

Using Augmented Reality to Explore Gender and Power Dynamics in STEM Higher Education

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We report on results from a pilot study that used Augmented Reality (AR) to explore gender and power dynamics in STEM Higher Education. The so called “leaky pipeline”, affecting retention and recruitment of women in higher education fields of Science, Technology, Engineering and Mathematics (STEM) is a well-documented issue. We conducted a co-design workshop with six academics, asking to reflect on an AR storyboard prototype, discuss aspects of personal and professional identity, and imagine alternative endings for the storyboard. The storyboard depicted a hypothetical workplace conflict involving an episode of gender-based discrimination. Participants collaboratively imagined possible responses to the situation depicted using a combination of paper-prototyping and open discussions. The found themes were that 1) reflecting on personal identities can drive empathy and understanding for others; 2) co-creating the AR experiences was an engaging way of scaffolding these reflections, and 3) the co-created AR prototypes offered constructive and community-centred approaches to supporting diversity. We contribute a preliminary format for an identity-based AR co-creation workshop and opportunities for applying AR to support dialogue on gender and power dynamics.

CCS CONCEPTS • Human-centered computing → Systems and tools for interaction design; Human computer interaction (HCI)

Additional Keywords and Phrases: Augmented Reality, Co-Design, Diversity, Gender, Equity, Empathy

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1 INTRODUCTION

The underrepresentation of women in Science, Technology, Engineering and Mathematics (STEM) higher education is a well-known and documented problem in Australia [1] and worldwide [2]. The problem is particularly felt in technology-

related disciplines like engineering and computer science in which as little as one in 6 professionals are women [1]. There is a problem in recruitment but also in retention – many women choose to change fields of study or careers [3].

There is a growing body of research using virtual and augmented reality for social change and activism (e.g. [4]), equity and inclusion [5] and learning empathy and prosocial behaviour (e.g. [6]–[9]). In the space of gender equity, many interventions have looked at VR to deliver immersive experiences (e.g. [10]). Very little research has explored the new opportunities offered by Augmented Reality, for example, its inherent situatedness, availability on a vast range of devices, and its social nature.

Our research is aimed to explore how the immersive experience that AR makes possible can help with creating more inclusive cultures, narratives, and challenge stereotypes in STEM in academia. We piloted a co-design study with 6 computer science early career academics, 3 women and 3 men from various cultural backgrounds. The participants were shown an AR prototype featuring a story on gender-based discrimination and asked to discuss and design an alternative ending to the situation. The pilot involved two phases, one asynchronous online activity that participants completed individually, and one workshop in which participants collectively reflected on a prototype.

Key findings of this pilot were that 1) reflecting on personal identities can drive empathy and understanding for others; 2) co-creating the AR experiences was an engaging way of scaffolding these reflections, and 3) the co-created AR prototypes offered constructive and community-centred approaches to supporting diversity.

Our contribution is twofold: firstly, we offer a preliminary format for the identity workshop, a method to reflect on the interplays of personal and professional identities, narratives, and stereotypes; secondly, we contribute opportunities for applying AR to support dialogue around gender and power dynamics.

This paper is structured as follows: first, we briefly describe the background of the gender representation issue in general in STEM in academia and then more specifically in technology and HCI. Next, we describe our methodology in detail. Then we discuss the findings of the pilot and finally offer our conclusions and suggestions.

2 BACKGROUND

In Australia, only 29% of STEM university-level qualified people are women, compared to 63% of women in non-STEM fields. [1] Furthermore, out of the STEM fields, women are most under-represented in technology (23%) and engineering (15%) [1]. In the Human-computer interaction discipline there is a generally less unbalanced gender distribution compared to computing more generally [11]. However, as McKay and Buchanan noted [12] many indicators, such as the list of ‘top published’ authors, remain male dominated [12], likely a consequence of the ‘glass ceiling’ hindering the careers of female academics. Gender is not the only or the most important, aspect of diversity, and intersecting identities of a different race, religion, financial status, and cultural background may have a compounding effect on discrimination [13]. However, most of the data and research available are specifically about women, often because gender data is generally more publicly available [11].

Many women do not leave STEM degrees because of a lack of competence, but because of a lack of motivation, usually stemming from a culture that undermines them [14]. Surprisingly there is a lack of attention placed on how computer science and engineering faculty staff can contribute to creating an inclusive culture for diverse students [13], [15]. This can be seen with STEM initiatives that aim to recruit a more diverse base of students without also actively advocating for inclusive culture [16]. Female and nonbinary students report technology cultures as “dude culture” [17] where they do not feel included without changing themselves [18], they face low expectations of their abilities [19] and sexual harassment [14]. The often questioned, but well-alive stereotypes of the innately brilliant, anti-social, white male, can deter many people that do not suit the stereotype. On the other hand, the false idea that women are not naturally gifted

in mathematical thinking or programming can lead to the anxiety of conforming to this stereotype which ironically has been shown to worse performance [20]. This phenomenon is known as the “stereotype threat” [21], [22]. These expectations often create a gap in the skills between women's and men's mathematical or programming skills even before studying at university level. [14] These barriers are shown to lead to lower self-efficacy, a person's belief in their own skills and abilities, which is directly correlated with the motivation of persisting in their studies [22].

2.1 Existing Interventions

The lack of diversity in computer science has led to calls for interventions (e.g. [23]). Diversity training historically has evolved from compliance to be seen as a valuable competency and a business advantage [24]. Diversity in teams leads to better outcomes that can serve a wider group of people [11]. No diversity in teams could lead to overlooking certain aspects of product design, some examples including research, that indicates that it is more likely for women to feel sick when using VR [25] and tests of face recognition tools that were found to only recognise white faces [26].

Diversity training can be met with resistance and perceived as “politically correct nonsense,” [27]. People with already existing high prejudice could perceive diversity efforts as a threat to their identity. Fein and Spencer theorize that prejudice is a way of self-affirming, and to reduce prejudice some other manner of self-affirmation should be provided, or the perceived threat to self or group identity might result in more discrimination [28]. This type of resistance to addressing any issues of diversity is common, especially in fields that are predominantly white, male, and heterosexual [29]. Studies show that diverse environments benefit men, or the “majority group” since when stereotypes are questioned, men have more freedom to express themselves in ways that are less traditionally conforming [30]. Framing these efforts in a way that benefits everyone is more likely to be received well.

Evidence shows that well-designed interventions, especially ones that include a reflective element are shown to be more effective in promoting change in the numbers of representation [24]. Interesting examples include a board game, the Workshop Activity for Gender Equity Simulation (WAGES), that allowed exploring the additive effects of gender bias through gameplay. This setting provided a lot of information, without evoking reactance and instilled more empathy and confidence in the ability to act compared to other conditions in the study [31]. A study with STEM faculty from 4 universities in the US showed reduced bias against women in STEM relative to control group participants after a brief diversity training [32]. Another promising intervention conducted at the University of Wisconsin-Madison showed increased willingness to address gender bias and greater awareness of it, compared to controls [33]. Video-based interventions for diversity in STEM, VIDS, showed in two studies that an intervention can increase awareness of gender bias and reduce sexism [34]. These studies show promise that well-designed interventions can be used in reducing gender bias.

2.2 Immersive interventions

Milk dubbed VR as the ultimate empathy machine [35] and this has brought a lot of excitement but also critique. Many interventions aiming to increase inclusivity refer to these as empathy training or empathy learning, idealising the effect of “walking in someone else's shoes.” This has evoked hope that virtual reality and other immersive technologies could be a tool for reducing bias.

Studies show promise that XR (Extended reality – an umbrella term for Virtual, Augmented and Mixed realities) facilitated empathy can decrease individual prejudice, for example, different gender, race, or financial background, can be increased with immersive virtual interventions (for example, [7], [36], [37]). Yet it is challenging to present nuanced, complex, and often controversial topics in a format that has a limited potential for reflection, which might lead to

misunderstanding. For example, Nakamura [38] raises concerns that these XR interventions create a superficial feeling of experiencing and understanding other's perspectives, thus helping the creators and players to feel better about themselves rather than helping the communities in question. Rouse [39] critiques the instrumentalization of empathy and argues that seeking quick, easy, and painless methods using XR to unlearn prejudice falls short of actual change. These concerns highlight that the marginalised or misrepresented communities should be included in the design and development of tools or interventions like this; and that the tools are not a silver bullet to more inclusive communities but should be seen as a way for enabling and facilitating conversation on sensitive topics.

Despite these challenges, the allure of technological solutions is the potential for scalability, compared to resource-heavy face-to-face deliveries or interventions. An overview of studies showed that XR positively impacts the learning experience by increasing levels of learners' confidence, interest, and motivation [40] Coley argues in her positioning paper [41] that immersive virtual technology has the potential to train faculty about minoritized experiences and should be further investigated. A recent study in Geoscience faculties from 27 universities in the United States showed that mixed reality stimulations increased self- and collective efficacy in addressing diversity, inclusion, and equity. [42]

2.3 Why AR? The importance of place and narratives

Augmented reality layers virtual content on top of the actual lived world connecting both virtual and reality. The affordances of AR include having the virtual experience situated within the real world [43]; increased place attachment [44]; and the possibilities to explore dismissed or alternative perspectives – making the invisible visible [45].

While early research on AR hardware can be dated back to the work of Sutherland [46] several decades ago, more recent definitions highlight the quality of AR as a novel 'medium' characterised by complex and semantically meaningful interactions between the material world and digital representations, see e.g., Azuma [47], [48]. Compared to virtual reality, where the experiences are situated in fabricated worlds, where creators have control over what the user sees or does not see; augmented reality has the potential for serendipitous events and more natural connections to the real world. We see this as a benefit – while the virtual simulated layer might add a comfortable distance to a potentially difficult topic; it is still grounded to the user's location, reminding them that these things are happening in this place, in this community.

Engaging with location-based augmented reality games is connected to increased attachment to a place. [44] Place attachment, the bond experience by a person towards a location, is linked to numerous benefits: research shows it can increase feelings of belonging, safety, and wellbeing [44], [49]. When people have a meaningful connection to their environment, they tend to care more about it. This increased pro-environmental behaviour is shown to link to increased willingness to contribute to community or organisation culture. [49] The place is a key driver for participating in conservation campaigns and fosters a sense of stewardship and custodianship [50], [51] Especially in contexts in which narratives are recognised as a powerful vehicle of knowledge transmission and making, such as in Indigenous epistemologies, maintaining the connection between the narratives and the places where those narratives belong is crucial to their power. The place where stories belong, the right to tell those stories, and the narrator belonging to a community and country are all inextricably related [52], [53]. The place is thus linked to identity; it acts as the backdrop for the narratives we tell about ourselves and our communities. [54] We argue that increased place attachment with AR can benefit interventions for social causes, such as making STEM culture more equitable.

AR has been embraced by activists and artists who use it for layering the real world with additional or alternative information: making the invisible parts of common narratives and public spaces visible [45]. For example, the "Whole Story" project, an AR app for erecting virtual statues of historically important women next to statues of men [55]. Another example is the "Hack de Patria" project for overlaying digital messages over political propaganda in the Venezuelan

election in 2015 [45]. We aim to use AR as a technique to “empower people to see themselves as creators of their culture”, as beautifully put by Shafer & Zulkarnain [4].

3 METHOD

In preparation for this study, the leading author and one co-author attended an existing gender equity training activity offered to senior academics in our institution. We further conducted a thorough literature review focused on VR and AR applications for diversity/equity training in the workplace which is partly included in the related works above.

These preliminary activities helped us to refine the initial aims and scope of this research, specifically to look at ways to support potentially confrontational, but still necessary, conversations. We considered that a properly designed platform may create a space in which people can discuss their perspectives on equity scenarios, and potentially reflect on ‘taken for granted assumptions. Overall, our guiding research question is: how can AR support STEM professionals and students in exploring Gender and Power Dynamics, and contribute positive change to the existing gender underrepresentation problem?

Our approach is inspired by Cross-Cultural Dialogical probes [56] and Future Technology Workshops [57]. Dialogical probes are pieces of technology, often loosely related to the design problem at hand. These are used as conversation starters in co-design to, at once, demonstrate a given technological possibility, and encourage participants to explore ideas that can be developed and unpacked in collaboration with the research team. Future technology workshops are a method for co-design, initially developed in the education sector [57]. They consist of 7 sessions that explore interplays of current and future technologies, and current and future activities. Future Technology Workshops are known to be time-consuming and require considerable effort on the participants’ part, with the 7 sessions often requiring at least 4 hours. In our approach, we sought to blend the two methods into a more agile program, split across an online pre-activity conducted individually by participants, and a synchronous workshop to be conducted in around 2 hours with an identity reflection exercise and co-designing content for the prototyped AR application.

For both activities, we offered an example prototype as a prompt to initiate reflection. This consisted of a comic format storyboard, representative of an AR experience, created using Figma (<https://www.figma.com/>). Comic based storytelling has been shown to be an effective medium for facilitating identity shaping narratives and self-expression. [58], [59] The prototype was displayed via the Figma prototype preview for the online discussion (phase 1) and printed on paper for the Identity workshops (phase 2). For the characters presented on the storyboard we utilised free vector graphics by Stanley [60] (creative commons attribution licence 4.0). The storyboard is presented in Figure 1.

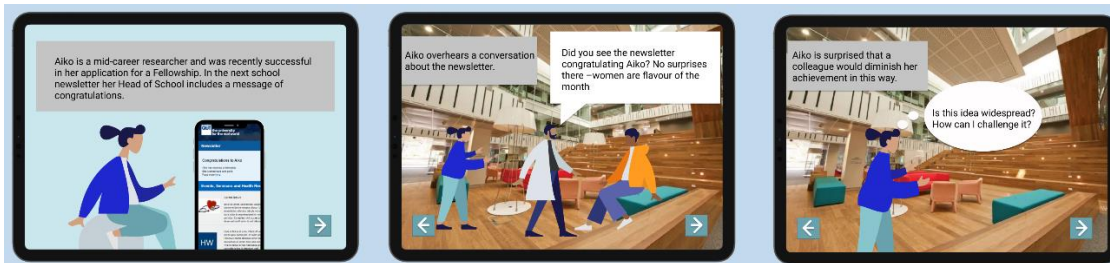


Figure 1: In the AR prototype storyboard, participants were invited to click through the scenario. After the last vignette, the participants were redirected to an online discussion board in which to enter their thoughts and read or respond to the entries left by other participants.

We conceived this storyboard to show the affordances of AR with as little detail as possible and to avoid distracting the conversation with details of the user interface. For us, the most important aspects were the background – which is presenting an area of the campus, and the characters layered on top of it, giving an idea of how the augmented reality application could look like, and most importantly a sense of the overall experience of using it on campus. This approach allowed us to explore what a gender equity scenario could look like in AR without committing to a particular technology at this stage.

3.1 Participants

Table 1: The participants

Code	Gender	Mode of attending
P1	Female	Zoom
P2	Male	Zoom
P3	Female	Zoom
P4	Male	In person
P5	Male	In person
P6	Female	In person
P7	Female	Did not attend the identity workshop

Seven people participated in this pilot study, as listed on Table 1. Of these, 6 participated in both the first phase (online platform) and the second phase (identity workshop). The workshop was conducted in hybrid mode with 3 participants joining in-person and 3 joining via Zoom. The participants were STEM academics and PhD students from various cultural backgrounds and included 3 men and 4 women, recruited via word of mouth among the researchers’ circle of colleagues. We are conscious that the narrow scope of our recruitment will reflect on the breath and nature of possible findings. We considered that this was appropriate to this pilot study, but we reflect on the limitations in section 5.3 and in our analysis, we proceed with these limitations in mind. The participants received a \$25 shopping voucher as a token of appreciation for their participation in the study. This research was approved by Queensland University of Technology’s Ethics committee.

3.2 Phase 1 – an online platform

We created a low-fidelity AR prototype consisting of an online storyboard (see Figure 1). The story sketched the experience of a fictional female academic called Aiko, who has received a fellowship and overhears a conversation between a male colleague and a bystander. The male colleague is diminishing her achievement based on her gender. We asked the participants to click through the prototype and answer three questions on an online discussion platform. The questions were directly inspired by the equity training workshop in use at our Institution: 1) How do you think others you know might respond to this situation? 2) What would you say to Aiko? The colleague? The bystander? 3) Who has influence here and how could it be exercised to prevent the impact? The anonymous answers were collected in GoSoapBox, an online discussion platform, and informed the design of the next step in the pilot which was the identity workshop. The online platform conversation focused mainly on the individual level. This led us to consider if encouraging self-reflection on personal identity could change the perspective of individuals towards structural causes and interventions.

3.3 Phase 2 – Identity Workshop

We developed a workshop format to further explore the interplays of personal (professional) identities and how people reflect on inclusion and diversity in STEM, the workshop was audio-recorded, and the first and last author collected notes and pictures during the proceedings.

The workshop included 3 sessions, each lasting approximately 30 minutes. In the first session, we invited participants to reflect on their own personal identities, and then to try to take the perspective of the various characters in the storyboard. This activity was inspired by Tatum [11]. Tatum noted that when invited to reflect on their own identity, members of a minority group tend to make explicit they are belonging to those groups (e.g., being a woman, Black, etc.) whereas members of a dominant or advantaged group take the position for granted and do not mention that category (e.g., White people do not mention being White, males do not mention being males, etc.) [11].

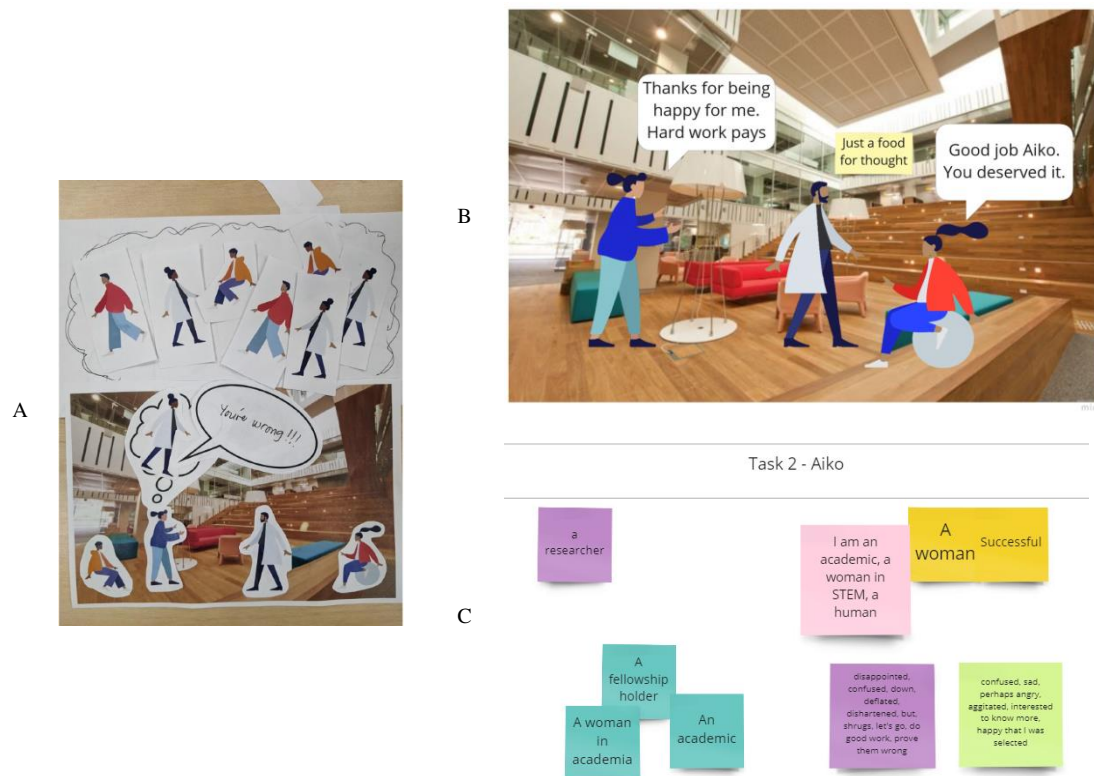


Figure 2: Examples of in-person participant (A) and Zoom participant (B & C) outputs

In 4 subsequent tasks, we asked participants to complete a list of “I am _____” statements, including as many examples as they could think of in 60 seconds. In the first task, this was a description of the participant themselves. Then, in task 2, each participant was asked to repeat the exercise from the perspective of Aiko. In tasks 2 and 3, the perspectives of the male colleague and of the bystander were explored respectively. How would they answer if they were this fictional person?

The participants attending the workshop face-to-face, filled in a paper form, while the Zoom participants used virtual post-its on a shared Miro board, as seen in Figure 2C. We chose this approach to get an idea of their most immediate impressions and stereotypes and reflect on their own identity before taking the place of the fictional academics. The results of this first activity were then explored in an open discussion.

After this exercise, we moved on to co-designing content. We asked the participants to think about different next steps in the situation presented in the prototype. The participants were given pictures of the campus and little images of the characters that they could cut and paste to create a paper prototype of an AR experience (see Figure 2 and Figure 3). Once again, face-to-face participants were given paper prints of the storyboard background and characters, whereas the Zoom participants used digital equivalents that were prepared on the Miro board.

The participants created individually their versions of potential outcomes, and these were then shared and used to support an open discussion.

3.4 Data Analysis

The data analysis followed a mixed (theory-driven top-down and data-driven bottom-up) approach. Our research questions and method alerted us to themes of professional/cultural/gender identity. Bottom-up analysis was based on thematic analysis as described by Braun and Clarke [61]. Thematic analysis is “a method for identifying, analysing, and reporting patterns (themes) within data” [62]. The authors reviewed the transcribed audio looking for interesting themes, and through iterative discussions decided on three general themes: shared self-reflection, comments on AR as a platform and calls for community interventions. We acknowledge the limitation of a small study with 7 participants. Additionally, the workshop setting is not likely to result in ‘frequent themes’, but rather is conducive to identifying topics that resonate more strongly with more participants’ experiences. Therefore, themes were chosen mostly because they were found by the authors to have led to insightful discussion, and to resonate particularly well with the research aims and gaps, and for further development of the project.

4 FINDINGS

We present here our findings. As hinted above these are preliminarily grouped into three broad themes: 1) how the workshop and discussion format led to insightful shared self-reflection; 2) ways in which AR is an engaging way to support discussions and reflection on gender and power dynamics in STEM; 3) that the co-designed endings to the AR storyboard insisted on community interventions, as opposed to individual action as is more common in immersive interventions found in the literature. Quotes from the workshop are referred to the participants who contributed them as P1, P2, etc. Quotes from the online discussion (GoSoapBox) were contributed anonymously and are reported here as [GSB].

4.1 Shared Self-reflection

Reflecting on personal identities can drive empathy and understanding for others. In line with what Tatum writes [63], the “I am _____” prompt made participants realise what parts of their identity were taken for granted, so that these did

not come to their minds as qualifiers when asked to describe themselves. P2 reflected: *"I first and foremost identify with what I do as in like academic work and research. (--) I don't think of myself like I'm a man in academia. But if there were potential roadblocks because of my gender, then it would be more of present thought."*

This conversation led P4 to share an experience, where he too realised an aspect of their identity taken for granted: *"I was talking to my friend back home. So, he's gay. This is late night I said that I feel safe walking the streets. And then he turned to me, and he was like, yeah, because you're heterosexual. And it didn't cross my mind until that moment when he said that because he is homosexual because my mind that whenever he walks after 9 PM, he feels afraid. But as a heterosexual, you don't think about it, right?"* P6, a female participant also shared a story about an occasion where a panellist made a questionable comment – but no one immediately challenged this comment: *"People I personally know would be happy for Aiko and genuinely congratulate her. The scenario reminded me of a Zoom panel session I attended where one of the male panellists made a side comment similar to Aiko's colleague. It was about grant opportunities in that research space, and he implied that if you are a woman, you would surely get it. I believe many were taken aback by his comment, but people just ignored it."*

She wondered if the situation would have been different if there would have been more open discussion on how to respond to such incidents and openly expressed values that this is not acceptable.

Another participant also shared a story pointing to episodes in which senior academics weighed in with their authority to challenge a similar situation: *"[A] professor picked up on [a] conference [that was hosted on University premises] with only male speakers, and few others reacted taking sort of power talking in front of the department [and] saying that they don't want to host this conference at the premises of at university"*. The shared reflection on identities and personal experiences helped the participants to understand some complexities of identity and power and how it reflects on how we experience the world.

4.2 AR as an engaging method

The participants welcomed this format of co-designing AR as an engaging way of workshopping on potential interventions for gender-based discrimination. P4 commented the advantages of having a space for expressing oneself and becoming aware of other people's positions: *"I am glad there was a space for this kind of conversation, where I could hear how my colleagues see themselves and looked at the gender issue from a new perspective"*.

By comparison, some of the comments in the pre-workshop online exercise either reflected somewhat defeated attitudes: [GSP1] *"I don't have enough capacity to talk about these sorts of things, they shouldn't even have been a problem in the first place."*; [GSP2] *"It does not matter, they are ignorant, I do not have the energy to argue with them right now"*; or suggested mostly individual responses to the challenging situation: [GSP2]: *"I have girlfriends who are quite outspoken. So, they would most likely interrupt the conversation and firmly contest their opinions."*



Figure 3: Participants crafting alternative endings for the AR prototype.

All participants created at least one alternative scenario, with one participant creating three. All but 2 of the alternative scenarios introduced new characters (other colleagues, and the Head of School) in various roles and capacities. All scenarios included verbal contents, generally in speech bubbles, from various characters besides the original speakers, however, at least one scenario expanded on the position of the male character, adding therefore nuance to the overall narrative.

We observed in the workshop that the conversation was more hopeful, positive and more action driven. This is likely because the participants were asked to create a new scenario themselves, setting them into a more active frame of mind.

4.3 Calls for community interventions

Crucially, most alternative outcomes imagined by the participants were in general more actionable and called for community support and change, compared to the thoughts contributed to the online discussion. Our low fidelity prototype was used by participants to think through the problem and possible solutions and helped to imagine new possible responses to the scenario in the storyboard. Taking the place of the fictional characters brought empathy, not just for Aiko, but for all people present, even the person making the comment. P2: *“maybe [The bystander is] just non-confrontational and maybe doesn't agree with what he's saying, but he just doesn't want to speak up and make big scene. Maybe that's the kind of person he is.”*

One participant expanded on the perspective of the male character (who had been nicknamed ‘bearded guy’ by the group). P4: *“[bearded guy]: I have every right to know why and how Aiko was selected. Was it based on her merits? I have my doubts.”*. This conversation is imagined happening with the head of School, *instead of* the scenario offered as prompt, therefore avoiding the conflict and potential misconduct.

P1 designed an intervention where the person making the comment was taken into the conversation and addressed his potential doubts about the rigorousness of the selection process. She described her creation: *“I had a co-worker stand up to the bearded guy saying the fellowship went through a rigorous selection process and I'd be happy to talk you through it. The idea was to try to educate them on the actual process behind the fellowship, organizing a meeting where everyone can learn more about the process, which might help in removing the bias.”*

P4, on the other hand, for example, suggested an event for a university-wide debate on the gender gaps and issues, where everyone is heard but the values of the institution and reasons for their policies are explained. As seen in Figure 4A, many members of the university have been gathered. The text under the picture says: *“Today we gathered here to talk about what happened recently. Some people are not happy with Aiko was nominated for the fellowship. We would like to have a dialogue, a sort of debate on this matter. This is very important so let’s start!”*

In P3’s scenario a female bystander supports Aiko, who comments sarcastically on the overheard comment (Figure 2B) She explains: *“I did specifically put a woman as the other person because I felt like a woman would be more likely to stand up for another woman.”*

P5’s scenario suggests that Aiko should feel empowered to challenge the situation personally, but also supported by the Head of School, who may intervene: *“It has come to my attention what you have said about Aiko’s achievements, we have decided to take disciplinary action.”*



Figure 2: Outputs created by P4 (A) and by P1 (B) showing different approaches to the issue

In the discussion P4 explained his creation further: *“This shouldn’t be black and white. Whoever is deciding on further action, needs to carefully consider all of this and really try to understand all parties, even Professor Beard. That’s why, for me that this would be the ultimate goal - creating a space, where it is safe to exchange opinions. So, I know it’s hard to do that, but that’s what I would aim for.”*

5 DISCUSSION

Based on the above findings, we wish to highlight the following key contributions. Firstly, we reflect on the Identity Workshop format, and how it helped to support useful conversations on an otherwise complex and conflicted territory. Secondly, we summarise our insights on the opportunities and challenges of using Augmented Reality as a tool for exploring gender and power in STEM.

5.1 Identity Workshop.

Self-reflection is argued to be an important aspect of effective diversity training [24], but this element is often missing from immersive interventions, which by their very nature are aimed at putting the user in someone else’s shoes. Nakamura

[38] and Rouse [39] specifically critique the commodification of empathy in VR, the idea that an empathy machine can be packaged with pre-existing experiences, in a way that seeks to create predetermined desirable reactions in the audience.

In planning for the identity workshop, our hope was to facilitate participants to see each other's humanity beyond the identity labels, reflecting on their own and others' experiences, seeing that identity is another story that we all tell about ourselves. This story can be complex and unique and punctuated with conflicts. It often includes bias and stereotype, as a function of human cognition [64]. Yet, some parts of this story can be changed and tried on and explored showing that we are different but ultimately the same.

In the workshop, the opening reflection on identity worked to this end. Firstly, it invited participants to share taken for granted aspects of their personal and professional persona and seeing how other participants put emphasis on unexpected aspects. Secondly, it explicitly invited to take in turn the perspectives of all the characters in the story, and not just Aiko as the target of a sexist comment. Notably, the participants had to take the perspectives of everyone including less 'likeable' characters, therefore looking constructively at shared ways forward. This brings an interesting, complementary nuance to what Nakamura described as 'feeling good about feeling bad' [38]. In doing so our goal was of course not to side with or defend the person making the comment, but rather to lead the discussion towards inclusive action and positive change.

In asking our participants to subsequently create their own solutions to the conflicting situation, the proposed endings resulted in pragmatic, actionable ideas. There is a longstanding research tradition in HCI to adopt and adapt ethnographic methods, as these can provide rich and deep insights into human behaviour. It is however also well known that these methods rarely provide direct 'implications for design' [65]

In our research, comments on the online platform pointed to the limited possibilities of changing systemic issues for individuals. The outcomes of the co-design task can instead be almost directly translated into working prototypes that can be then trialled back with the participants, to identify the next design move.

Practical lessons learned from conducting this pilot were to reserve enough time for the workshop to run at a leisurely pace. The initial plan was to run the workshop in an hour and half and the workshop ended up being almost an hour longer. Fortunately, all the participants were able to stay for longer than planned. Our recommendation is to reserve at least 3 hours for the workshop, to have more time for a break in the middle and more time for the conversations.

Finally, as we discussed in section 2.1 (Existing Interventions) discussions around equity can be perceived as a threat to personal identity [28]. While we acknowledge that the workshop participants were certainly sympathetic to gender and power issues in STEM, having volunteered to participate in this research, it is interesting to see how the discussions on identity and the subsequent crafting of AR narratives, played together in a constructive, rather than conflictual, way. Certainly, repeating this research with a more diverse group of participants could lead to very different outcomes, which encourages us to further develop this workshop format and apply it systematically in the future.

5.2 AR for gender equity.

Augmented reality is a less explored method for gender equity compared to VR. We argue that the affordances of AR, provide a unique set of benefits that suit these goals especially well, having the virtual content layered on the real world, and thus being better situated to the place and the culture of the user.

By layering digital information in the real world, AR is a tool for supporting alternative ways of seeing the everyday [66]. Silva et al. further suggest that "AR experiences encourage a certain radical imagination among participants." [45]. Unlike VR or video – AR is in the real world and thus situated in the place, increasing place attachment [44]. This can benefit interventions for social causes, such as making STEM culture more equitable by encouraging the users to take responsibility for what happens in the community.

Furthermore, a virtual simulated layer might add a comfortable distance to a potentially difficult topic while remaining grounded to the user's location, reminding that discrimination is happening in the particular social and geographical location. There is key distinction to be made here, between a traditional approach to 'empathy training' as found in much literature, and our goals of supporting constructive discussion. Rouse noted that "the idea of using [...] AR/VR to 'change minds' via empathy [...] plays into a fantasy that neatly aligns with a privileged positionality, seeking quick, easy, and relatively painless methods of mitigation that fall short of actual change." [39] On the other hand, an AR intervention conceived as a tool for giving voice to under-represented identities in STEM can better mitigate the risk of potentially traumatising or re-traumatising survivors [67], a known barrier to large scale adoption of mandatory training.

We identified three opportunities for designing AR narratives, based on the alternative endings created by the participants. A first theme consists in exploring possible actions from Aiko's perspective, what she may do or say to challenge the comment made about her fellowship [P5, P4, P6]. A second theme explored what community leaders can do or say to set shared expectations and standards of respect [P1, P4, P2]. Finally, a third theme suggested example ideas for finding like-minded people to work together, build confidence, and make community support visible [P6, P2, P3]. These themes overlapped in several scenarios: e.g. Aiko may speak up when she is sure to have community support.

Co-designing AR in the Identity Workshop was welcomed as an engaging way of having a conversation about gender issues. This aligns with previous studies on AR where in comparison playful approaches are seen as more motivating methods for learning [68].

5.3 Limitations

Limitations of this study are participants who were sympathetic to gender and power issues in STEM, who were recruited through colleagues of the researchers which might have led to a biased sample. The method, although based on frameworks mentioned earlier, is still experimental and will be further developed. These preliminary findings from the pilot study show promise for AR as an engaging platform for visually enhanced conversations about equity in STEM. However, we see that this pilot showed some promising results for further studies.

6 CONCLUSION

There is still a lot of work in improving the gender representation in STEM in Australia. In addition to finding ways to improve recruitment also retention should be improved. There are many strong cultural narratives on who belongs to STEM. Augmented reality is a tool for situated narratives that can foster place attachment and commitment to culture and help to confront and transform assumptions and stereotypes of a STEM academic. Our study gave us insights to refining a co-design method focusing on identities and narratives. This work is leading towards developing and testing a working AR prototype.

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