineer and act like an engineer. The processes of becoming an engineer, as well as the being and doing of engineering, have a gendered, raced, and classed recent history: male, white, and privileged [34–38]. For members of the dominant class and members of non-dominant classes who have internalized dominant ideologies, this history and its effects can be hard to see. For example, the frequency with which profanity, semi-sexual double-entendre, and violent metaphors are used by faculty and male students to communicate in the engineering classroom can contribute to the hostile climate in engineering experienced by female students [39]. While instructors and students using these communication devices are probably not purposefully trying to make non-participating students feel uncomfortable, this can be an unintended result.

Students born and raised in the dominant culture have been exposed to and understand academic expectations: the educational system is constructed to reward their accumulated advantage. These students have learned to succeed in the educational system through advantages derived from their parent's investments in them, such as hiring academic tutors, paying for college admission test preparation classes, and sending them to summer science camps. The student quoted below is one of two comparator students, both Caucasian resource-advantaged females, who are also engineering majors. We selected these students as comparators because they are exemplars of students at the other end of the resource spectrum.

> Comparator: I used to be really interested in history of science type stuff. I used to read a lot of things of old texts and things, I've read Newton's *Principia* and just a lot of stuff…
>
> Interviewer: …What was their [your parents] input into your future career?
>
> Comparator: Ah, definitely heavy. (laughs) Heavy on engineering. At one point, I even wavered into going into math, and my dad said, 'No, no, no.' (Bigger laughs) … He really pushed me into engineering. I think, he knows that I can do it, and he doesn't want to see me give up, that kind of thing… They always heavily pushed me to do science. I think they realized that I really liked it when I was young, And, you know, they did everything they could. Bought me all the little science books and (laughs) telescopes and things, and chemistry sets and all that and (laughs) really tried to push me into science, I think.

Like the comparator's parents, Inez's parents also tried to provide her with appropriate cultural capital. They had a computer in the house, although Inez's experience with it was less than ideal.

> Inez: My first experience with computers was … in first or second grade. We had a computer in my house. I don't know if it worked, or if it didn't. I would just sit and type on it. I would ask it questions and pretend like it responded to me. And I would fool around with it. I don't know, I thought it was talking to me, but that's my first experience with computers.

These advantages continually accrue. Students with higher college admission test scores obtain more scholarships, which makes it possible for them to focus on academics instead of work, which makes it possible for them to attract the attention of faculty, which makes it possible for them to get a research assistantship which leads to publication of their work and even more advantages. Advantages beget advantages [40]. Students of lesser socio-economic means have not had the benefit of these specific investments and are often viewed as different, difficult, and problematic by teachers and administrators who have internalized the dominant sensibility. Mehan [20] explains:

> Students from the dominant class, by virtue of a certain linguistic and cultural competence acquired through family socialization, are provided the means of appropriating success in school. Children who read good books, visit museums, attend concerts, and go to the theater acquire an ease–a familiarity–with the dominant culture that the educational system implicitly requires of its students for academic attainment. Schools and other symbolic institutions contribute to the reproduction of inequality by devising a curriculum that rewards the 'cultural capital' of the dominant classes and systematically devalues that of the lower classes.

The comparator quote below demonstrates the differences in accumulation of advantages from greater opportunities. The fact that these advantages might have been available, in part, as a result of race or ethnicity is not fore grounded in this student's mind.

> Interviewer: And describe how you think your ethnicity may have affected your academic choices.
>
> Comparator: I don't think that ethnicity has anything to do with it. I think I have been very fortunate to go to good schools. When I was young in preschool and kindergarten, instead of just going to a regular daycare my parents put us in a Montessori school. I really, really think that made a big difference on my academics because I was in Montessori school until the second grade. In second grade I went to the public schools. It made such a huge difference. I was so far ahead of the other students. And then also when my mom moves to {suburb of large city}, right next to {large

government installation}, I think {suburb of large city high school name} helped me out a lot. It's a private school. We had maybe 25 people tied for valedictorian that had perfect grade points. It is just real competitive. Being in those classes helps a lot. I don't think that ethnicity has so much to do with it.

Interviewer: Okay. So what brought you to college?

Comparator: It was pretty much a given. Growing up it was never question. Yes, I am going to college. It is just a question of where.

A student's ability to understand the rules and play the game is a result of accumulations of what Bourdieu calls capital. Bourdieu identifies three types of capital. Social capital is the accumulation of resources based on networking and personal relationships; cultural capital is characterized as certain forms of knowledge, education or skill; and symbolic capital is explained as prestige that accumulates as a result of possessing more cultural capital relative to another. An example of social capital in engineering education is having a parent who is able to forward their child's resume for a summer internship to a friend working at a company that hires engineers. Examples of cultural capital include knowing how to study, to write a cover letter to go with a resume, or to get a haircut and wear a plain dark suit and white shirt when interviewing for a job. The prestige of a degree from an Ivy League institution, relative to a typical state institution is an example of symbolic capital. While students earn similar degrees from both types of institutions, the symbolism of the Ivy League degree carries cultural weight. Consider the experience of the comparator student below:

Interviewer: How did you get, uh, connected with that job?

Comparator: Ah, my dad actually is friends with the plant manager. So, it kinda worked out well. (laughs) I guess, he got to thinking one day, and he said, 'Oh yeah, that's right. You are an {engineering major}, aren't you?' (laughs) So I, I interviewed out there and, I really do, I like it out there; it's a lot of fun.

Unlike our comparator, Inez did not have appropriate social, nor cultural capital.

Interviewer: So I got the impression earlier that the {institution} has an office that is specific to co-ops and internships through the {institution}… Did you talk to them at all before your sophomore or junior year?

Inez: No. They would always come in {freshman orientation class} and talk, but they made it seem to me that I had to have a good grade point average, and I was right there. 2.0. No one was going to pick me up with this. And um, I really didn't say anything to anybody. Later on, like three years later, I realized I could have co-oped and someone would have picked me up with a 2.0. And they don't mention that at all. So.

Inez's lack of knowledge regarding the cooperative education reflects a second concept important for our understanding: habitus. Habitus can be thought of as the internalized set of experiences, outlooks, and beliefs that individuals accumulate from their immediate environment. The habitus of students from the non-dominant culture contains only rudimentary knowledge of the dominant culture. In other words, students from the non-dominant culture do not know how to play the game of academia as well. Academia considers the ability to play the game to be the responsibility of the non-dominant who are expected to stretch out and bridge the gap between the experiences of their lives and those of the dominant. According to Lorde, in order for non-dominant students to survive in the dominant culture they have to be the watchers to become familiar with the language and customs of the dominant [41]. Members of the dominant culture have no burden to learn the language and customs of any non-dominant culture. The critical cultural theory concepts of capital and habitus provide a framework for understanding Inez's experiences in engineering education.

IV. Results

A. Inez as an Engineer

We have already described this student as an extreme case of the other with little social, symbolic, or cultural capital. On paper, Inez is an average-achieving, first generation college attending, multi-minority female who epitomizes the diverse student Wulf wants added to the engineering gene pool. Far from being a passive victim of deterministic social structure, Inez is actively attempting to achieve her educational and professional aspirations. In person, she is an inspirational story of perseverance, creativity, motivation, and dedication—the essential qualities of a good engineer. Inez has already had an experience parallel to Wulf's "moment of creativity" that hooked him on engineering [1].

Inez: My boyfriend's mom got her kitchen redone, and I was there during the process. They had the sink and right next to the sink was a counter and then the refrigerator and then the stove. I was like, 'Why are you putting the refrigerator there? That's not going to be really convenient for her to go from the stove to the sink.' He told his Mom and they made the change, and now it works out a whole lot better for them…

Interviewer: Has your interest in {engineering major} increased or decreased?

Inez: Increased, definitely increased. For example, the kitchen. I enjoyed being able to say that and it be something they had not realized. I don't know if it is just me, or they just really didn't think about it. I don't know. I enjoyed that.

Inez wants to be an engineer. She sees engineering as enjoyable and productive work. She sees engineering as prestigious and desires the symbolic capital that comes from being an engineer. Her determination to be successful in engineering is demonstrated throughout her interview, particularly in the passages below.

Interviewer: When did you decide you wanted to be a {discipline} engineering major?

Inez: When I figured out that I couldn't go into {a different engineering major}, because of the chemistry thing. I was

like, 'What am I going to do?' I have taken all of these science and math courses and I am not going to go down because that is a waste of all of that stuff. I didn't want easier courses just to get the grades. I wanted to do something that I liked. I couldn't go up because that was going to be probably more chemistry and biology. I was like 'What else can I do that would interest me?'

Interviewer: What do you mean 'down' and 'up'?

Inez: I think that's wrong really, of me to say, that's how we [engineers] refer to business classes and general studies and stuff like that. It's not as hard as engineering. And after engineering, there is medical… I kind of think that engineering is in the middle. I didn't want to leave engineering to get better grades. I wanted to enjoy what I was doing. And I knew engineering was what I wanted to do. And everyone said to switch majors if I am not doing good. I was like 'No. It's not about doing good.' It's more about what I want to do. And I enjoy what I am doing.

Inez's determination to pursue engineering is unchanged by the perception of others that she is not good enough to be an engineer.

Inez: Like my advisor, I really don't think he feels I should be an engineer. It doesn't matter to me because I like it and this is what I'm going to do. There is nothing else that I want to do, and so I'm going to make it work…

Interviewer: So what has kept you in the program and kept you going? You are just about done, so you are successful here?

Inez: Because I like what I do and I enjoy it. I'm not going to quit it because other people don't think that I'm doing good or don't think that I should be doing it. My parents are proud of me, everyone is proud of me back home. So I'm going to stick with it. I'm proud of myself, even if others don't think I can.

Even though Inez has the desire to be an engineer, and values the symbolic capital which accrues to the profession of engineering, the absence of cultural and social capital makes it difficult for Inez to be accepted by others as an engineer.

Next we describe the sources of cultural and social capital which Inez brought with her to college and her descriptions and perceptions of their impact on her experience. Then we will present details of her college academic experience, and finally conclude with her description of the marginalization that has been a consequence of her journey through the mine field of accumulated disadvantage.

B. Inez's Background

Inez grew up in a small town with fewer than 10,000 residents whose economy and population drastically fell with the collapse of the region's sustaining industry. The town is predominately white. Most citizens live in segregated neighborhoods. Unemployment is higher than the national and state averages, while the county's median family income is significantly lower than the U.S. average. Access to social and cultural capital is limited in this environment. Typical jobs are found in educational or service occupations. Employed individuals are likely to commute almost 30 minutes each way to work. Inez's parents' occupations reflect this trend.

Inez: My Mom is a {health worker}. She came over from {country of origin}…and got her GED, went through community college, and struggled really hard to get to where she is now. She's the supporter of my family. My Dad was in the {military branch} for awhile, but now he is into sales, he sells cars.

Inez's high school graduating class consisted of less than 100 students. The percent of non-white students in the school is higher than the state average. Nearly half of the students in her school qualify for free or reduced price lunch. Overall, her school's performance on a state-wide mandated, high school mathematics achievement test showed the fraction of students scoring proficient or better is higher than the state average. However, a significant achievement gap exists among students of different ethnic and socio-economic backgrounds. Overall her high school's students' performance on the reading test was at the state average. Results from the writing test fell below the state average; in addition, both of these tests also show significant achievement gaps among the students [42]. Higher education has not been attained by many of her town's residents. According to the 2000 U.S. census data, only 15.6 percent of the population over the age of 25 had a bachelor's degree or higher. Only 4.6 percent of the population over the age of 25 had a graduate or professional degree. Few role models with symbolic capital of a professional degree are available to students in this environment.

Inez is very cognizant that the socio-economic circumstances of one's community and family directly impacts one's opportunity, not just to attend college, but also what degree one can pursue. She also recognizes that her socio-economic circumstances mark her as different. When asked the question why women do not pursue engineering degrees, her answer did not contain any of the usual cultural reasons such as appropriate gender roles, enculturation, innate mathematical ability, etc. Her response focused exclusively on socio-economic circumstances which mark her as an outsider; not from a gendered perspective, but from a class perspective.

Inez: I can only speak from what my group of friends thinks. My opinion is very biased because where I grew up is very different. It's hard work and we have to work. Money wise. We don't have money. Even though people may think I have money because my Mom is a {health worker}, there are certain situations of my family life that people do not know about that cause us not to have money. Therefore I have to work.

She calls upon the experience of a friend who majored in communications as an example of why someone would avoid a more time consuming major such as engineering.

Inez: So my one friend had to work to pay for school. Of course she got some aid, but that doesn't compare with how much you have to work. She majored in communications. It's not really hard. It's not really time consuming. It might be hard, but it is not time consuming.

When pressed to explain what she meant by "where I grew up was different," she clarified by providing a description of her non-affluent community as a "bad type" and how being from such a community without a strong support system would prevent one from considering such a difficult major.

> Inez: Lots of drugs and violence. Our downtown area is being knocked down, so we are trying to rebuild right now, but it's like most of us can say we are all depressed. I went to school depressed and having hard classes doesn't work unless you have a strong background. My whole family was behind me. But in my community, that wasn't there for some people. They don't have strong families.

Following this same logic grounded in economics, not innate ability, she suggests that more women choose her particular engineering major (a question asked of all interviewees) because "it probably isn't the hardest."

Inez suggests that her socio-economic position is at the heart of her experience. While race and gender reflect her "visible minority" status, we believe she would say that her lack of financial resources has impacted her college experience to the greatest degree. She did not apply for nor receive any minority scholarships from her institution. Inez says: "I don't know if {university} does that or not." This statement reflects several issues: naiveté about college preparation and admissions, inadequate high school advising, and a general lack of social capital. She, in hindsight, seems to understand that now. When asked "what advice would you give incoming freshman?" her very first response after a long pause was "I would tell them that they don't *have* to get a job."

The comparator student, however, possessed knowledge as a result of social and cultural capital to understand the value of a good scholarship package prior to going to college, and to apply for scholarships and to research and compare programs.

> Comparator: … I got a really, really good scholarship package here, … and that's basically why I chose it. You know, I could either pay to go to school somewhere else or stay here and be close to my family and basically go for free, so … (laughs)… I mean, it's kind of silly to pay for it when you don't really have to… And we have such a great school here, too. You know, at first I thought, '{school name}, I don't wanna stay in {state name} and go to engineering school,' (laughs) you know. But I did so much research and, about {school name} and I was impressed with their engineering program.

Inez did receive a scholarship from a private source, a graduate from her high school who provides scholarships to students from that school who intend to major in the sciences. According to Inez, "he is an engineer working in {different state} now. I guess he is a billionaire…" Inez must have had adequate high school grades to qualify for this scholarship. However, she struggled with the transition to college.

> Inez: I got homesick. My first semester, I had headaches every day. I went home during the week. My dad would come and pick me up. My brother lives in {nearby town}, which is ten minutes away, and I would go over there a lot. I was very depressed.…I was scared and I didn't have any friends.

Her first year grades fell below the predetermined minimum and she lost the scholarship. The resulting hardships, strain on study time, inability to network and general stress meeting financial obligations are heard in her responses.

> Interviewer: About how many hours a week are you working?
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> Inez: I've had to cut it down since it is my second to last semester and I want my grades to be good. Last year I was working about 30 hours a week with 5 classes. And I had to do it because I had to pay rent. My parents helped me out, but they couldn't help me out that much.

The semester that Inez cut her work hours, her GPA rose by more than 1.3 grade points on a four point scale. The following illustrates the impact of the competition between the work Inez has to do to pay for her expenses, and her academic responsibilities.

> Interviewer: How often do you interact with the faculty?
>
> Inez: Sometimes if it is really needed and I need to see them about a problem, then I will go. But it is unlikely because I have to work and I can't waste my time getting help when I have to work to make money to survive. You know, I have to have a place to live. You have to kind of balance it [work versus office visits]. So usually I can't go see them. They want people to come and see them, but it is hard because you have a job. And I don't know what I am supposed to do about that. I would take a lot of hours, but I have so much work that the only time I can take off work is done just to do homework and not just to study. I have no time to study. It's just to do homework.
>
> Interviewer: Have you tried to make an appointment? Can you make an appointment for time?
>
> Inez: Sometimes, but usually they redirect you to their office hours.
>
> Interviewer: As you have become more comfortable, have you started participating in things?
>
> Inez: I had to work, so that's when I found out that maybe I should have joined something.…
>
> (later) Inez: I work so much that I really try to…

And finally, perhaps her future expectations reflect her lived experiences: When asked about her plans after graduation she responded pragmatically:

> Inez: To get a job. Anywhere. Right now I am not picky. I mean, I know I don't have a lot of experience, so whoever will help me along and teach me, I am willing to start interviewing.

As we consider Inez's life in the context of Bourdieu's notions of capital and habitus, it is important to note that her depressed economic conditions did not preclude her from considering college as a possibility or dreaming large about what she could become. She uses the world at large as her range of possibilities and the advantages that she can claim to propel herself onward and upward. Thus, her family support system and the guidance of her mother are very important mediators between social class and attainment.

Interviewer: Why did you decide to come to college?

Inez: I guess I felt like that was what we were supposed to do. When I was little, I always wanted to be a brain surgeon and work part time at McDonald's because I love their fries. And I also wanted to be a champion Olympic star, running track. All the same time…

Inez: She [Mom] came over here and got her GED, went through community college, and struggled really hard to get where she is now. That is the person I really look up to. She had no high school education at all. She came over here and didn't know to speak English very well and she's the supporter of my family.

Besides her mother's community college experience, Inez has an older sister who deferred attending college, but is now in school pursuing her Mother's profession and an older brother who received an engineering degree from her institution who encourages her in her path. Her family was also influential in her decision of what university to attend.

Inez: I was considering a lot of colleges. I considered going to an all Black school. My Mom was like, 'don't limit...you need to broaden your horizons and meet a lot of different people. That's the way you make connections and things like that.' She encouraged me to open up to everyone and not stick with one kind.

Interestingly, had Inez chosen a Historically Black College or University (HBCU), her chances of succeeding in engineering would have been substantially greater [43]. According to 2004 ASEE statistics, six out of the top ten schools with the highest percentage of bachelors' degrees awarded to women were HBCUs [44]. Yet Inez's mother clearly recognizes the importance of social capital, since she thinks that attending a predominantly white institution would offer her daughter more "connections" to "different people."

Despite the struggles Inez encountered in her early classes in college, she perceives her high school preparation to have been good and credits some of her perseverance to lessons from there.

Inez: I think the classes in high school prepared me a good amount. Better maybe, I came from a small high school, so I graduated with maybe {less than 100 students}. I think it competed with high schools that had more. Our teacher taught college courses at community colleges. I took Calc I, Calc II, Analysis, Trigonometry. But they weren't, how do you say, I wasn't credited for them. They were hard for me there. There were some things we didn't get and he didn't go into as deep, but you know, it was hard for all of us in the class. I think it prepared me well. I did struggle here a lot. I probably would have dropped out of engineering if I didn't have that basic stuff that he gave us.

C. College Academic Experience

Inez came to college knowing she wanted to major in engineering.

Inez: As I went to high school, I realized that I enjoyed math and that I wanted to do something with that. Reading and writing were not really my strongest points. My brother told me this [engineering] is what I should do.

It is interesting that while reading/writing are, according to her, not her "strong points" she lists a technical writing class as her favorite class of general engineering requirements. When asked what was so great about the class, she responds:

Inez: I guess the guy, our teacher that taught it, this older guy, he was just funny. I learned from him, but it was fun. I got an A in class. That made me feel better, because it was the first A I got.

Inez arrived at college with study skills that were poorly matched to college requirements. Like the grade school child told to look up a word in a dictionary when he or she can't guess the first letter, Inez is told to teach herself. The learning style that served her well in high school did not, initially, support college level expectations.

Interviewer: What was different about the testing here?

Inez: I don't know. Maybe I think it was more that I didn't know how to study. In high school, I didn't study at all. I absorbed what the teacher was telling us, because she told us in a different way. I guess, professors expect you to know things, and if not, then look it up yourself. If you don't know what you are looking for, it is hard. It's a difficult way to study. That's why I always tell people that it is not about the grades you made in high school, but rather learning how to study. That's how you survive in college.

Her initial major was in a major requiring more chemistry.

Inez: Actually, I chose {first major} and then, because I like chemistry also, but I couldn't pass the chemistry courses. I enjoyed them and loved what I learned, but I couldn't pass the tests and then couldn't pass the classes.

When asked what was her worst class, she responded:

Inez: The worst class I had was physics. I couldn't understand it. They say: "Here's the equation, plug and chug." But it wasn't like that for me. I pretty much failed every test I took. I passed because it was curved.

Her physics professor actively discouraged her from continuing her career in engineering.

Inez: Well this was in my physics class. I went for help with one of my problems and I guess I didn't understand the basics of physics, really. So I didn't understand one of the basic principles. He was like, "What are you doing? Why are you an engineer? I would quit if I were you." Like, he might have been trying to motivate me, but I don't know. I was a sophomore, and I was crying. I didn't cry in front of him, but I was like, how do you say this to me? I am asking you for help. You are supposed to be helping me.

Her favorite course in her major was one that included a lab and projects.

Inez: …partly because it had a lab and allowed us more hands-on. I am a more hands-on person than a test taker…and it really interested me. I like a lot of discussion. I don't mean when the teacher asks the class and someone answers. Like I like it when five kids know the answer and want to share the answer. And we are supposed to give back examples. I think it helps us interact better with the teacher. And then of course when we are given labs to do things…to know how to use the things we are learning to do in some classes.

Inez's experiences with introductory freshman chemistry and physics for engineers are not unique among the students we interviewed, except for the active discouragement of the physics professor for pursuing her chosen degree path. She may be correct in her analysis that he was trying to motivate her to do better or perhaps he felt he was doing her a favor by suggesting she should choose a new path sooner rather than later. However, if the field of engineering is to achieve the diversity that Wulf calls for, academia, both in engineering and in the fundamental sciences that support it, will need to adjust their pedagogy to students whose learning styles do not fit the traditional collegiate "I talk, you listen" mode.

D. Otherness: Us and Them

While it may be hard for those comfortable in engineering culture to see insiders and outsiders, Inez experienced very early in her science education the notion of an "us" and a "them" based on both achievement and opportunity. For example, as part of a science competition in high school, the students were split into different groups to tackle the task of constructing a catapult.

Inez: My group, actually, people didn't think we were smart kids and so what they called us…the[y] called us the eccentric group. I don't know, whatever. Our project ended up winning. The people who were supposedly smart and the top people in the class, they failed the project.

Thus even in high school an academic dynamic was established where Inez felt pushed out of the upper stratum in the class. Despite winning the competition, she did not consider herself one of the "top people in the class." According to Inez, her group followed solid engineering principles and "stuck to the basic things" while designing their catapult. Why was her group called eccentric? From her report of the catapult design, the "eccentric" label did not represent their engineering strategy. The perceived eccentricity possibly follows from some external sign(s) of difference, such as appearance, gender, or skin color.

Additional achievement fissures between "us" and "them" run throughout her narrative from experiences in different courses and different perspectives. Inez delineates between those that "get it" (subject comprehension) and those that do not. From one fundamental class for her major:

Inez: …half the class did bad and the other part was everyone who gets As in every class so, you can't really beat them.

Although Inez may not know this, we know from our interviews that nine of the eleven students who mentioned this class listed it as their favorite class. Inez and one other student, who also reported feelings of alienation and marginalization, disliked the class.

Her feelings of alienation are exacerbated by falling out of her initial cohort. Because of her financial needs and employment load, she has fallen behind her entering cohort and is now taking classes with the group who entered a year later.

Interviewer: Do you interact much with your classmates?

Inez: I do, some of them. The ones that need help just like me. The others that do know things, they really don't like to help you. I found. I really think that it might be in the class that I am in right now. With the class that is going to graduate in {year}. Because originally, I was supposed to graduate in {previous year} and people there were very helpful.… I am asking for help to understand what I am supposed to do to get everything right. And they don't want to be helpful. And they compete. And they are cliquey. Yeah, it's kind of hard because we [the others] are all on the same level. The things we got in class, we all got. And the things we didn't, none of us got it.

Other feelings of marginalization occur in the classroom but arise from differential opportunities. Few programs can reasonably expect all of their students to participate in internships or three-semester co-op programs. Many faculty may think that encouraging extramural participants to share their experiences in class is beneficial to the whole class, especially non-participants. However, this practice contributes to a faculty-student dynamic of favoritism and exclusion and a student-student dynamic of elitism and "us" versus "them." When Inez says below that she is "not a co-op," she is using "co-op" to define a category of people. By not having had the opportunity to participate in a co-operative experience, she cannot claim that symbolic capital. Being "a co-op" puts one in elite company at this institution.

Inez: I am not a co-op and have not done an internship. Most of the other students have. They really get to apply their knowledge. The teachers then think that I don't know anything. I haven't had a chance to be involved in something like that. You can tell that certain teachers click with certain groups of people. We have seven people in my class and every class I have with them the teacher calls on them first. Not just calls on them, but points them out. [For example] 'Oh, well (female student) is blah, blah, blah.' Nothing against her. Teachers don't realize that it is not inviting for other students when they do that. Makes it like they are buddy, like they are buddying.

Interviewer: So you think the teachers have favorite students in your class?

Inez: Definitely.

The following comparator student agrees with Inez that internship experience is crucial to her academic success.

Comparator: It's really neat to be able to be in the class room in the morning and, and learn something and then go out in the factory and apply it that afternoon. You know, I mean, it really makes a big difference in learning.…I think it's really helped my grades, actually, too, to be able to apply it and learn it at the same time.

Inez makes another distinction of opportunity between students who have entered college with college credit and those who have not. Those who have college level credit are, according to Inez, "at a higher level" than students who did not have the opportunity provided through their high school.

Interviewer: [asking for explanation from Inez's previous statement] Why did you think people were going to be at a higher level?

Inez: Automatically. Some people come into college with 10 credits or more already. And I am like, wait a minute. How do you even get this? My school didn't provide that, you know, because we don't have the money to provide those types of classes. It's like, oh. It's amazing to me. How did you get the opportunity to learn that?

Contrast Inez's experiences with a comparator student:

Comparator: … I took basically every AP thing I possibly could. (laughs) Trying to CLEP [College Level Examination Program, a method of receiving college credit for taking examinations in high school] college credit of course. Ah, I took physics, math, went through calculus AB in math.

According to Miller and Kimmel [3] enrollment and success in senior year high school calculus plays a central role in students' choosing STEM majors. However, this same student's accrual of advantages, her habitus, started long before high school.

Comparator: When I was in elementary school… we were bussed to a school in {location} and, once a week we got to do all science and math classes. It was great (laughs). (chuckles) I guess we were tested when I was in first grade or so, I don't really remember it, but my whole elementary school time, we got to go there once a week and, we did a *lot* of science there, there was a lot of projects, I took classes in physics and chemistry and things and (pause) in electrical science type stuff. It was really great.

Interviewer: Was that your first introduction into any engineering related …?

Comparator: Yes. Yeah. We had great, great teachers, and that's probably what started it all (laugh), back then…

Besides otherness derived from achievement and opportunity, Inez is multi-minority. Inez chooses to claim and foreground part of her heritage.

Inez: I say I am half {racial group}, half {ethnic group}. I let people know. They'll say, 'Are you {racial group}?' I will say, well no, actually I am 50 percent {ethnic group}. I am more that than actually {racial group}. I don't want them to not consider that, because my Mom is a big part of my life and I want them to know that.

Actions bear out her desire to foreground her ethnic heritage with her attempt to become involved in a particular student organization.

Inez: I tried to be involved in an {ethnic student association}. …there wasn't too much to do. Other than that, I didn't do anything because I was scared and I didn't have any friends. I ended up not doing anything.

One must wonder, however, how much her physical appearance separated her from her co-ethnic classmates, and engineering classmates, and caused her fear and feelings of isolation. According to Beverly Tatum [45]:

While it is clear that biracial children can grow up happy and healthy, it is also clear that particular challenges associated with a biracial identity must be negotiated. One such challenge is embodied in the frequently asked question, "What are you?" While the question may be prompted by the individual's sometimes racially ambiguous appearance, the insistence with which the question is often asked represents society's need to classify its members racially. The existence of the biracial person challenges the rigid boundaries between Black and White [substitute Outsider and Insider based on who is doing the answering and asking], and the questioner may really be asking, "Which side are you on?" "Where do you stand?" Choosing a standpoint and an identity (or identities) is a lifelong process that manifests itself in different ways at different developmental periods.

V. Discussion and Conclusions

Institutions of higher education are transmitters of dominant culture. Therefore, educators are in a position to change the dominant culture to be more inclusive of diversity. This responsibility is particularly critical for STEM educators in light of the need for increasing individual diversity in STEM. STEM educators are generally untrained in critical cultural theory and are often unaware that cultures, like technological artifacts, are constructed and engineered by people. To meet this challenge, STEM educators must take ownership of their roles in constructing and transmitting the culture of STEM. A requisite step is to examine the underlying beliefs of the dominant culture and their differential impacts on diverse faculty and students, like Inez.

Conefrey lists five cultural myths of science in the United States [46], as enumerated below. These myths are self-fulfilling prophecies. They contribute to the STEM environment, but are also sustained by it. In accordance with Conefrey, Inez's narrative shows that the beliefs below are myths. The STEM community's naive acceptance of these beliefs continues to perpetuate the dominant culture, the need for capital, and the dynamics of insider/outsider in the college classroom.

1. *Science is above or beyond gender, race, class, and other socio-cultural distinctions*. Inez was silent on the issue of whether race or gender had an impact on her academic success; she told us about the impact of her class and socio-cultural distinctions. For example, the faculty at her institution probably were not seeking to disadvantage a student of limited means by redirecting Inez to office hours. This redirection, however, penalized Inez since she had to work to support herself and could not meet at the designated times.
2. *Science is a meritocracy*. Science and engineering are assumed by scientists and engineers to be played on a level field. It is assumed that everyone understands the rules and can play the game, and the result is therefore a measure only of individual merit. However, some students enter college with greater accumulated advantages. These advantages continue to accrue throughout college. Perhaps, the faculty who went to her freshman orientation class to promote cooperative education experiences and referenced GPA requirements was trying to use this as an incentive to encourage students to work hard and maintain high GPAs. Inez, however, was discouraged from trying to get a cooperative experience. As a result, Inez accepted an unpaid internship later in her career further compounding time pressure, without resolving financial pressures. Not understanding that a 2.0 GPA would not preclude a co-op experience further demonstrates Inez's lack of particular cultural capital. In the end, it reinforced the insider-outsider dichotomy as cooperative experiences were used in classroom pedagogy, and enhanced Inez's impression that other students were favored. This impression drove Inez to tears during the interview.
3. *No changes in curriculum or pedagogy are necessary to accommodate different ways of learning or knowing*. The ability to balance chemical equations and plug-and-chug in an algorithmic physics class are not as representative of the skills requisite in a successful engineering career as are the abilities to write and communicate effectively, to discuss and reason through problems, and to get into the project and use one's hands and practical skills to find a solution which were the classes, skills, and abilities that Inez felt comfortable in, did well in, and generally enjoyed. Traditional pedagogical methods, such as requiring students to find information independently, assume a basic competence that not all students possess. If an instructor had shown Inez how to look up information independently, she might have been able to pass her early chemistry classes. In turn, Inez might have retained her scholarship, worked fewer hours at her job and more on homework, had a higher GPA, and gained the advantages associated with co-ops and internships. While this chain of events might seem improbable, small advantages do tend to accrue.
4. *Challenge and competition are essential to science and weed out classes are necessary to winnow the wheat from the chaff*. It is hard to be competitive when you do not know the rules. Inez states "I like [competition], but not when I'm new at something." That something, in this case, is engineering. Many other students have more engineering specific socio-cultural capital, which makes it substantially easier for them to succeed in the competitive environment of engineering.
5. *Failure is the individual's own fault*. Although Inez is not a failure, if she had failed we could identify a number of factors outside of her control which would have contributed to that failure, such as weak high school preparation, the necessity to work long hours (and subsequently an unpaid internship), and the absence of social and cultural capital in engineering. This cultural myth is so pervasive that Inez herself bought into it. When asked why she does not fit into engineering she replies "I'm too shy and I don't open up." When asked what a professor can do to make a class easy, Inez replied "I don't think there is anything that they can do (laughs). It is really just about you." Tobias is discussing "second tier students," like Inez, when she says:

   > Unless they are unusually self-motivated, extraordinarily self-confident, virtually teacher- and curriculum-proof, indifferent to material outcomes, single-minded and single-track, in short *unless they are younger versions of the science community itself*, many otherwise intelligent, curious, and ambitious young people have every reason to conclude that there is no place for *them* in science [47].

A consequence of the acceptance of these beliefs is that decisions and actions within the dominant culture can have an unintended and differential impact on disadvantaged students. Many of Inez's experiences illustrate this mismatch between intent and impact.

An example of the intent-impact mismatch in Inez's experience is the role the cooperative program is playing at Inez's institution. Inez did not benefit from a cooperative experience because of her uninformed perception that her low GPA would make placement impossible. While cooperative experiences are undoubtedly beneficial to many students, the lack of a cooperative experience led Inez to feel that she was outside of her major looking in. However well intended, the faculty member's choice to highlight students with cooperative experiences in class exacerbated this feeling. On a more material level, a cooperative experience could have helped finance Inez's education instead of her reliance on low-wage, menial jobs. Her lack of a cooperative experience also will directly impact Inez's ability to find a job and her earning potential. In other words, Inez's lack of social and cultural capital makes it difficult for her to gain the social, cultural, and symbolic capital that would have accrued as a result of a cooperative experience.

Another example of the intent-impact mismatch is Inez's experience with active discouragement from her physics professor. We presume that the professor was trying to help Inez graduate from college by recommending that she find another major because he perceived her to be unsuited to engineering. Inez chooses to believe that the professor was trying to motivate her, perhaps to maintain the appearance that the faculty member had good intentions. However, the impact on Inez was demoralization. This experience informed Inez's expectations when interacting with faculty. Instead of faculty being encouraging and mentoring sources of support, she now knows that an interaction with faculty can result in abject rejection.

A third example of the intent-impact mismatch is Inez's experience with having difficulty finding help from faculty when she needs it. Her work schedule, necessary to her financial survival, does not allow her the flexibility needed to match restricted faculty office hours. When she tries to make appointments for times when she is available, faculty redirect her to office hours. From the perspective of a faculty member, redirecting students to limited office hours is viewed as necessary for their professional survival. Maximizing research time allows faculty to publish instead of perish at a research institution. From Inez's perspective, she was being asked to choose between a roof and food now and the help she needed for a better future.

While these actions are undertaken by individuals, they collectively represent the dominant culture's acceptance of Conefrey's myths. The faculty member's individual decision to recognize students with cooperative experiences in class is a reflection of the importance the institution places on the cooperative program. The faculty member's individual decision that Inez was unsuited to engineering is a reflection of STEM culture at large, where only the A and B students are valued. The faculty members' individual decisions to restrict student interaction to class and office hours reflect the importance the institution places on research at the expense of teaching.

The institutional values represented above are not bad values. Cooperative experiences are good for students. We need the very best engineers we can get in our society. Research is beneficial to education, the institution, and society. However, actions resulting from these values can have the unintended impact of exacerbating inequities, particularly when disadvantaged students are not fully considered and represented during decision making processes. In order to represent these students, faculty ranks need more individual diversity.

We have to get more diverse faculty to get more diverse students, but to get more diverse faculty we need more diverse students. It is tempting to look at this situation as a chicken and egg paradox; however, this attitude is a pretext for inaction. A more accurate analogy is found in the traditional and new meanings of "pulling yourself up by your own bootstraps." The traditional meaning tells people that they must help themselves, no matter how limited their resources. Recruiters for engineering tell prospective disadvantaged students that engineering careers are a way to pull yourself up by your own bootstraps. But as any engineer knows, you cannot literally accomplish this task. Computers, however, do accomplish something similar, not coincidentally called bootstrapping (or booting the computer): they take a simple set of instructions (or in human terms resources or capital) and repeatedly use these to locate more numerous, powerful, and useful instructions.

Instead of hiding behind the chicken-and-egg paradox, we should approach this issue of increasing individual diversity among engineering students and faculty as a bootstrapping process in the modern sense. We need to help disadvantaged students effectively utilize their meager capital resources to locate and acquire the additional social, cultural, and symbolic capital resources needed to excel in engineering programs and pursue academic careers. Then, we will have more eggs, and eventually more chickens. Several changes that would have made it possible for Inez and more students like her to excel include:

- Career placement representatives making it clear that cooperative placements were available to students with less than stellar GPAs.
- Faculty paying attention to "us" and "them" classroom dynamics that are established as a result of differences in capital (such as the cooperative program).
- Faculty recognizing that students with average grades can excel as engineers.
- Faculty being more accessible for help, instead of redirecting students to office hours they cannot attend because of work.
- Institutional representatives making sure that the news of scholarships reaches all eligible students.

Luckily, Inez seems to have found her place in engineering. However, we are going to have to change the culture of engineering if we are to enable more students like Inez to succeed.

VI. In Closing

Accepting qualitative research, especially ethnography of the particular, into the toolbox of engineering education research provides a microphone for the voices of the marginalized to be heard. Ethnography of the particular allows us to hear each and every voice that would otherwise be lost in aggregate ethnography or statistical analyses.

We have presented Inez's words to you, but what we cannot hope to convey are the emotions we interpreted from changes in her pitch, rhythm, and inflection. As Inez discussed her background: her small, non-rigorous high school, her community's and family's economic situations, her ethnic identity and the difficulties she faced fitting in with the ethnic student association, her voice and manner were cheerful, upbeat, and positive. She presented these challenges as facts of life that had influenced and impacted her, but over which she had prevailed.

For example, she laughed about her departmental advisor thinking she should not be an engineer. "It's the questions he asks; he isn't a friendly sort of advisor that talks. He asks me questions to make me think, but it's the way he does it." When asked if he recommended classes or seminars to help her, such as time management or study skills workshops, she dismissed this as a role an advisor should take. She said that he is like the advisors that students in other colleges have. She seemed to accept that his proper role was simply to check her degree sheet and question her resolve. Though the wistfulness in her voice implied that she would have liked to have an advisor who was more involved, she did not say that directly.

Her tone, her composure, and her voice strength all collapsed when she reached the stories of the faculty whom she felt played favorites in class. Her voice took on a sharp edge, began quavering, and at several points she held back tears. For the rest of the interview, even when talking about the job offer that she has waiting for her after graduation and her future plans, she never returned to the cheerful, accepting optimism that she had exhibited in the first half of the interview. While Inez's perseverance and focus on her goals allowed her to tolerate and rise above challenges, we cannot expect many students to demonstrate this exceptional courage. We must make engineering a more welcoming place if we are to gain individual diversity.

Near the end of the interview, she was asked if she could offer advice to faculty. She responded:

> Inez: Try to make people feel more welcome. That may be hard, but I never felt like I was welcome. Not a comfortable place to be.

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AUTHORS' BIOGRAPHIES

Cindy E. Foor is Assistant Director/Research Associate at the Research Institute for STEM Education (RISE) at the University of Oklahoma. As an anthropologist, her research interests include ethnography of marginalized populations, cultural theory, issues of gender and underrepresented populations in STEM education and the cultural/historical construction of women's cultural identities and roles in past and present societies, with special focus on emerging nationalist projects.

Address: RISE, 112 Fourth St., Box 6, University of Oklahoma Norman, OK 73019; telephone: (+1) 405.325.5775; e-mail: cynthia.e.foor-1@ou.edu.

Susan E. Walden is the founding Director of the Research Institute for STEM Education and a Research Scientist in the K20 Center for Educational and Community Renewal at the University of Oklahoma. She received her Ph.D. in Computational Organic Chemistry from the University of Oklahoma. She has taught organic and general chemistry, but her primary interests are in researching educational equity and applying democratic pedagogies to the sciences and engineering. She is also interested in educational outreach to K-12 and gifted education for K-16. She is an active member of the American Chemical Society and the American Society for Engineering Education.

Address: Research Institute for STEM Education, 112 Fourth St., Box 6, Norman, OK 73019; telephone: (+1) 405.325.5775; e-mail: susan.e.walden-1@ou.edu.

Deborah A. Trytten is an Associate Professor in the School of Computer Science at the University of Oklahoma. Her research interests include gender and racial/ethnic diversity, building educational games, introductory software engineering education, and integrating teamwork into undergraduate Computer Science courses. She is a founding member of the University of Oklahoma's Research Institute for STEM Education. She earned M.S. degrees in Applied Mathematics and Computer Science and a Ph.D. in Computer Science from Michigan State University. Her B.A. in Physics and Mathematics came from Albion College, in Albion, Michigan.

Address: Engineering Laboratory Room 108, Norman OK 73019-0631; telephone: (+1) 405.325.4299; fax: (+1) 405.325.4044; e-mail: dtrytten@ou.edu.