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Engineering a New Reality: Using virtual reality to cultivate inclusive mindsets among engineering faculty

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I. Introduction

Background

Inclusion, [from latin inclusio -onis] by social sciences is described as "the idea that everyone should be able to use the same facilities, take part in the same activities, and enjoy the same experiences, including people who have a disability or other disadvantage [1]." This definition from the Cambridge Dictionary is then reinforced with "The act of allowing many different types of people to do something and treating them fairly and equally [1]." It is stated to be a social responsibility. Along the lines of responsibility, the American Society for Engineering Education (ASEE) discussed the topic of inclusion in its 2017 statement regarding diversity describing that even if the amount of people from underrepresented communities in engineering had increased over the years, there remained a significant amount of work to be done to achieve diversity and inclusion [2]. It was further stated that institutions should commit to training community members—administrators, faculty, staff, and students—on the subjects of inclusion, equity and implicit bias. In 2018, ASEE changed its statement on diversity by uprising the need from the engineering community to act on creating awareness in stating "no individual should experience marginalization or non-inclusiveness of their contributions or talents because of visible or invisible differences [2]."

Universities have the role of shaping future generations by contributing significantly to the development and sustained belief in freedom and equality between people, communities, and societies [3]. The principles of a democracy therefore have to pass from intermediaries such as faculty and staff members that might not be educated in such subjects enough to recognize implicit bias or behaviors that contradict the promotion of inclusion. Researchers have shown that more than 75% of the population holds an implicit bias towards some marginalized group [4]. This sort of behavior could be potentially damaging for institutions while also inhibiting their ability to truly move the needle in establishing inclusive cultures.

One of the major limitations in this space is the fact that most members of the engineering community have no training on diversity and/or inclusion. To better understand how norms are embedded in the culture, an added focus must be placed on other individuals in the environment, such as the faculty, and the roles they play in socially constructing the culture through their interactions with colleagues or students in the classroom and research settings. Particularly, when we think of faculty as being on the frontlines of student engagement, they take on a role as the gatekeepers of culture. And yet, little is known regarding the extent to which faculty espouse values and perceptions of inclusion, which are critical to establishing an inclusive culture.

Historically, scholarships, service and grant dollars of engineering faculty have out prioritized efforts to cultivate inclusion, which seldom make the list of explicit tenure requirements. This devalued significance of inclusion is a fundamental barrier to transformative change. Essentially, faculty are placed in classrooms with little to no information regarding their perceptions, attitudes and behaviors toward inclusion or their ability to empathize with people outside of themselves. Institutions advocate explicit and intentional messages around inclusion, and yet, there is little institutional infrastructure to ensure and/or facilitate that faculty also espouse

inclusion and empathy as core values. One obvious way to incentivize faculty to prioritize responsibility for cultivating a culture of inclusion would be to have explicit metrics around inclusivity embedded into the tenure and promotion process. However, until that becomes a reality, the institution must find creative ways to provide continuous opportunities for faculty to be exposed to and engage in inclusive and empathetic awareness promoting activities. Additionally, faculty have not been held accountable for their roles in contributing to the cultivation of inclusive cultures and have had minimal exposure to trainings with the potential for sustained impact or ability to shift mindset. It is imperative that we begin engaging the engineers in the environment as a means of identifying ways to cultivate inclusive cultures.

Rarely are intentional efforts to learn to be inclusive or empathetic embedded in formalized training as an engineer. However, Kaufman and Libby described experience-taking as an effective way of changing mindsets and hearts—showing changes in participants' goals, attitudes and behaviors fostered by a reduction in the self-concept that allows for the taking on of the thoughts, feelings and traits of another [5]. The potential to change mindsets exists and both inclusion and empathy are teachable and learnable constructs. What if engineering faculty could be exposed to a host of underrepresented individuals and their experiences directly through an immersive virtual experience?

Literature, story and media commonly enable us to transport ourselves into the experiences of a character who is very different from ourselves. Immersive experiences in virtual environments present a novel opportunity of taking a walk in someone else's shoes. This vicarious, yet real-to-life experience, facilitates a heightened level of awareness and in other arenas has shown promise as a means of changing attitudes that lead to changed behavior [8]. By increasing their own awareness and understanding of the experiences of marginalized people navigating engineering environments, individuals could potentially have an opportunity to confront their own 'inclusion privilege'—referring to a phenomenon where those who already feel included often fail to recognize inclusion as an issue, perceive the barriers to inclusion faced by other engineers or see the need for action to remove those barriers [6].

A growing body of evidence for analogous techniques verifies the effectiveness of simulated experiences. Techniques targeted at creating or sharing the experience of another have been used in many applications and are referred to by many different names—role-playing and perspective or experience-taking [7], player focused story-telling through games and 2-dimensional simulations [8], and voluntary mimicry [9], [10] to name a few. Attempts to address implicit bias and inclusiveness have been made by multiple researchers, a great example is the creation of the game *Fair Play* [8]. However, the game provides a third person experience and does not enable the user to experience embodiment of the main character. Therefore, although the approach is valuable, it fails to generate the bond between the character, Jamal Davis, and the user that would more naturally evolve in an IVR experience.

VR is the only modality through which an individual, in a safe space, can directly encounter challenging situations without negative consequences and through the directness of the experience have the potential to create a level of sustained awareness that could influence mindset and behavior. Interaction within a virtual environment is qualitatively different from interaction on a desktop system enabling capability for mobilization of the participant's whole body in the task [11]. Specifically, immersive virtual reality (IVR) provides an effective way of

generating a first-person experience not limited by the constraints of reality, possessing the ability to essentially create the impossible in a potentially transformative way. Virtual technologies are transforming our external experiences by focusing on the high level of personal efficacy and self-reflectiveness generated by their sense of presence and emotional engagement [12].

The power of IVR is its ability to enable a person to change their body representation, i.e. gender, race, age, ability status, etc., in a process known as virtual embodiment. In IVR, when the individual looks down towards themselves in the VR environment, they see a programmed virtual body, or avatar, substituting their own body. This creates the ability to walk in someone else's shoes to experience their perspective in a seemingly real way without judgement being cast and people feeling exposed. Virtual reality can allow experiences of taking on another's identity to reduce prejudice and are likely to become more commonplace and more convincing in the future as altering self-perception could serve as a novel technique to increase empathy and decrease prejudice towards other social groups [11][12][13][14].

Evidence shows that IVR can be a powerful tool for education and training with research in higher education showing direct benefits of IVR on learning [15][16]. Virtual embodiment has been shown to influence agency, ownership and interpersonal attitudes through experiences that enable the possibility of experiencing another person's perspective first-hand. It is quite plausible that similar transformations could occur in IVR for engineering faculty to temporarily transfer into the student—veteran, person with a disability, woman, woman of color, LGBTQ individual, low socioeconomic status or first-generation perspectives—to live firsthand some of the marginalized experiences that 'inclusion privilege', power and implicit bias commonly circumvent. IVR shows promise as a tool to influence the development of empathy towards people, careers and identities that are not our own.

IVR has this potential because of the power of narrative. Stories make things familiar and concrete [17]. More than just passively receiving a story, IVR creates the opportunity for people to be inside the story and experience it from a first-person perspective. From a psychological perspective, IVR is a subjective experience that cheats an individual out of an illusion making theme feel as if the experience was real [12]. This induced sense of presence enables a feeling through this media that is not afforded by any other mechanism. The experience of IVR engages multiple modalities of experience—sight, sound and even more commonly, haptics. This experience creates an environment beyond the capabilities of text, a lecture or even a video. The opportunity to experience something real and direct formulates a concrete experience that stands to have more lasting memories and impact.

B. Research Purpose and Questions

Past efforts to foster inclusion have primarily focused on the numbers and been limited in the ways we teach, train and expose people to learning inclusiveness and empathy. Moreover, such efforts are also linked to the misconception that increasing demographic representation necessitates an inclusive environment. Cultures must change to achieve inclusion. The role of the faculty in shaping culture, specifically in engineering, is critical and yet, understudied. Through faculty, this project seeks to address a major area of engineering research, broadening participation, in a novel way. Specifically, rather than focusing on increasing the representation

of a particular demographic, this study aims to identify methods that could be used to promote the cultivation of more inclusive engineering environments. Striving for inclusion in the absence of critical masses will stand to introduce a new way of prioritizing and acting around diversity and inclusion. The goal of this project is to investigate whether experiences of embodiment promote inclusive and empathetic awareness among engineering faculty. The guiding hypothesis is that immersive experiences in virtual environments will be an effective way of promoting a heightened awareness of the experiences of others that enhances individuals' capacity to think inclusively and empathetically.

This work in progress study represents the development of a pilot phase that will set the groundwork for a larger, nationally focused project to study faculty in a way that would promote the cultivation of more inclusive environments. This work serves as the first step towards investigating whether and/or which IVR experiences stimulate greater inclusiveness and empathy among faculty. This work will yield insights describing the power and potential of immersive virtual reality experiences and inform our understanding for the development of future scenarios. It is anticipated that through this initial work challenges to using the IVR approach (i.e., what factors might make IVR more or less successful for this purpose) will be identified.

Specifically, this work will address the following research question:

RQ1. In what ways might participation in immersive virtual reality experiences promote empathy, impact shifts towards more inclusive mindsets and result in corresponding behaviors that cultivate inclusive environments?

   A. How might exposure to complex and delicate scenarios enable engineering faculty perceptions to shift towards being more inclusive?
   B. How might exposure to complex and delicate scenarios raise an awareness that fosters empathy for engineering faculty?
   C. How might perception of the physical world change when virtual embodiment pushes the boundaries by what is felt and seen in the virtual world?
   D. How might mindsets, and ideally behaviors, be modified by being exposed to the marginalized experiences of people navigating engineering environments?

When answered, these questions should allow us to gain a better understanding of the potential for IVR experiences with specific scenarios to cultivate empathetic and inclusive mindsets for faculty and thus support the cultivation of inclusive environments, overall. We are reminded that individuals stand to learn from the experiences of others; as ASEE states "We learn from experiences, beliefs, and perspectives that are different from our own [2]." This work gives individuals a window into the world of others. Establishing what will be the process of getting to the answers for RQ1A will be the focus of this paper.

II. Methods

A qualitative method approach is required as there has been relatively little research examining the experiences of people navigating engineering environments as it relates to faculty interaction with marginalized students and their perceptions of these groups. The scenarios, derived from the literature review and data from focus groups interviews, addresses issues such as ableism, gender stereotypes, homophobia, racism, etc., and presents experiences shared by multiple people to

represent common encounters to specific groups in engineering rather than unique individual experiences that may more likely represent outliers. The research team has developed, and continues to develop, virtual reality content in-house to provide exposure to the marginalized experiences of people navigating the engineering environment.

A. Participants

Institutional Review Board approval to conduct this study was received. The pilot study aims to expose 15 faculty and 15 students to the experiment. Participants are recruited based on their affiliation with engineering as either students or faculty. All student participants receive an Amazon gift card for their participation and participating faculty are recognized as Virtual Reality (VR) Inclusive Scholars, which includes a letter sent on their behalf to their Dean acknowledging their efforts to support work on inclusion in engineering. At completion of the data collection, the project participants will receive a customized report to advance their own understanding and potential behaviors towards cultivating inclusiveness that could support them personally in their learning/teaching and research.

B. Equipment

The VR experience is powered by a Dell Precision 7920 Tower equipped with an NVIDIA GTX 1080 Ti to ensure the hardware is capable of supporting any stress from the software in terms of resolution and framerate. The chosen headset is an HTC VIVE VR System with a VR Deluxe Audio Strap. HTC is one of the leading VR headsets manufactured and at the moment of selection was the best hardware solution. The general requirements to run the software match the minimum requirements of the HTC VIVE System [18].

C. Procedures

All participants will be subjected to a pre- and post-instrument for screening their baseline levels of inclusiveness. Following completion, each participant will also complete a qualitative reflection on their experience.

This pilot phase of the work will investigate 10 participants (5 faculty and 5 students) from each of three different conditions. The first sample of 10 participants will be invited to read a script that contains the same dialogue presented in the IVR scenario. This group's condition will represent exposure to the content, but with the participant having to envision the characters and voices involved. This will simulate the content only (CO) condition. The next sample of 10 participants will be exposed to the video of the scenario played by actors. This group's condition will represent seeing the interaction of the scenario, but observing it from a third-party perspective. This will be the content and context without immersion (CC) condition. The final 10 participants will experience the IVR and represent experiencing the scenario first-hand as the participant will become the avatar experiencing the marginalization in the scenario. This group will constitute the content and context with immersion condition (CI).

In all groups, participants will be informed prior to the start of the test that they are free to withdraw from the study at any time and that their participation is completely voluntary.

Participants experiencing the VR simulation will receive a basic introduction to VR enabling them to be mindful of the expectations and also understand the ways to maneuver in the IVR experience. For many, it is their first-time using VR, so the orientation is beneficial to not interfere with actual data collection and/or effectiveness of the embodiment experience.

Lab personnel get the participant equipped with the headset and position them to the starting area for the experience. Once the experience has been initiated, participants are able to proceed at their own pace and are followed at all times to ensure their safety and awareness of the surrounding space. After completing the scenario, they will be administered the post-screening instrument to capture any changes from their pre-screening score. One-week post the experimental testing, but not to exceed 10 days, participants complete a reflective interview, which allows participants to describe their immersive experience. In this qualitative interview, participants are prompted to discuss what, if anything, from the scenario most resonated with them, recall any things they found particularly challenging or informative and describe whether they felt it had an impact on their inclusive awareness.

D. The Scenarios

When the full study is completely developed, the experiment will involve 6 immersive scenarios. Participants in this pilot phase of the study will experience one scenario where they become the character, Becky Nelson, a female avatar with an Afro-Cuban intersectional identity. The character is introduced to the participant by mirroring, an approach where the participant looks into the mirror seeing the avatar that responds to the movement of their own limbs to convey that they are now this avatar in the scenario. In this particular scenario, Becky Nelson is applying to work with a renowned research professor at predominantly White institution. The participant is first introduced to Becky in her living space as she prepares for her interview. Several cues regarding Becky's identity are presented through her surroundings (i.e., that she is a mother) and the participant is given context regarding her background

Figure 1. Character Becky Nelson in IVR view.

experiences and current priorities. The major interaction of the scenario takes place when Becky arrives to the office of Professor White for her interview where she becomes the target of several microaggressions relating to traditional gender role prejudicing, ascriptions of her intelligence and perceived meritocracy. The dialogue develops organically as Becky, the participant, is provided real-time response options in conversation with Professor White. The conversation is broken up into several segments and at the conclusion of each segment, participants are asked to identify the presence of specific issues in the scenario. The issues highlighted are racism, sexism, stereotype, prejudice, microaggression and implicit bias, which are also defined consistently at each checkpoint for participants to convey whether they identified any of the stated issues in this last experienced part of the scenario. This enables the evaluation of the participants' inclusive literacy, knowledge of relevant terminology and ability to make connections between definitions and actions. At the conclusion of the scenario, participants record an audio reflection of their

experience as Becky Nelson. This reflection will later be compared to their reflection in the qualitative follow-up to observe if and how their sentiments vary with time elapsed to process their experience.

E. Data Handling and Design

The Virtual Reality module has multiple parts in which the subject has to respond to questions orally. The developed program automatically transcribes the responses of the participants into a .txt file, and this is the primary source of data to analyze their in-scenario responses. The majority of the data gathered from this study will come from interactive choices during the scenario, self-reflection and a multiple-choice survey at the end of the scenario. However, the reflective interviews will serve as a critical source of data as it will enable participants to articulate their perceptions of the immersive experience as well as whether they felt exposure to the scenario was effective at increasing their awareness of or empathy for the experience of marginalization common to specific people in engineering.

III. Anticipated Findings

The majority of the efforts to date have been on developing the scenario content. This is an extremely arduous process as it must balance achieving being true to the actual marginalized experiences while also making sure each participant experiences core overlap in the scenario as one attempts to make the experience immersive rather than passive. The next step is to expose faculty and students to the immersive experiences. It is anticipated that this approach will have the potential to enhance awareness that could lead to behavior changes and influence shifts towards more inclusive engineering communities [2][5]. As perspective taking has been demonstrated to be an effective method [7], we expect that participants will be able to embody the character Becky Nelson and fully encounter her perspective as a first-hand experience. It is quite possible that many members of the engineering community will be unfamiliar with some of the experiences encountered in the scenario. Such is the goal. It is anticipated that such is necessary to create the awareness needed to generate empathy and impact inclusiveness. This pilot is our attempt to investigate whether immersive experiences show potential at being able to achieve such in this context. Furthermore, it is anticipated that comparison across the different condition groups will show variation in the degree to which participants are able to experience the scenario, given that both the video and reading experiences are third person felt compared to first-person immersive.

Further, although the focus is on faculty, students were added to the study with a particular goal in mind. It is intentional that 50% of the students recruited for participation will share at least one of Becky Nelson's marginalized identities (i.e., be a woman, Black, Latina, non-traditional student, have studied at a Historically Black College or University (HBCU)). By doing this, we include students that may be more likely to have had similar experiences and seek to use their input regarding the integrity of the scenario as an indication of how closely the depictions accurately capture the essence of the experiences of the marginalized. A similar way of vetting will be conducted for each scenario as it is developed and the feedback from the individuals will be used to tweak the scenario to be most representative of their actual experiences.

It is the hope that this pilot study will demonstrate an increased faculty awareness—as marked by potential acknowledgement of their own privileges, power, implicit biases or behaviors—and a potential of immersive experiences to inform a shift in mindset. This increased capacity, or shift in mindset, could potentially lead to more inclusive attitudes and behaviors among people navigating engineering environments. From the available literature surrounding cultivating inclusive cultures in engineering, we believe this novel approach to cultivating inclusive and empathetic mindsets could have promise for engineering environments and beyond.

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