Advancing Diversity, Inclusion, and Social Justice Through Human Systems Engineering

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15 Facilitating a Sense of Belonging for Women of Color in Engineering

The Case for Virtual Internships

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INTRODUCTION

Historically, women and people of color have been underrepresented in engineering fields. In 2017, women represented 51% of the U.S. population, but they earned only 21% of B.S. engineering degrees. Latinxs represented 18% of the U.S. population, but they earned only 11% of B.S. engineering degrees. African-Americans represented 13% of the U.S. population, but they earned only 4% of B.S. engineering degrees (U.S. Census Bureau, 2017; Yoder, 2017).

Recent reports claim that increasing the number of underrepresented groups in STEM is important for improving the U.S. economy and creating a more diverse STEM workforce will provide opportunities for heterogeneous productivity and innovation (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2007; U.S. Department of Education, 2016). However, such arguments are rooted in the U.S.'s self-interest and conceptualize the inclusion of underrepresented groups in terms of U.S. scientific, technological, military, and economic dominance (Philip & Azevedo, 2017). Vossoughi and Vakil (2018) argue for diversity in STEM as rooted in *deep moral concern* for students of color as opposed to rooted in U.S. competitiveness and expanding markets. This includes *expanding and democratizing* the values and purposes of STEM education, along with *reimaging and transforming education* such that students have access to intellectually respectful learning experiences and the resources to fulfill their individual and collective potential. This social justice perspective of broadening participation in STEM requires more empirical study around designing for equity and inclusion (Gutiérrez & Jurow, 2016) and expanding the definition of empirical work (Bang & Vossoughi, 2016).

This chapter describes *Nephrotex*, an engineering virtual internship program designed as an inclusive engineering design experience for first-year undergraduate students to democratize access to authentic engineering practices. Using pre-post surveys and team chat data, analyses classified the experiences of women of color in the virtual internship. Through the lens of human factors engineering, it is argued that certain features of Nephrotex—intentionally designed to maximize the experience of underrepresented youth in engineering—facilitated a positive experience for women of color.

Why Are There so Few Women and People of Color in Engineering?

Studies have shown that women battle perceptions and unconscious beliefs about gender in mathematics and science (Heilman, Wallen, Fuchs, & Tamkins, 2004; Marra, Rodgers, Shen, & Bogue, 2009). In educational settings, the design of curriculum may be dominated by masculine culture, such as encouraging competition or aggressive hacking, and perpetuate feelings of exclusion for women in computer science and STEM (Margolis, 2010; Margolis & Fisher, 2003). Archer and colleagues (2012) examined girls' experiences within STEM and found that notions of being "girly" or feminine contrasted with heteronormative, masculine depictions of STEM as highly academic and technical. As a result, women experienced tension between their femininity and scientific identities.

Such issues can be more pronounced for underrepresented women of color in STEM—women self-identified as Black, Latina, Native American, or mixed race—who often experience a *double bind* of race and gender marginalization (Malcom, Hall, & Brown, 1976) resulting in simultaneous racism and sexism (McGee & Bentley, 2017; Ong, Wright, Espinosa, & Orfield, 2011). The intersection of race and gender is an important avenue for describing the distinct experiences of those who are in intersecting marginalized groups in STEM (Ireland et al., 2018).

Researchers have consistently argued that women of color leave engineering and STEM fields because of isolation and a lack of social belonging to the broader community of engineers (Carlone & Johnson, 2007; Charleston, Adserias, Lang, & Jackson, 2014; Rodriguez, Cunningham, & Jordan, 2017). Moreover, women of color may have more difficulty than others negotiating their identities in environments where STEM is depicted as highly academic and technical (Archer et al., 2012). This pattern may be the result of dominant educational discourse that associates and normalizes high academic performance with White and/or male students, and which associates Black women as incompatible with academic success (Neal-Jackson, 2018).

Communities of Practice as a Lens for Inclusive Learning in Digital Environments

In response to the marginalization of women and students of color in engineering programs, researchers suggest providing high-quality, authentic, and broader learning experiences (Hilton, Hsia, Cheng, & Miller, 1995). This approach allows students to take on academically and technically rigorous roles (Flowers, Milner, & Moore, 2003; Moore, 2006), provides support structures to increase confidence and self-efficacy (Rice & Alfred, 2014), exposes students to examples of successful professionals from their race and self-identified gender (Hill, Corbett, & St. Rose, 2010;

Rice & Alfred, 2014; Tate & Linn, 2005), and provides safe social spaces that offer support and enhance feelings of belonging in STEM (Ong, Smith, & Ko, 2018). Such research on education supports the design of more inclusive digital learning environments for women and students of color in which they feel a sense of belonging to the community of engineers.

From a learning sciences perspective, engineering can be described as a *community of practice*—groups of people who share ways of working, thinking, and acting in the world (Wenger, 1999). Learners who are new to a community of practice engage in a reduced role that mirrors authentic interactions and practice but with less intensity, pressure, and risk. This learning process of *legitimate peripheral participation* is fundamentally an identity transformation process as new learners adopt the practices and identities of the community. Equally important is the process of negotiation. New learners are placed into positions that allow them to negotiate the practices and identities of the community, and to take an active role in reshaping the boundaries of legitimate membership. Thus, acknowledging the tension between adoption and negotiation, and designing opportunities for such negotiation, are important for inclusive and supportive digital learning environments.

Human Factors Engineering Approach for Design and Putting the Learner First

From a human systems engineering lens, students are the "users" of a digital learning environment. In this view, the environment should consider students' broad goals, needs, and capabilities and maximize their user experience (Gould & Lewis, 1985; Roscoe, Branaghan, Cooke, & Craig, 2018). A learner is a particular type of user who does not have substantial domain knowledge, has a variety of motivations and interests, and is changing their understanding of a domain as they learn the material and interact with the tools (Quintana, Krajcik, & Soloway, 2000). A *learner-centered* design approach respects such characteristics and "constructs learning opportunities for who the learner is and wants to be" (Guzdial, 2015).

In a learner-centered approach, the designer of the digital learning environment considers how design choices can affect student experiences. For example, the chosen aesthetics of digital media or websites can significantly influence students' enrollment decisions, anticipated success, and sense of belonging. In two recent studies, when women were presented with computer science websites or virtual environments that had stereotypically masculine designs (e.g., Star Trek imagery and computer terminal imagery), they were more negatively impacted than women who were presented with non-stereotypical imagery (e.g., nature designs) (Cheryan, Meltzoff, & Kim, 2011; Metaxa-Kakavouli, Wang, Landay, & Hancock, 2018). For both studies, the men were unaffected by the conditions. In addition, learning environments become more complex when designing for collaborative work and knowledge-building. In digital collaborative spaces, the design of the tools can either afford or constrain the ability of learners to communicate, share, or build knowledge. Designers should consider when students receive access to tools and the nature and timing of support provided during collaborative work (Rummel, 2018).

Once designers have constructed an environment, they can perform usability testing to gather insights as to how learners will interact with the environment and whether the goals of the learner and designer are met. A typical usability test consists of a series of tasks conducted by participants who are similar to the target user (Wichansky, 2000). After usability testing, the next step may be beta testing: an initial, low-risk form of testing that includes actual users. For each usability or beta test, designers collect information about users and use this information to optimize their design and user experiences.

Nephrotex: The Design of an Inclusive and Legitimate Learning Experience

To create an inclusive learning experience, Arastoopour and colleagues (Arastoopour, Chesler, & Shaffer, 2014; Chesler, Arastoopour, D'Angelo, Bagley, & Shaffer, 2013) incorporated principles of legitimate peripheral participation and learner-centered design to develop Nephrotex. Nephrotex is an 8-week long engineering virtual internship program in which students role-played as interns at a fictional biomedical engineering design company and worked in teams to design filtration membranes for hemodialysis machines.

To avoid experiences of exclusion and isolation that may occur with women of color (Charleston et al., 2014; Ong et al., 2011; Tate & Linn, 2005), students were assigned teams at the start of the internship rather than asked to self-organize into groups. All research and design activities and team interactions took place through WorkPro (Figure 15.1), a fictional web-based, simulated workplace environment, that included an email and chat interface (Figure 15.2). Students accessed the website at any time but were required to log in and participate during class sessions, which were two or three times a week for 50 minutes. In most implementations, students were given the option to (a) log in from home or (b) attend class and log in from the classroom setting.

Students took on the role of interns who exchanged emails with their supervisor (a pre-scripted character) and used chat-based instant messaging to communicate

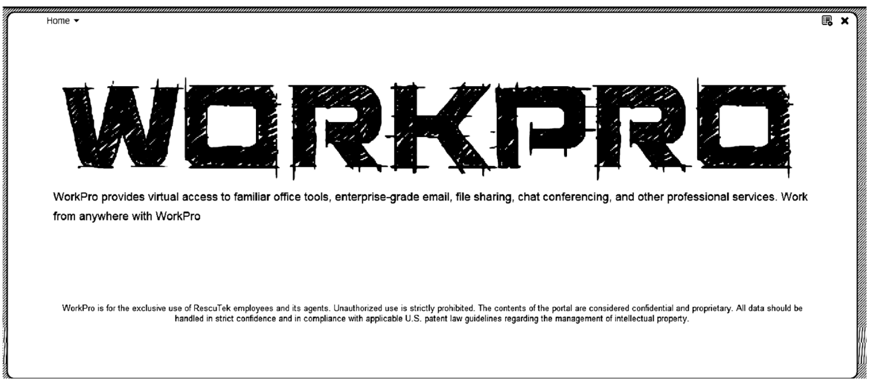

FIGURE 15.1 The homepage of the fictional Nephrotex company portal interface, WorkPro.

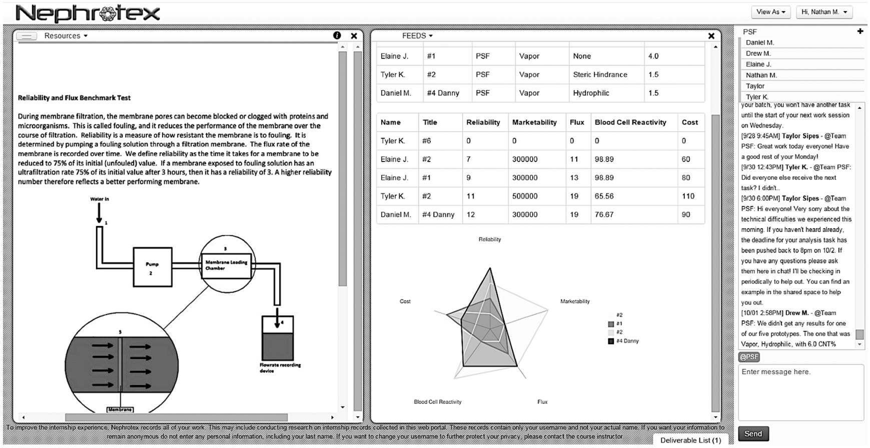

FIGURE 15.2 Nephrotex simulated company portal interface, including a research report, data analysis tool, and chat window.

with team members and their design advisor (an instructor who chatted with students in real-time). Throughout the program, interns worked in teams to perform tasks that they would conduct in a real internship: reading and analyzing research reports, designing and performing experiments, responding to client and stakeholder requirements, and proposing and justifying design prototypes. Interns also addressed multiple internal stakeholders' requests, which were often in conflict with one another (e.g., as flux increases, cost also increases). Thus, interns considered and justified tradeoffs associated with their proposed design solution.

Students communicated with team members through a chat tool. Each team researched one polymeric material for the filtration membrane design. Halfway through the internship, students switched teams and shared their knowledge with their new team members in the chat tool. This *jigsaw* structure, in which students mastered different subtopics, then formed new groups to peer-teach their respective subtopics, has been shown to increase empathy and compassion among students (Aronson, 2002). In conjunction with explicit prompts for students to explain their reasoning, jigsaw structures can reduce the negative impact of inequitable groups (Theobald, Eddy, Grunspan, Wiggins, & Crowe, 2017). For tasks in Nephrotex, all students were assigned a technical research component and given prompts; there were no passive or nontechnical options for participation because prior research shows that such tasks tend to be assigned to women (Tonso, 2006).

Students also used chat tools to communicate with their human mentors regarding questions or concerns, such as confusion about the website or technical tools, the content of their readings, or clarification on an assigned task. Beyond serving as a resource for students, Nephrotex mentors were also available when students logged in and used various monitoring tools to view student activity. Using this information, mentors intervened to support students if there were team conflicts or praised students for their valuable contributions. Research has suggested that women of color who receive peer and faculty recognition for their contributions have more positive identities as STEM professionals. However, individuals whose work goes unnoticed and unacknowledged have difficulty establishing their identity within their academic communities (Carlone & Johnson, 2007). Thus, in Nephrotex, mentors were trained to provide personalized feedback to students and recognize their contributions.

In addition, all mentors and stakeholders had staff pages with photos that were accessible to students. Photos were chosen to reflect a variety of races, genders, and prior experiences, such as women, African Americans, and Latinxs who may have immigrated to the U.S., grown up in rural and urban areas, and/or attended graduate school. Although students did not communicate with characters outside the digital environment, exposing students to professional engineers who have the same race and/or gender may increase their sense of belonging (Charleston & Adserias, 2014; Tate & Linn, 2005). Table 15.1 summarizes a selection of design features in Nephrotex.

Usability and Beta Testing

The design and implementation of Nephrotex was a collaborative effort among researchers, developers, instructors, and students. In the early stages of the project in 2009, researchers and developers worked together to develop an initial Nephrotex platform. The researchers organized a user-testing session with professional engineers, developers, graduate students, and undergraduate students. Each user tester was asked to role-play as a first-year undergraduate student and to try to "break the website." User testers were given tasks identical to those that would be given to students, such as designing and testing prototypes and communicating with team

TABLE 15.1
Summary of Selected Nephrotex Design Features and Associated Goals for Student Experiences

Design Feature	Goal(s)
Digital system randomly assigns students into teams	Avoid experiences of exclusion and isolation when self-organizing into teams
Digital system automatically jigsaws students into different teams	Facilitate empathy and compassion among students
	Reduce the negative impact of inequitable groups
Each student is assigned a technical task	Reduce the chance of nontechnical tasks being assigned to women In conjunction with the jigsaw, all students contribute technical knowledge to teams
Human design advisor is immediately available through chat tool during class time and intermittently available through email tool	Provide guidance and support if students have issues with navigating the website or understanding a task Provide positive feedback and recognize students for their contributions
Diverse set of staff pages and photos	Increase sense of belonging for students who are underrepresented in STEM

members through chat. Testing sessions were typically 1–2 hours in length. At the conclusion of the session, each user tester submitted a list of bugs and errors they had discovered, and then engaged in a discussion with the researchers about the usability of the website. For example, some testers found bugs in which links were broken or messages from team members were not visible in the chat window. Regarding usability of the website, some testers suggested that the interface should include access to multiple windows so that students could, for example, write in their notebooks as they designed their devices or conducted analyses. Afterwards, the researchers and developers made changes to the program and tested again.

In 2010, researchers implemented a beta testing session with volunteer undergraduate students. This differed from usability testing in that the program was implemented with participants in a classroom setting and was 10 hours in length. After the beta testing, students completed a questionnaire about their experiences with Nephrotex and the design of the program. From 2010–2015, Nephrotex underwent several cycles of design-based research iterations with annual usability testing sessions after major changes took place. During this time, the course was continually implemented in engineering introductory courses at seven universities.

Previous Work

Previous studies of Nephrotex have demonstrated that after participating in the virtual internship, students overall exhibited significant gains from pretest to posttest on science and engineering content (D'Angelo, Arastoopour, Chesler, & Shaffer, 2011), exhibited higher levels of engagement and immersion (Chesler, Arastoopour, D'Angelo, & Shaffer, 2011), and demonstrated evidence of developing a social identity as an engineer (Arastoopour & Shaffer, 2013). Importantly, women who learned with Nephrotex reported significant increases in confidence and commitment to engineering compared to women in a control group. These increases were also correlated with more frequent design-related discussion in their team chat logs (Arastoopour et al., 2014).

Current Study and Research Questions

The current study further investigates the experience of women of color in Nephrotex and addresses the following research questions:

1. Do women of color who participated in Nephrotex have an increased sense of belonging to the field of engineering after participation?
2. Do women of color who participated in Nephrotex generally have positive or negative experiences when engaging in collaborative design work?

METHOD

Participants and Setting

Participants in this study were first-year undergraduate engineering students (i.e., biomedical engineering or undecided) who were enrolled in an introductory engineering course that incorporated Nephrotex. From 2013 to 2015, data were collected from 29 instances of Nephrotex at seven public universities. None of the universities were designated as a Minority Serving Institution (e.g., Historically Black College or University, Hispanic Serving Institution, or a Tribal College or University). All 29 instances contained five teams of three to five participants each, for a total of 150 teams and 750 individuals. Participants were invited to take part in the study because their instructors indicated an interest in implementing Nephrotex in their course curriculum.

Participants who preferred not to respond to gender and racial demographic questions were removed from the analysis, resulting in a total of 721. The resulting self-identified gender and racial demographics of the participants were 68.5% male and 31.5% female; 78.9% White, 12.3% Asian, 4.2% Black, 3.7% Hispanic, and 0.8% Native American. If participants indicated two or more races, they were categorized by their non-White identification. Considering the intersection of race and gender, there were 54.8% White men, 24.8% White women, 8.3% Asian men, 4.0% Asian women, 2.9% Hispanic men, 2.6% Black men, 1.8% Black women, and 0.7% Hispanic women. Out of these 721 students, this analysis categorized the Black and Hispanic women as "women of color" (n = 18) and the remaining participants as "others" (n = 703). As a comparison, full-time undergraduate engineering graduates in the U.S. in fall 2016 were 78.7% men and 21.3% women; 62.3% White, 14.6% Asian, 11.1% Hispanic, 4.1% Black, 3.6% Other, and 4.2% Unknown (Yoder, 2017).

Data Collection and Analysis

Data were collected in three forms: pretest and posttest survey questions, participants' staff pages, and team chat logs. All participant and university names were replaced by pseudonyms.

Participants answered 20 Likert-scale questions on their perceptions of engineering careers and their commitment to the field in a pretest and posttest survey. Answers were presented using a five-point scale ranging from "1" (strongly disagree) to "5" (strongly agree). In this analysis, four questions related to a sense of belonging: (a) *Someone like me can succeed in an engineering career*, (b) *I feel confident in my ability to succeed in engineering*, (c) *I feel like I know what an engineer does*, and (d) *I am good at designing things*. Responses were summed across these questions; scores could range from 20 (i.e., high sense of belonging) to 4 (i.e., low sense of belonging). A non-parametric Wilcoxon rank-sum significance test was conducted to determine if there were gains from pretest to posttest on this measure for women of color (n = 14) and others who answered all four questions (n = 546).

After completing the pretest survey, participants browsed the staff pages of company employees and created a three- to five-sentence-long biography. Because some instructors opted their students out of this activity, only seven of the 14 women of color created a staff page. The contents of these staff pages (n = 7) were collected and analyzed for emergent themes.

The third data source was chat logs. Team chat transcripts were collected and segmented by chat utterances, defined as any message typed and sent by a participant. The tidyverse collection of packages from R was used to pre-process the text data and conduct a sentiment analysis. Sentiment analysis used the AFINN list of English words rated from –5 (negative) to +5 (positive), resulting in ten levels (Nielsen, 2011). Each participant was assigned a sentiment score that was calculated by multiplying the rating level, *r*, by the number of sentiment words used, *n*, and then divided by the number of sentiment words used:

$$Sentiment\ Score = \frac{\sum r * n}{n}$$

A non-parametric Wilcoxon rank-sum significance test was conducted to determine if there were differences between the sentiments scores of women of color and others.

To gain a better understanding into the context of the sentiments, the top 20 words that contributed to the sentiment score of women of color and others were identified and qualitative examples were found in the data.

TABLE 15.2
Collaborative Design Coding Scheme Based on Computational and Qualitative Analyses

Code	Definition and Keywords	Example
Company Cost	Discussing cost related to the company's interest and how expensive or profitable the device will be	"Yes, cost has been my main restriction too. My previous group constantly struggled with cost so I think that prototype 2 is the best from both of my teams."
Consultants	Discussing the internal consultants' (as a group of stakeholders) concerns and requests	"so, did you notice that all of our designs failed one consultants' requests?"
Dialysis	Discussing the physical principles behind dialysis such as flow and membrane fouling	"Exactly, as those [flux and reliability] affect blood flow from the machine to the blood, which goes to the heart."
Experimental Design	Discussing attributes of the design, the testing process, or the analysis of the results	"Should we have tried the same as Prototype 5 but change the surfactant to hydrophilic?"
Internship	Discussing technical tools or professional aspects related to the internship	"Are we creating a batch for our notebook though? Because if so, we can just share the data through this site."
Patient Cost	Discussing cost related to the patient's interest	"$110 was our best but that was without any surfactant. And it still does because mostly older people are on dialysis and they usually have Medicare which doesn't cover the whole cost."
Patient Health	Discussing the patient's health in relation to dialysis and the filtration membrane design	"I don't think cost impacts the patient as much as treatment time/pain associated with the other factors. Patients have insurance to help with cost issues."
Tradeoffs	Discussing the advantages and/or disadvantages of particular design choices for the filtration membrane	"Does anyone have opinions on the results? It seems that everyone had major pros and major cons in each design."

To explore sentiment in the context of collaborative engineering design work, topic modeling (Latent Dirichlet Analysis) and word pair correlations were employed to identify themes in the data related to engineering design. Using a mixture of these computational methods and qualitative analysis, the researcher identified a coding scheme with topics related to the collaborative design process (Table 15.2). This analysis identified utterances from women of color that contained sentiment words and keywords from the coding scheme. These utterances were then examined across coding categories to characterize the level of sentiment for women of color in the context of collaborative engineering design.

RESULTS

Sense of Belonging: Pretest and Posttest Survey Scores and Staff Pages

Participants in this study answered survey questions pertaining to their sense of belonging and potential success as an engineer. The scores of women of color increased significantly from pretest (Mdn = 16) to post (Mdn = 17, $Z = 1.42$, $p < .05$) using a Wilcoxon rank-sum test (Figure 15.3). Others also had a significant increase in median scores from pretest (Mdn = 16) to posttest (Mdn = 16, $Z = 3.41$, $p < .05$, $r = .14$) using a Wilcox rank sum test. However, the effect for women of color ($r = .38$) was nearly three times larger than the effect for others ($r = .14$). However, although women of color appeared to have higher gains than others, there was no significant difference between women of color's change scores (Mdn = 1.5) and others' gains (Mdn = 0, $Z = 1.13$, $p > .05$).

Instructors could choose whether or not to include an activity in which their students created a staff page for the Nephrotex company portal. As a result, only seven of the 14 women of color created a staff page. All seven women who created staff pages included their current majors, current extracurricular activities, and goals for continuing education and careers (Figure 15.3). For example, Denise, who identified as a Black woman, wrote:

> Denise is currently pursuing her BS degree in chemical engineering at Springfield University. She has done research in her field and hopes to continue to do so throughout her undergraduate career. She is also heavily involved with the National Society of Black Engineers where she serves as the finance chair for the 2013–2014 academic year. She is currently an intern here at Nephrotex and she is working on a project with her design team.

Collaborative Design Work: Team Chat Logs

The primary communication platform in Nephrotex is the team chat portal through which students chat with their team members and design advisor. A total of 61,770 chat utterances were collected.

According to a sentiment analysis to identify the use of positive and negative emotion words, women of color appeared to have higher sentiment scores (i.e., more positive emotion) (Mdn = 1.0) than others (Mdn = 0.85), although this difference was

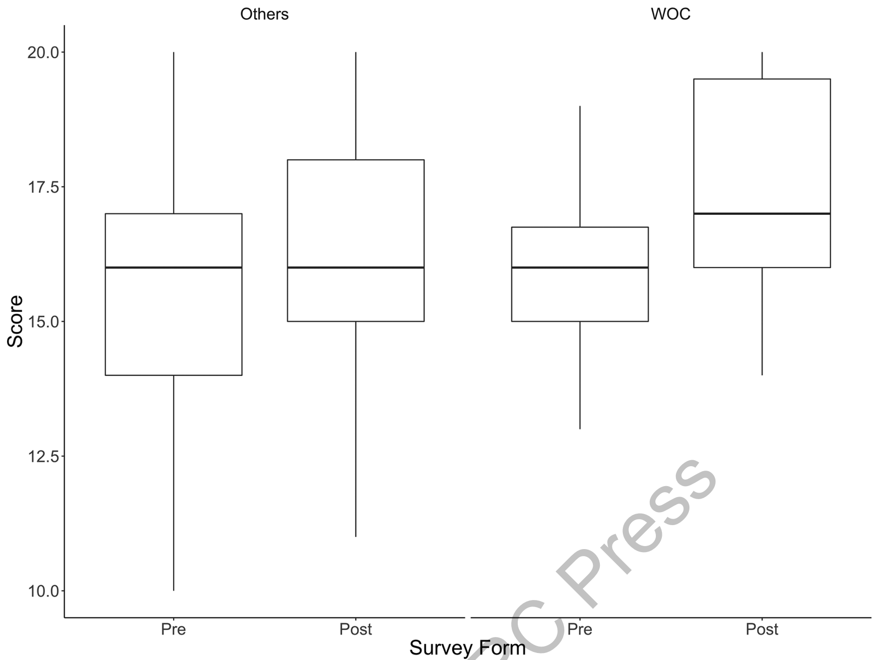

FIGURE 15.3 Boxplot for women of color's and others' pretest and posttest scores on sense of belonging in engineering.

not significant ($Z = 1.6$, $p > .05$). Examining the top 20 sentiment words from each group reveals that women of color and others used similar words and were mostly positive (Figure 15.4).

Women of color used positive sentiment words when agreeing with team members on choosing a device for testing or final prototype submission, describing the desirable attributes of a potential prototype, and engaging in friendly discourse with teammates (i.e., "lol" and "haha"). For example, near the end of the internship, Edna, who identified as a Black woman, and her team (Jon—White man, Lisa—White woman, and Mark—Other man) discussed their final prototype and various polymeric materials (abbreviated as PMMA, PESPVP, and PAM):

Jon: Basically from PMMA to PESPVP, reliability and cost becomes better, while flux and BCR become worse.
Edna: Exactly, that's why I feel it should be b/w PMMA and PAM but not PESPVP
Jon: It's one helluva tight race.
Mark: PAM reliability is so low though
Lisa: PAM is better in Flux and BCR but is less reliable. However, both prototypes are the same cost.
Mark: I CAN'T CHOOSE
Edna: lol I know right

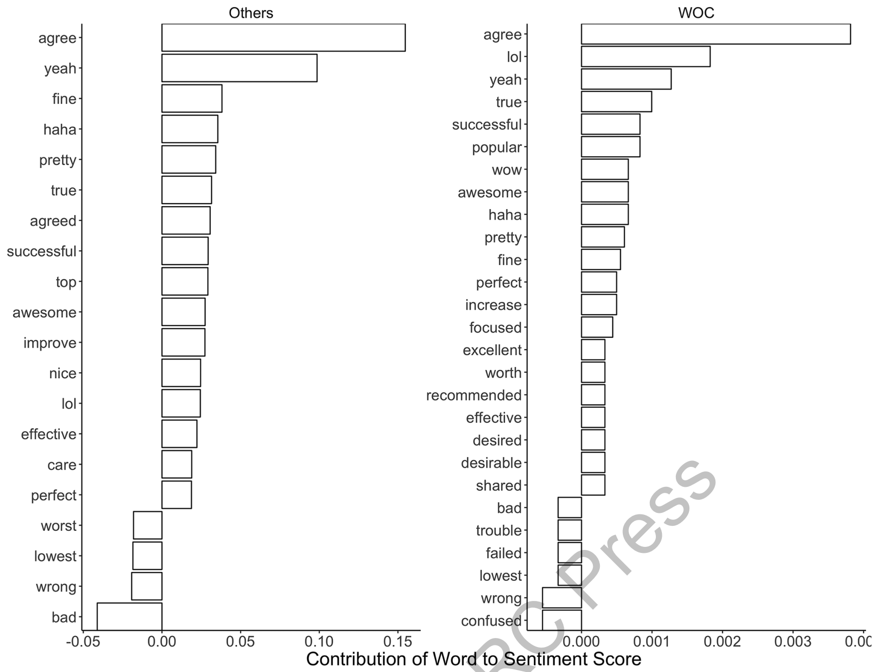

FIGURE 15.4 The top 20 sentiment contributions to each group's (women of color and others) sentiment score. Women of color have more words because of tied contribution scores.

Edna: Do we want to refer to previous results?
Edna: it may be of help

Due to conflicting parameters in choosing a design, the teammates considered tradeoffs in terms of membrane reliability flux, blood cell reactivity, and cost. When Mark comically exclaimed, "I CAN'T CHOOSE," Edna replied with "lol I know right" and offered a suggestion that the team review experimental results from previous rounds of testing.

In the few cases where women of color used negative sentiment words, these words were in the context of confusion around tasks or usability of the website. For example, Cecilia (a Hispanic woman), messaged her mentor to ask for clarification:

Cecilia: What does "a description of design attributes" mean? Do I have to talk about surfactants and other components or blood cell reactivity, flux, etc.?
Design Advisor: The design attributes are flux, reliability, blood cell reactivity, marketability and cost so I would just briefly explain what each attribute means.
Cecilia: Thanks! I was a little confused by that.

Although technical issues pertaining to the website or confusion regarding assigned tasks were coded as negative sentiments, all interactions in this category culminated with positive affect from students. Typically, positive affect took the form of thanking the person who answered their questions.

Women of color also used negative sentiment words to critically assess the performance of a prototype. For example, in a team meeting wherein students discussed potential prototypes to submit for testing, Jasmine, who identified as a Black woman, disagreed with her teammate, Allison (White woman), on choosing the polymeric material PAM:

Michael: PAM was a little on the high side of cost, but getting it down without sacrificing everything else would be difficult.
Allison: I think it is still worth testing as that is still only 4 prototypes
Jasmine: [But] Even our lowest cost [with PAM] had a super high bcr so I still don't know if we could bring that down and still have a decent product.

To gain a better understanding of how sentiment was related to the collaborative engineering design process, a coding scheme was developed with eight emergent topics related to engineering design. As described in the method, the engineering design coding scheme was created using topic modeling and word pair correlations that identified emergent themes and keywords from the chat log data. After the chat utterances were coded for the eight engineering design themes, the researcher identified utterances from women of color that were coded for both sentiment words and engineering design.

Chat utterances from women of color that were coded for engineering design topics ranged from −2 to +4 and were skewed toward positive sentiments (Figure 15.5). The topics that had the most occurrences of negative sentiment were in the categories of company cost, experimental design, and consultants (Table 15.3).

These examples suggest that women of color engaged in critical discussions about the design of their team prototypes; negative sentiment words (in the context of collaborative engineering design) were typically used to critique the design of the prototypes.

DISCUSSION

This chapter described the features of Nephrotex, an engineering virtual internship, designed to facilitate an inclusive environment for underrepresented youth in engineering. Women of color's experience in Nephrotex were analyzed via pretest and posttest survey responses and their collaborative design work. The results demonstrated that women of color had an increased sense of belonging to the field of engineering after participating in Nephrotex, according to pretest and posttest surveys. Other students also had an increase in sense of belonging, but the effect for women of color was stronger.

A sentiment analysis revealed that women of color engaged in positive sentiment more often than other students, although this difference was not significant. The positive talk involved agreeing with other team members, joking behavior, and talking about desirable aspects of the prototypes. Negative sentiment pertained to technical issues while navigating the website or confusion about tasks, but these

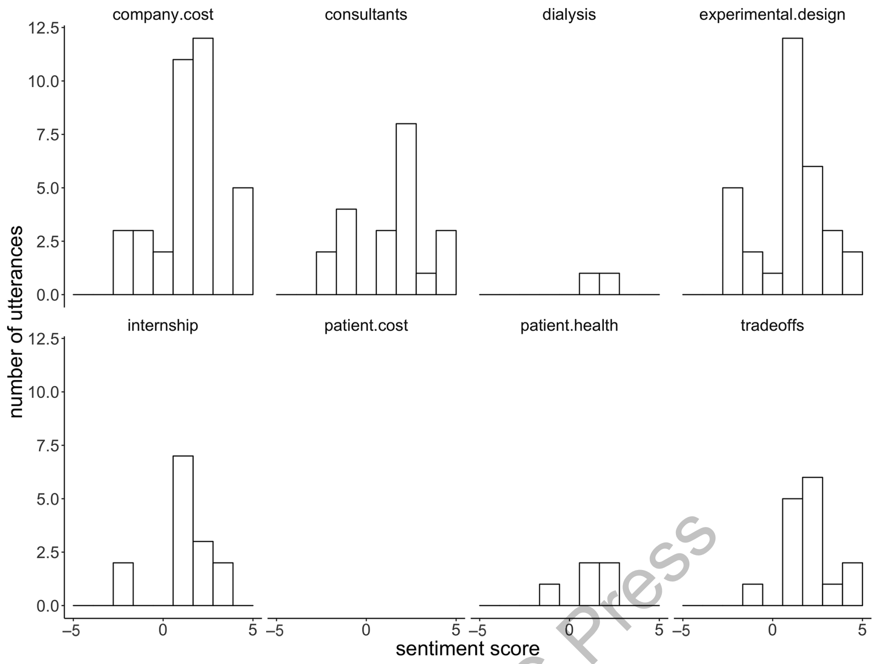

FIGURE 15.5 Histograms of women of color's sentiment scores on their chat utterances for each of the eight engineering design codes.

TABLE 15.3
Coded Engineering Design Discourse Examples and Sentiment Scores from Women of Color

Codes	Sentiment Score	Utterance
Company Cost, Consultants	−2	"The only category that we failed to meet every time was cost."
Company Cost, Experimental Design	−1	"I think prototype 4 was the best because it fit all the reliability, marketability, and flux preferred standards. It had the same reactivity as the rest. The only characteristic for which it was unacceptable was Rudy's but it's the closest we are going to get for an acceptable price with fulfilling all other requirements."
Company Cost, Experimental Design	1	"Agreed. None performed best in every one, but steric hindering performed very well overall. It was the most marketable and was the second best in reliability and the blood cell reactivity test. The only real downside is the price, which I believe is worth it for the quality of the product being developed."
Internship	2	"Do you guys want to look at my notebook? I shared it. I think what we are saying pretty much is exactly what I wrote for all 5."
Consultants, Tradeoffs	3	"Yeah I agree. Although the flux was pretty low, it still meets the threshold of the internal consultants."
Company Cost, Tradeoffs	4	"It is still important to consider, but if the benefits outweigh the costs, it is worth it. I don't really think any one factor is more important than the rest."

did not occur as often as positive talk. When the sentiment analysis was combined with the analysis of engineering design content, women of color appeared to engage in positive talk about the design of their devices. Negative sentiment was primarily related to critical discussions of a device's undesirable qualities, indicating that women of color were involved in the technical deliberations of their teams' prototypes.

These results are of importance because women of color in STEM report feelings of isolation and exclusion in the academic environment, particularly when working in teams (Johnson, 2011). This lack of a sense of belonging can negatively affect how women of color develop and maintain their identities as scientists and engineers; some may choose not to persist in a STEM career (Ong et al., 2011). In addition, women of color report that instructors have low expectations regarding their academic abilities and may view their gender and race identities as unsuitable for academic success (Neal-Jackson, 2018; Rodriguez et al., 2017). One approach for ameliorating such adversities of women of color in STEM is through the design and implementation of inclusive virtual internships.

Although direct causal claims cannot be made about particular design features affecting students' increased sense of belonging and positive experiences in this virtual internship, it is evident that women of color in Nephrotex engaged with the design features and provided tools and had positive experiences when collaborating with other students. These design features included diverse staff pages of Nephrotex employees, automatic and random team assignment, opportunities for students to contribute technical knowledge, and human mentor support through chat and email tools.

In addition, the design challenges presented in Nephrotex did not have one correct answer. Instead, students considered the tradeoffs of each proposed prototype, attempted to meet the conflicting concerns of the internal consultants, and justified their reasoning. While engaging in such authentic activity, students may adopt the identities and practices of internal consultants, design advisors, team members, or other members of the engineering community of practice. Students may also negotiate identities and practices of the community as they argue for particular design choices that they value, such as the health of the patient or profit for the company. Thus, Nephrotex offers authentic, meaningful, low-risk participation for students (Lave & Wenger, 1991) and also space to develop their STEM identities in a way that does not negate their perspectives or identities that they bring to the collaborative design process.

In sum, both the features and the engineering design problem in this virtual internship were purposefully designed to create an inclusive, positive experience for underrepresented youth in engineering. The results in this study suggest the importance of applying a critical lens for the design of digital learning environments and to challenge the ingrained design choices that ignore non-dominant groups.

Future studies of virtual internships as inclusive learning environments should include problems that are more closely to connected to students' lived experiences and offer opportunities for activism and empowerment. In Nephrotex, students designed a filtration membrane for a hemodialysis machine that is used to treat patients with kidney disease. The rates of kidney disease are disproportionately higher for people of color (Nicholas, Kalantar-Zadeh, & Norris, 2013) and thus, is an issue that affects African-American and Latinx communities more strongly than other communities. However, future implementations could offer more open-ended problem exploration, options for students to choose a design project that is personally meaningful to them and their communities, or providing opportunities to discuss the racial, historical, and social implications of design products.

Finally, the pretest and posttest surveys collected information about students' race and gender identities, but future studies should include additional demographics such as socioeconomic status and geography. Moreover, it would be beneficial to collect information about students' prior STEM experiences and their current feelings of isolation (if any) within the STEM community. Although the survey results suggested an increase in self-reported sense of belonging, this small sample of women of color in this study may not have experienced significant feelings of isolation prior to participation in Nephrotex. That pattern could explain their positive experiences in the study. In addition, the sample size for women of color in this study ($n = 14$) was small compared to the sample size for other students ($n = 546$). For future implementations, it would be beneficial to collaborate with universities and communities with larger populations of women of color in STEM and to explore differences among Predominately White Institutions and Minority Serving Institutions.

CONCLUSION

This study demonstrated that inclusively designed virtual internships were an overall positive experience for women of color and increased their sense of belonging to the engineering field. Facilitating a positive experience for women of color is critical because of their underrepresentation in engineering, the double bind that they face being in both a racial and gendered marginalized group (McGee & Bentley, 2017; Ong et al., 2011), and the lack of research on their experiences in STEM (Johnson, 2011). Moreover, the underrepresentation of women of color in STEM is an issue of social justice and, as Vossoughi and Vakil (2018) argue, requires expanding and democratizing the purposes of STEM education and transforming education such that students have access to intellectually respectful learning experiences and the resources to fulfill their individual and collective potential. Pursuing this vision involves implementing inclusive, legitimate virtual learning experiences for underrepresented youth in STEM.

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