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Counterspaces: Underrepresented Students Find Community and Supportive Learning Spaces During a Global Pandemic

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Introduction

RedShirt programs in engineering are intended to support the success of historically marginalized groups in STEM by providing alternative access pathways into engineering undergraduate programs and support systems to succeed through to degree attainment. These programs unto themselves are one means of structurally changing academic institutions by disrupting traditional admissions pathways which have historically restricted access to engineering futures. This paper extends this work by examining the experiences of particular students in RedShirt programs during a global pandemic, to further understand how these programs operate to dismantle oppressive educational barriers in the specific forms of spaces and places - like educational settings - where students can either feel included that they belong as engineers, or excluded from meaningful participation.

Background

Counterspaces, or "safe spaces" for marginalized individuals to be able to express themselves freely and challenge dominant narratives have been understood to be important in maintaining a positive self-concept for anyone outside of the mainstream of STEM education (Ong et al., 2018), or on the periphery of campus cultures (Keels, 2020c). Originating from the scholarship of critical race theory (CRT), counterspaces have been defined as "sites where deficit notions of people of color can be challenged and where a positive climate can be established and maintained" (Solorzano et al., 2000, p. 70). Counterspaces have been theorized to support marginalized populations by providing spaces for individuals to connect and be seen while challenging stereotypes and deficit-oriented cultural narratives (Case & Hunter, 2012). In doing so, counterspaces provide settings for marginalized groups to promote authentic and nuanced representations, affirm their own identities, and adaptively respond to changing conditions in order to resist oppression and exhibit resilience (Keels, 2020a).

Studies of counterspaces have included investigations of professional development programs for early career scientists (Margherio et al., 2020), discussions of how women of color in higher education navigate isolation experiences and microaggressions in STEM fields (Ong et al., 2018), and how instructors can create counterspaces within classrooms to support students of color in a formal academic setting (Masta, 2021). Our study focuses on understanding counterspaces within the context of undergraduate engineering education and RedShirt programs.

Engineering in the United States has grappled with the limitations of being a predominantly "pale and male" discipline for many decades (Wulf, 1998), despite overwhelming calls to diversify the field and broaden participation from the federal government, the National Academies, and individual citizens. While "women in engineering" and "minorities in engineering" programs were once the norm across engineering colleges, these programs were often founded from a deficit perspective, seeking to make up for what these populations apparently "lacked" in terms of preparation or experience as compared to the mainstream (Louie et al., 2017). Moving to recognize the uniqueness of students as an asset rather

than a liability, many of these diversity programs required fundamental mindset shifts to move past "remediation" to be able to celebrate the cultural wealth, special motivations and distinctive skills that diverse students bring to our engineering colleges and universities.

RedShirt programs are one example of this type of asset-based student support program aimed at broadening participation in engineering for students from minoritized racial or ethnic backgrounds or from under-resourced high schools and geographic regions (Myers et al., 2018). RedShirt programs provide an alternative admissions pathway for students who do not meet traditional admissions criteria for highly selective engineering colleges, but still have the desire and potential to be an engineer. RedShirt programs focus on building strong peer networks and communities to support academic success, communities that are initiated through required summer bridge experiences and reinforced through "high-touch" advising, study sessions, and targeted coursework throughout the RedShirt first year (Knight et al., 2021). Since the founding of the first RedShirt program in 2009, the model has now expanded to six institutions mainly in the Midwest and West to improve the success of engineering students from low-income backgrounds, minoritized within the institutions these programs are embedded in (Knaphus-Soran et al., 2018).

RedShirt programs in engineering are also a type of first year program that includes counterspace features, focused on underrepresented students and associated diversity issues (Ennis et al., 2011). Research has established the benefits of including diversity, equity and inclusion curricula into first year programming (Rambo-Hernandez et al., 2019). Preliminary research has been conducted to determine the extent to which RedShirt programs have attributes that match the characteristics of counterspaces with favorable outcomes related to retention and academic performance (Knaphus-Soran, under review). Early successes for students in these types of programs can facilitate the development of connection to the field and lay the foundation for an identity as an engineer.

Research into identity development in STEM fields, including engineering, has found that gender and ethnicity in pre-college settings are mitigating factors in identity development and that home support, parental education and discussion around engineering topics are all important factors in early engineering identity development (Dou & Cian, 2022). All of these early factors are less prevalent in students in first year RedShirt programs that enroll women, ethnic minorities, students from low socioeconomic status families, and students who would be the first generation in their family to attend college (Ennis et al., 2011). To the extent that they are constructed as counterspaces, RedShirt programs can help with the development of engineering identity through forming a strong cohort among participants, helping integrate an engineering and cultural identity and facilitating discussions about engineering as a career that includes diversity, equity and inclusion practices (Knight et al., 2021).

From a research perspective, less is known about what happens to RedShirt students as they transition into their major during the middle years of their undergraduate career (Knight et al., 2021). These years include a number of challenging engineering science and math courses with large majority populations of white males; underrepresented students can struggle to integrate and develop an engineering identity. Fewer studies have investigated their ability to find spaces that support diversity concerns in the

middle years and their ability to integrate into the larger, fast-paced classes associated with their major (Han et al., 2018).

The development of an engineering identity can be challenging in large classes that are more focused on mastering technical concepts and solving homework problems. There can be little emphasis in these classes on solving real world problems which can leave students feeling alienated. For underrepresented and diverse students in general, these problems are confounded by the intersectionality of a developing engineering identity interacting with one's personal identity associated with a diverse cultural background (Ogilvie & Knight, 2019). The present investigation delves deeper into this question of the impact of RedShirt programs on the transition into the middle years of engineering education with a particular focus on the impact of such programs on the development of an engineering identity outside of the counterspaces associated with the RedShirt programs. These investigations occurred during the global pandemic Covid-19 which added complexity to these transitions in the middle years.

This study focuses on three existing RedShirt programs embedded into the engineering colleges of three distinct sites, all public universities located in the Midwest and West. Considering race and ethnicity, University A is not a predominantly white institution, instead it is over one-third Asian, one-quarter Hispanic/Latino(a), one-fifth White, 4% African American, and almost 12% International students across undergraduate enrollment. University B includes a larger fraction of White students at 36%, but sizable enrollments of Asian students (23%), International (15%), Hispanic/Latino (9%), Southeast Asian (6.7%) and African American (4.5%). Finally, University C is truly predominantly White with over two-thirds of undergraduate students reporting as White (66%), 12.5% Hispanic/Latino, 9.3% Asian, 6.8% International, and under 3% African American. These numbers are offered to help contextualize the differences in populations that comprise each of the campuses under study, as the experiences of racial/ethnic marginalized groups is certainly different across each of the campus contexts presented here. As counterspaces have been theorized to be particularly effective in educational environments to affirm identities within same race-ethnicity peer networks (Keels, 2020b), it is important to understand what the context surrounding these race-ethnicity peer networks looks like across our three sites of study.

The present study will investigate the experiences of RedShirt students through the following research questions:
- Research Question 1: What are characteristics of physical and virtual spaces which enable RedShirt students to develop engineering identities?
- Research Question 2: How are spaces utilized by RedShirt students to form connections and identities in engineering?
- Research Question 3: How have the spaces in which engineering students live, study, work, socialize, and exist changed during the COVID-19 pandemic and after returning to in-person learning?

Methods

Data Collection

The dataset this paper focuses on includes a total of six focus group sessions convened across three study sites, with each site having an initial focus group session of approximately 60 minutes to establish a baseline and provide instructions to student participants regarding subsequent photo-elicitation data collection. Each focus group was co-facilitated by the two lead authors of the study. In the initial focus group sessions participants were asked to introduce themselves, describe their choice of major and year in school, and explain how their current semester or quarter in school was going. Students were invited to share who they typically worked with on assignments, and where they tended to work on assignments or study for class - both during the remote learning phase of the pandemic and as instruction gradually returned to in-person. Probes regarding forming study groups and transitioning into major-specific courses were employed to encourage participants to expand on their responses. The initial focus group sessions closed with instructions from the facilitators on collecting images in the following weeks related to three different prompts. Students were asked to find images or take photos each week for three weeks which captured environments which (1) make you feel like an engineer; (2) make you feel like you belong; (3) make you feel out of place.

Each focus group participant was given access to an individual secured folder on a shared cloud drive to upload their photos directly in the three weeks between the initial focus group session and the follow-up focus group session. In the follow-up focus groups, students were invited to go through each set of images, choosing their favorite to share with the group and describe the meaning and significance of the image to them. Each participant present would share their image that made them feel like an engineer before progressing to images which made them feel like they belonged, before closing with images which made them feel out of place. Occasionally students would use the same image for multiple prompts, as for some students images that made them feel like an engineer also made them feel out of place. Students were invited to comment on similarities and differences across the sets of images presented in each round. After all images had been presented, students were also asked to consider if these environments as shown in each image had changed along with the onset of remote learning during the pandemic. Each student brought around 9 images each to the follow-up focus groups; one image for each of the three weeks to address each of the three prompts.

As all focus groups were convened virtually on Zoom, focus group participants were able to share their screens in real-time to share their images with the group during the follow-up focus groups. University A included five student participants for the initial and follow-up focus groups, University B had four student participants, and University C also had four student participants. These students were recruited by RedShirt advisors and program staff at each individual institution, and incentives in the form of $50 Amazon gift cards were delivered electronically to each participant after each focus group session. Per Institutional Review Board policies, the research team was not involved with the recruitment process and did not ask the individuals for their personal demographic information. Instead, aggregate demographic data from each participating RedShirt site is available in the Background section above as a

proxy for the demographics of the students participating in the study. As RedShirt program participants tend to be more diverse than the undergraduate population at large of the institutions they are also members of, the participants in our research study generally represent more diversity than indicated by the racial/ethnic breakdown of each institution. See Knaphus-Soran et al. (2018) for details on institution-by-institution demographics and context.

Photo-Elicitation

As a method, photo-elicitation offers a chance for the participants to co-construct knowledge and meaning from data that they created themselves in the form of images collected or photos taken. While relatively new in the field of engineering education research, photo-elicitation has been used to study the development of student identities in construction (Kaminsky, 2014), uncover feelings related to belonging in engineering (Pitterson et al., 2016), and examine cross-disciplinary identity development (Hatten et al., 2013). As a newer form of qualitative data collection, social scientists across a variety of disciplines have described photo-elicitation as an immersive technique that enables research participants to "show rather than tell" (Croghan et al., 2008), particularly helpful for uncovering identity aspects that may be challenging to reveal or are hidden at first glance. Also known as "participatory photography", this technique must be employed with care so that the data collection does not cross the line from "empowerment" to "surveillance" (Prins, 2010). Photos chosen to be included as part of the results purposely do not show the research participants. With that in mind, we discuss our positionality and limitations before proceeding to present student data and results.

Data Analysis

Data analysis focused on the text from the student transcripts. Research participants used the images to better describe their experiences but analysis did not focus on coding the images themselves. Data analysis followed grounded theory techniques developed by Charmaz (2014) for analyzing qualitative data. These techniques focus on specific types of qualitative coding strategies used for finding patterns in the transcripts developed from qualitative interviews and focus groups. Three specific coding strategies were followed for this investigation. The first strategy is known as initial or open coding that is focused on finding on reviewing the text, trying to determine what is happening in the data, and uncovering initial patterns that emerge. The next strategy is focused or thematic coding which attempts to bring initial categories into themes that describe patterns across the transcripts. A third strategy is theoretical coding which brings in the research questions to look for patterns related to the literature review. These strategies produce a set of themes and subthemes and associated quotes that describe the experience of the research participants.

Positionality

Both authors are employees at University C, with limited interaction with the student populations invited to participate in the research and no prior relationships with any of the students at University A or B.

The lead author is an Asian-American woman and teaching professor, who has taught numerous courses that have included RedShirt students across all years of undergraduate. Two of the student participants

in the focus groups at University C were once students of the author over three semesters prior to the data collected as part of this study.

The second author is a white male research professor with a background in educational psychology and engineering education. This author has been involved with previous research and evaluation of the RedShirt program at University C but has not interacted in other ways with the students being investigated.

Both authors are aware of the inherent power dynamics that structure the interactions between students and researchers in the context of these focus groups. While the authors were not a part of the recruitment process for research participants, the participants know we are not students and were specifically researching aspects of the student experience related to RedShirt programs. Consequently, the students may have felt a subtle need to speak favorably about RedShirt programs or their experiences in engineering, despite our preamble to each focus group assuring students that we wanted their honest and personal experiences and perspectives.

Limitations

This study relies on data collected across six focus groups at three different sites, two focus groups at each site. While the photo-elicitation method allows for students to share images captured across multiple weeks, the entire data set does not represent prolonged exposure between the researchers and the participants. One limitation of the study is thus that the researchers did not have a deep rapport with the research participants, as we did not really know them prior to the focus groups being convened and have not touched base with them about the research since the data collection activities were completed. All focus groups were convened on the Zoom virtual meeting platform, which only allows for one speaker at a time to be heard. As a result, participants occasionally had to wait their turn to share their perspectives, and it was challenging to build a true dialogue as students who spoke up simultaneously would often defer to one another, disrupting the smooth flow of conversation.

It is also notable that the data was collected during fall 2021 and spring 2022, as these educational institutions were beginning the slow return to in-person teaching activities after extended disruptions due to the COVID-19 pandemic. Student participants often discussed their experiences with remote learning during the pandemic, drawing comparisons to how they were beginning to feel as campuses returned to a semblance of normalcy. However, as we have all experienced, society and higher education institutions are still adjusting to the "new normal" as the pandemic continues.

Results

Research Question 1

Results will be organized by research question. Research question 1 regarding the characteristics of physical and virtual spaces which enable RedShirt students to develop engineering identities yielded two themes, (1) characteristics which help with identity development and (2) characteristics that hinder

identity development. Under theme 1, helpful characteristics included spaces that had a real world component to them and spaces that were supportive of learning in ways that were easily accessible and assisted with learning difficult material. One University B student discussed the advantages of a tutoring center on campus,

> *"The IC (Instructional center) has help, easily accessible, makes it easy for students to understand hard class topics."*

Similarly, another University C student described the advantages of working in a machine shop in a design facility,

> *"So this was one of the first ones where I felt very "engineery"....we did it at (Design Facility). They have a machine shop there and then they have a laser engraver there. It was so fun, I loved it. Because I've never really, I've never used those tools before either. So it was nice to learn all those and actually get to do it yourself."*
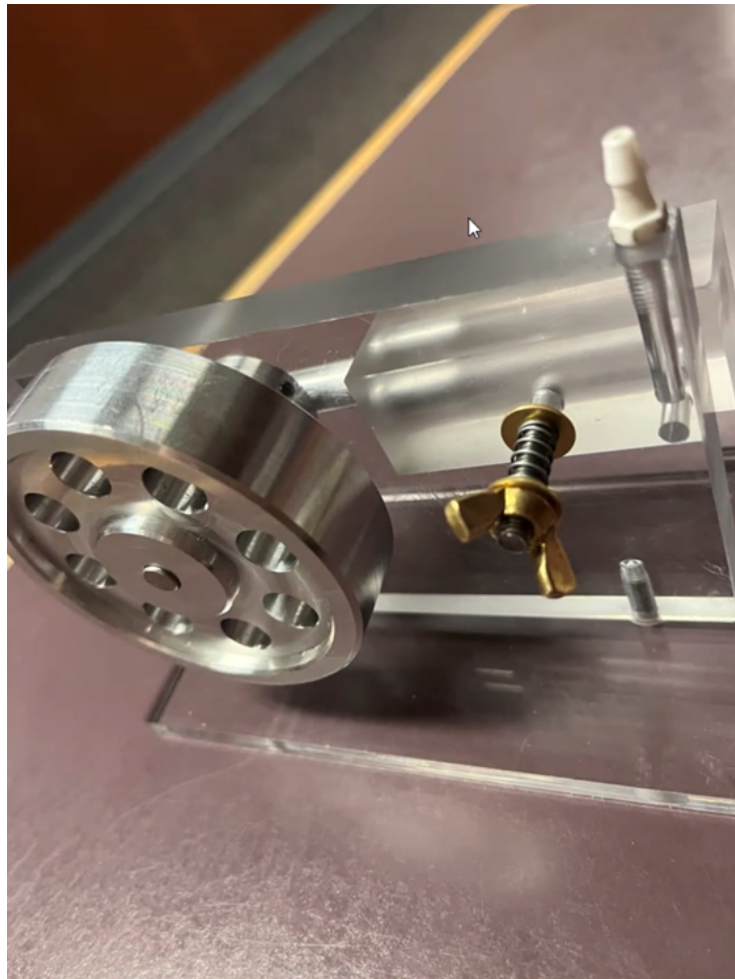

Figure 1: Part made in the machine shop used by RedShirt student

In contrast, characteristics for theme 2 that hindered identity development included both large classrooms and online spaces. Large classrooms that served as high stakes testing environments could be intimidating for RedShirt students while online environments made them feel isolated and limited connections with other students. Student comments supported these themes. For example one University B student described their photo as follows,

Figure 2: Photo of lecture hall used by RedShirt student for taking a midterm.

"…(*The photo) is one of our biggest lecture halls….we essentially sat in this gigantic hall full of hundreds of other students and took this midterm, and I definitely felt out of place in engineering after taking it, because I also did not do very well…It's also known as a weed-out class, where they make it as hard as possible to, I guess, weed out students they wouldn't want or something. It's very fast paced. And I constantly feel like one of the dumbest people in the room, because I feel lost all the time."*

Another University B student described the challenges of online environments,

"*Sitting in one place studying, it is draining to be alone all the time."*

Research Question 2

Research question 2 asks how spaces are used by RedShirt students to form connections and identities in engineering. Results revealed four themes: (1) collaborative hands on work, (2) using spaces to make social connections, (3) comparing themselves to other students, and (4) using spaces to set up counterspaces. Under theme 1, students described spaces that allowed them to design and build, both

for classes and co-curriculars, where they were able to learn how to use the equipment such as this description of a photo by a University B student,

Figure 3: Structures lab used by RedShirt a student for building a concrete canoe.

"Within the civil department, there's a structures lab where I did the tools training for it earlier in the school year. And then this (photo) is with the construction team for concrete canoe. And then this was my first time entering the lab and going to our work area. And this is the whole of the canoe which concrete gets placed on. And then that's how the canoe is created. So, I think this glimpse made me feel like an engineer because throughout my college career so far, most of our work has been just very ... Like writing, you don't actually get to see real-world applications."

Under theme 2, students described spaces where they were able to get together with other students to socialize and plan outside of the classroom setting such as crafting projects, club meetings, and potlucks. One University B student described her crafting project,

Figure 4: Cider made by RedShirt student to unwind after a test.

> *"I was like in a quiz section. I was in a class with one of my friends and afterwards we were like, "Hey, they're making cider somewhere. Do you want to go and make cider?" And we had just finished a test. I think that, I don't know. I just needed to unwind a little. So, we went and made cider and I felt like, I don't know. It was a really nice evening. And it was unique. And I think that being able to go through unique experiences with people you meet at (university) made me feel a lot like I belong."*

RedShirt students also discussed the benefits of living in dormitories and apartments with each other where they were able to build relationships.

For theme 3, students used spaces to discuss and make comparisons with other students related to their performance on assignments and in classes. Positive comparisons enhanced identity and connection while negative connections hindered identity development. One University C student commented along these lines,

> *"(The Photo), it's from my fluids class. He was trying to explain the homework and I didn't understand what he was saying or what equations he was using, but some of my friends did understand it and it made me feel like I didn't belong. It made me feel out of place."*

Finally, for theme 4, students were able to participate in couterspaces in some spaces where they were able to interact in settings that were more supportive of their diverse backgrounds. Examples included a RedShirt specific summer bridge and ethnicity focused society meetings. One RedShirt student commented,

> *"So this is a picture for my summer bridge. Here was most of the guys from my cohort, and the reason I chose them was just because I was kind of scared coming into (the) culture and college in general. And I just forced myself to make friends at first. And I was like, 'I'm not sure how many people (I will) actually end up being friends with long term or maybe they won't even like me.' And then three years later, and I still stay very close in touch with the majority of the people in this picture."*

Research Question 3

Research question 3 targets the changes to spaces during the global Covid pandemic and how these changes played out during the return to in-person learning. Analysis of the data revealed three themes: (1) increased appreciation of in-person learning, (2) challenges related to moving back and forth and the loss of hands-on learning opportunities, and (3) impact on belonging and the way RedShirt programs mitigated this impact.

Under theme 1, students described the benefits of being in-person for learning including the ability to form study groups, interact with instructors in the classroom to improve understanding, and using hands-on spaces. One University A student discussed appreciating all in person access to facilities,

> *"During the pandemic, we didn't really have many chances for hands on experience or 3D printing. I know on campus, there's a design studio that I wanted to check out, but I never got to in my first year because we went into quarantine. Now that I'm in my lab, I get really excited whenever I get to use like a 3D printer, a laser cutter, just that I now have the ability to get all these hands-on experiences that I didn't have before."*

Under theme 2, students discussed the challenges in terms of setting up study routines and getting their schoolwork done and then having to change them when the mode changed in response to the pandemic. One University C student commented,

"So for me it's been a lot of difficulty with consistency of how I learn, that's been an issue. I saw really a lot last semester where the first two months, I just could not figure out what's a good time to study or what's a way to study on campus that works for me because over the whole year prior I was just at my desk the whole time. So I guess a lack of consistency is what I was struggling with."

Finally, under theme 3, students discussed the benefits of the RedShirt program in terms of providing study groups including those living in the same dormitory as them and social connections to other RedShirt students. One University A student described this experience,

"It was hard for me to make new friends and then the pandemic came so I kind of just stuck to the (University A) people because we had a lot of similar classes. So if it wasn't for (University A), I literally wouldn't have had anyone to ask for help or anything throughout the year and a half we were remote."

Discussion

Summarizing across research questions, RedShirt students built an engineering identity and found belonging in smaller spaces that were easily accessible and supported their learning such as labs, machine shops, and tutorial environments. Students also expressed a preference for hands-on, real world projects to build a connection to the field.

There was a tendency to struggle with issues related to the transitioning out of the RedShirt program and into the middle years. The RedShirt programs provide supportive environments particularly in the first and second years, so RedShirt students faced challenges when they had to work with larger, more competitive environments and students. RedShirt students struggled with identity in larger classrooms and big testing environments where they felt judged or compared themselves unfavorably to majority students. Some RedShirt students also struggled in online environments prevalent during the pandemic where they were unable to connect with other students.

RedShirt students also reported a sense of belonging and identity in co-curricular activities such as clubs and societies where they could get together with other students who had similar interests. Some of these co-curricular activities had characteristics of a counterspace such as the Society of Asian Scientists and Engineers. Another example is a summer bridge program where RedShirt students make connections with their RedShirt cohort before beginning their first semester. Here students could work together with other underrepresented students, build connections and avoid the negative feelings associated with high stakes testing environments.

RedShirt students reported struggles during the shifts between in-person and online learning during the pandemic. They had a difficult time connecting with professors, study groups, and other students in the online format and struggled to find a consistent study strategy while switching back and forth. Students

gained an appreciation for the value of in-person learning during this time and gave a lot of credit to their RedShirt programs for helping them stay connected.

These results are in line with previous research that has found that counterspaces, such as the RedShirt summer bridge program, can build lasting connections with other underrepresented engineering students that will last into the middle years of their academic pathway (Case & Hunter, 2012). Results are also similar to previous studies that found underrepresented students struggle with identity in large engineering science courses common during the middle years that contain less material that is connected to the real world (Ogilvie & Knight, 2019). Recommendations for supporting students in the middle years of their program would include building intrusive advising strategies into major specific advising, forming additional supportive counterspaces within the major similar to those found in RedShirt programs, and expanding the reach of RedShirt programs to include supportive aspects beyond the first and second year for participating students.

Future research should investigate the fit of these types of programs with changes in admissions and affirmative action policies such as the elimination of standardized testing requirements. Positioning of these RedShirt programs within this changing context should be investigated to determine the future of diversity serving programs in engineering.

In conclusion, Redshirt students faced a number of challenges finding belonging and building identity as they transitioned to the middle years of their undergraduate academic careers. These challenges were increased by having to negotiate transitions from online to remote learning during the pandemic. Redshirt students did find spaces outside of the RedShirt program context that offset these challenges such as learning environments that focused on hands-on and real world experiences, and co-curricular settings that allowed them to build connections with other students with similar interests and backgrounds.

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