Perceptions of Accessibility and Inclusivity of Virtual and Augmented Reality Among Immersive Technology Professionals: An Interview Study

F. Fischer, R. P. Galindo Esparza, L. Yin, J. J. Dudley, V. Garaj, and P. O. Kristensson

Abstract As Virtual and Augmented Reality (VR/AR) integrate more seamlessly into everyday life, ensuring their accessibility and thus inclusivity for the entire population becomes a key challenge. This paper explores the perceptions of VR/AR accessibility and inclusivity among immersive technology professionals and identifies existing solution implementation barriers from the professional perspective. The perceptions were investigated through an interview study that included 24 immersive professionals across a range of industrial sectors, education and NGOs. While the interviewed professionals expressed general interest and willingness to consider VR/AR accessibility and inclusivity, we identified several obstacles that currently obstruct this objective of developing immersive applications and experiences. These obstacles include the nascent state of VR/AR technologies, the lack of established guidelines and tools for accessibility features and restricted access to users with disabilities for user studies, especially for smaller companies. Further technological advances in the immersive context, legally binding standards and greater social esteem for accessibility efforts may help drive forward accessibility and inclusivity in VR/AR.

Keywords People with disabilities · Older people · Disability · Ageing · Virtual reality (VR) · Augmented reality (AR) · Immersive technologies · Accessible computing

F. Fischer (✉) · J. J. Dudley · P. O. Kristensson
Department of Engineering, University of Cambridge, Cambridge, UK
e-mail: fjf33@cam.ac.uk

R. P. G. Esparza · L. Yin · V. Garaj
Brunel Design School, Brunel University of London, Uxbridge, UK

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1 Introduction

The immersive technologies of VR/AR have the potential to transform people's experiences of the world by extending reality through digital means. These technologies are particularly significant for people with disabilities and older people as they offer novel ways to, for example, entertain, socialise and learn remotely, without the requirement for full physical mobility [1]. As the immersive landscape continues to grow, consumer VR/AR applications are becoming more significant in everyday life. Ensuring the applications are accessible to and inclusive of the broadest population has therefore become a key challenge for the global immersive economy.

In the UK alone, there are more than 2,000 immersive technology companies, with a reported growth of 83% over the past decade [2]. As each of these companies operates under its own processes and agendas, it is still unclear to what extent the potential VR/AR accessibility and inclusivity issues are known and addressed by different professionals involved in the design, development and production of VR/AR. There are some examples of large-scale companies introducing dedicated accessibility guidelines [3] and accessibility tools for VR, such as the Microsoft's low-vision VR toolkit *SeeingVR* [4]. However, these guidelines and tools usually become obsolete within a few years of their release due to the fast-paced development of immersive technologies.

Other related work has raised awareness of current barriers to VR/AR use from the point of view of people with disabilities and older people, providing recommendations and guidelines for achieving more accessible and inclusive immersive experiences [5–8]. This line of research is mostly informed by studies that focus on the end-user usability testing of VR/AR applications, interfaces and content to gather accessibility requirements [see, for instance, 9–12]. Only a very few studies carried out to date involved key stakeholders beyond users [for instance, 13], including industry specialists, charity workers and academics. There is therefore an unfilled gap in exploring the perceptions of VR/AR accessibility and inclusivity among immersive technology professionals, which the work presented in this paper aims to address. Understanding these perceptions, as well as the practices and challenges faced by the professionals, is critical to achieving a balanced inclusivity strategy and effective solutions for more accessible VR/AR systems and applications.

We conducted an expert interview study with 24 immersive technology professionals of varying seniority from the industrial sectors of Information Technology (IT) and Consulting (e.g., software development, technology consulting and navigation technology), Entertainment (e.g., film and theatre), Healthcare, Culture and Heritage, Education (e.g., Higher Education and e-learning) and Non-Governmental Organisations (NGOs). By examining their own experiences of VR/AR accessibility and inclusivity, in this paper, we highlight the different degrees of needs and approaches to addressing them for disabled and older people in the design and development process of VR/AR technology and experiences, and we discuss professionals' perceptions regarding barriers to accessibility and inclusivity in VR/AR.

2 Expert Interview Study

Method. Semi-structured online individual interviews with 24 immersive technology professionals were carried out in 2022. Each interview lasted between 45 and 60 min. The whole interview guide is available upon request. Ethics were approved by the Ethics Committee of the College of Engineering, Design and Physical Sciences, Brunel University of London. As stated above, there is still limited research on the experience of such professionals in the context of VR/AR accessibility and inclusivity. Hence, our method was largely informed by inquiring into professional views in other areas of VR/AR [14–16], and similar work within the scopes of Human–Computer Interaction (HCI) and design [17–19].

The interview guide was designed to cover five different areas: (1) the participants' backgrounds, to gain information about the nature and level of their experience working with VR/AR, (2) their current creation process, to understand existing design and development practices, (3) their collaboration with internal stakeholders and overall professional interests, to learn who shapes the design and development strategy within their companies, (4) their knowledge and application of accessibility and inclusive design, to uncover the actual level of implementation of accessibility and inclusivity strategies and solutions within their projects, and (5) the potential business cases, to gauge the perceived commercial impact of accessible and inclusive VR/AR.

Participants. The 24 professionals were selected based on their background and experience working with immersive VR/AR technologies. Recruitment followed a sampling scheme that considered availability and ease of access while ensuring diverse professional levels and engagement with the development of immersive technologies and experiences. The participants were residents of the UK, USA or China and included designers, developers, producers, project and product managers, consultants, accessibility leads, directors and Chief Executive Officers (CEOs) from small, medium and large companies delivering VR/AR applications. An overview of the participants' areas of work, locations and job roles is provided in Table 1.

Analysis. Interview data was collected using video recordings of the interviews that took place on online platforms such as Zoom and Teams. These recordings were transcribed and analysed using a thematic analysis approach [20]. One of the authors generated an initial coding scheme by identifying a set of sub-themes using the NVivo software. The other authors then refined and expanded the scheme based on a deeper exploration of the interview data.

3 Findings

From the experts' individual insights and experiences, we synthesised the following findings divided into four categories: (1) potential benefits of accessibility and inclusive design in the immersive industry and society at large; (2) the accessibility

Table 1 Participants' ID, position, area within the immersive industry and location

ID position	Sector	Where	ID position	Sector	Where
P01 CEO	IT & Con	USA	P13 XR designer	IT & Cons	USA
P02 CEO	IT & Con	UK	P14 Designer-Developer	IT & Cons	USA
P03 Artistic director	Entertainment	UK	P15 Project manager	Entertainment	UK
P04 Director	Entertainment	UK	P16 Product designer	IT & Cons	USA
P05 Director	Entertainment	UK	P17 Product designer	Entertainment	UK
P06 CEO	Healthcare	UK	P18 Designer-Developer	Education	USA
P07 Accessibility lead	Education	USA	P19 Product designer	IT & Cons	USA
P08 CEO	Entertainment	USA	P20 CEO	IT & Cons	UK
P09 Producer	Entertainment	UK	P21 Designer-Developer	Culture-Heritage	China
P10 Outreach lead	NGO	USA	P22 Product manager	IT & Cons	China
P11 Artistic director	Entertainment	UK	P23 Developer	IT & Cons	China
P12 Consultant	NGO	UK	P24 Product manager	IT & Cons	China

and inclusivity skill sets of individual practitioners; (3) the current implementation of accessibility and inclusivity practices within the participants' sectors; and (4) challenges encountered around accessibility and inclusivity practices.

3.1 Potential Benefits

There was a strong consensus among participants about the potential benefits of embedding accessibility and inclusivity practices within immersive technology and experiences. The opportunity to expand the customer base by catering for people with disabilities and older people was a key point, as this would permit more people to enjoy mainstream VR/AR experiences. Interestingly, the interviewees who confirmed a high level of accessibility implementation listed the user as their primary motivation, seeking to reach as many people as possible (P08) while also providing a quality experience, on par with "*improving patient outcomes*" (P06). One interviewee (P23) pointed out that providing accessible products could also enhance the company's reputation, giving it a competitive edge.

A couple of interviewees (P07, P14) highlighted that the opportunity to positively impact people with "*temporary disability or situational disabilities could benefit all of us*" (P14) considering that many people will require more technology support as they age and consequently face new accessibility needs. Furthermore, offering accessible immersive VR/AR products was envisioned as a potential catalyst to "*solving the lack of equality, diversity and inclusion that exists in other sectors*"(P12) by setting an example of how it could provide support for a larger audience.

3.2 Knowledge and Technical Skills

While a couple of experts from larger organisations claimed to have sufficient in-house expertise (P09, P15) to address accessibility and inclusivity issues, most experts considered that they did not have the technical skills to develop accessibility and inclusivity solutions in their businesses (P02, P03, P04, P11, P13, P20, P21, P22). The professionals who had already spent some time gaining a better understanding of the individual needs of people with disabilities and older people, as well as relevant possible solutions, were more confident in their potential to improve accessibility and inclusivity. "*[At my company] I'm trying to help convert people to understand that these aren't just things that take a lot of time to do that don't benefit people.*" (P07).

3.3 Current Attitude and Importance

Experts reported that accessibility and inclusivity practices have mixed levels of consolidation within their workplaces and projects. Attitudes ranged from considering accessibility as a critical company asset (P05, P06, P07, P12) to treating the concept as a supplementary benefit rather than an actual practice (P04, P08, P23). Notably, several of the interviewees have, on their own initiative, taken an accessibility advocacy role to "*help convert people to understand that these aren't just things that take a lot of time to do*" (P07). For instance, one of the participants (P03) embeds accessibility from an early development stage by considering features such as subtitles and audio descriptions within the workflow. Conversely, companies that do not implement accessibility practices within their processes pointed to the challenge of creating something practical and functional for the majority (P24), leaving the intention to expand to other user bases as an extra milestone that only rarely gets realised (P16, P17, P19, P21). Although aware of the benefits of accessibility, constraints on financial, human and technical resources could lead some of these teams to dictate their process based on "*what's the bare minimum that [they] can get away with*" (P17) to meet deadlines and maximise outcomes. For example, accessibility might be given less priority during the development stage (P02) compared

to "*a new feature that might help [the companies to] be more competitive on the landscape of immersive experiences*" (P16).

Responsibility, Distribution and Timing of Work. From the participants' responses, it was generally unclear who is responsible for leading accessible practices. One interviewee (P02) suggested that company leaders have the responsibility to "*shake the attitudes*" so that the team integrates accessibility as a fundamental part of the process. Conversely, two other participants (P03, P07) placed responsibility on themselves as practitioners instead of top leaders. It was also discussed to what extent software developers can help drive forward accessibility in the immersive sphere. While their technical expertise was seen as critical to the creation of out-of-the-box accessibility features and tools, interviewees also identified a number of other challenging and sometimes conflicting demands on developers, including functional priorities such as high frame rates and low load times. Furthermore, as indicated by an expert (P18), many developers lack training regarding the user experience (e.g., mental models, or user journeys), which could fail to encourage a user-centred design process.

In addition, it is unclear at which phase in a product's development cycle accessibility should reasonably be considered. While P16 argued that accessibility should be accounted for from the beginning, P21 suggested that immersive ecosystems first need to become more mature to implement accessibility solutions.

3.4 Obstacles to Wider Adoption of Accessibility Practices

Immersive technology's fast-paced development poses high-level entry barriers to accessible and inclusive practices. Based on the expert interviews, we identified three key issues.

Nascent Technology and Accessibility Tools. The nascent industry around immersive VR/AR applications is still in flux, with many aspects of best practices yet to solidify. The recent advent of the Metaverse typifies this relatively ill-defined and rapidly evolving space. Applying accessible solutions can be perceived as "*conceptually quite new and hard to solve*" (P09).

The experts found that tools and guidelines for accessibility within the design process are not currently readily available. They particularly emphasised the lack of robust frameworks to transfer problems already solved in 2D to the 3D space, such as movement and rotation (P07), captions (P10) and Unity plugins for accessibility (P01, P19). It was noted that multinational companies in the area of immersive technology only offer basic accessibility features (P07, P10), "*mostly for screen readers tapped onto the end of it*" (P05). While a few existing solutions were scrutinised during the interviews, their performance and compatibility were generally classed as poor or outdated. For instance, P01 tried the Bluetooth keyboard compatible with Meta Quest for text-based communication with a deaf user; however, Messenger in Quest did not support the Bluetooth feature then, making their communication impossible.

This reported lack of systematic guidance and knowledge often results in empirical, non-validated approaches being taken by intending practitioners. As a couple of participants explained: "*we basically still rely on communication and on our imagination to understand and accommodate these things in design*" (P23) and "*we think we're doing the right thing but there's no reference point that I've found yet that's a clear guide*" (P02).

Restricted Access to People with Disabilities and Older Adults. Accessing groups of people with disabilities or older adults is challenging. Based on the results of our study, we identify the following main reasons. Firstly, and particularly for vulnerable groups, it is necessary to establish a working relationship with non-profit charities and agencies, as they often provide and safeguard normal access to specific communities. Particularly in the case of smaller companies, P02 highlighted the potential complications of engagement when the relationship involves financial investment throughout the project.

Secondly, as pointed out by P05, gatekeepers might perceive companies differently based on their size and reputation, making it more challenging for smaller businesses to interact with these communities. However, if there were a validated way to engage with these user groups, smaller companies driving innovation could be pioneers for the immersive industry as a whole.

Thirdly, we identified a lack of inclusion advocacy in the VR/AR industry culture. Only a couple of participants reported that involving people with disabilities and older adults had been a smooth experience (P03, P18). Particularly, P03 mentioned that advocacy was the key element that allowed them to establish a working relationship with a specific group of people with disabilities; this was mainly through a member of the specialist team who was already part of such a group due to their own accessibility needs. P18 proposed a more proactive approach by the team directly attending forums and assisted housing locations.

Uncertainty and Limitations in Accessibility Budgeting. Communicating the required technical and user research resources and the resulting commercialisation impact level to top leaders was reported as considerably difficult (P07, P09, P12, P20). While some experts raised the need to create a sense of community (P08) and develop more consistent regulations around accessibility (P02, P07, P08), others mentioned that accessibility could be implemented in their organisations and sectors, but only to the degree that a commercial benefit is directly perceived (P10, P20). It could even be argued that, ultimately, "*[the lack of accessibility is] almost purely down to budget and financial constraints*" (P20).

4 Discussion

All experts agreed that increasing the accessibility and inclusivity of immersive technology and experiences constitutes a generally desirable goal. It was also argued that the potential use of VR/AR systems by people with disabilities and older adults tends to be underestimated, a statement consistent with findings from previous work

on the amount of disabled and older users [6, 13]. Furthermore, experts in our study indicated that accessible features can be beneficial well beyond their original scope. In practice, however, the immersive industry faces some financial and corporate constraints regarding accessibility, which are more distinct than for other types of industry investment (e.g., sustainability).

Moreover, it seems unclear how best to share workloads between professional levels and market players in the immersive industry. Some experts argued that the responsibility of creating guidelines or tools for accessibility lies with the major companies that provide the core components of immersive experiences, such as Apple's *ARCore* or Google's *ARKit*. The observation that major companies have easier access to people with disabilities and older adults, who are usually protected by gatekeepers, adds to this proposed role distribution. On the other hand, small, non-mainstream companies could make a crucial contribution to advancing accessibility, as they often possess unique experiences of the specific challenges faced by particular user groups. Promoting further cooperation between specialised non-profit charities or small companies with very specific expertise and networks and the big players [as e.g., done by 8] therefore, constitutes a highly promising route.

Some interviewees also expressed concern about the nascent state of immersive technology, claiming that they will not be able to push accessibility and inclusivity further within the company culture until substantial progress, e.g., in terms of accessibility tools and guidelines, has been made. This simultaneously impacts the interest in implementing even simple features that could improve accessibility, apparently a vicious cycle. A multi-level approach defining out-of- the-box accessibility features to be implemented at the software level that can be used for more sophisticated systems could be a possible solution. A valuable example in this regard is the Quest Accessibility VRCs [3], a set of technical recommendations for VR accessibility. Moreover, an inclusive workforce with diverse backgrounds and experiences will be essential to promoting more sensitivity towards the needs of marginalised groups. For instance, established procedures for VR/AR accessibility could be a primary driver and potentially result in legally binding accessibility standards, similar to the *Web Content Accessibility Guidelines* [21].

The professionals' perceptions and experiences discussed here provide a brief overview of the current obstacles encountered in the development of accessible and inclusive VR/AR applications. Our study complements other early work with non-user key stakeholders [13]. Considered in line with the ample knowledge of relevant accessibility barriers from the perspective of disabled and older end-users [5, 7–12], the study could facilitate the capacity of the immersive industry to address such obstacles effectively. Thus, an increased demand for accessible and inclusive VR/AR applications, and a general social esteem, will be critical to promoting, improving and speeding up the integration of accessibility and inclusivity research into the VR/AR design and development process.

5 Conclusions

While immersive industry professionals generally reported interest and willingness to consider accessibility and inclusivity, this is not currently a top priority in many companies and organisations involved in the development of VR/AR applications. The lack of focus in this regard mainly results from the nascent state of immersive technology and accessibility tools, the limited access to users with specific disabilities or ageing, especially for smaller companies, and the resulting uncertainty, as well as general limitations in accessibility budgeting. We also identified a lack of consensus about who should be responsible for leading accessible practices and finding potential benefits in cooperation between small and medium companies, NGOs with expertise and access to hard-to-reach groups and large companies with the potential to set promising new standards. Legally binding standards and greater recognition of the need for accessibility efforts could also help to drive progress forward.

Based on the qualitative insights gained from this interview study, we plan to systematically explore the organisational structures and processes that affect the importance and feasibility of accessibility and inclusivity-based design within the immersive industry. Similarly, further exploration of the partnership opportunities between big and small players, research institutes and advocacy groups, and of the existing legal frameworks in the specialists' countries will provide a social contextualization of the current barriers faced by industry experts. Such in-depth analysis may enable the development of tailored accessibility tools and processes, providing a new momentum for accessibility in immersive technologies.

References

1. Garaj, V., Dudley, J.J., Kristensson, P.O.: A metaverse for all: pushing the boundaries of inclusive design. In: CHI Conference on Human Factors in Computing Systems, pp. 1–3. ACM, Hamburg, Germany (2023)
2. Immerse UK and Oxford Insights and Data City: the 2022 UK Immersive economy report (2022). https://iuk.immersivetechnetwork.org/resources/the-2022-uk-immersive-economy-report. Accessed 04 Nov. 2024
3. Oculus VR: Introducing the accessibility VRCs (2020). https://developer.oculus.com/blog/introducing-the-accessibility-vrcs. Accessed 5 July 2024
4. Zhao, Y., Cutrell, E., Holz, C., Ringel Morris, M., Ofek, E., et al.: SeeingVR: a set of tools to make Virtual Reality more accessible to people with low vision. In: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, pp. 1–14. ACM, Glasgow, Scotland, UK (2019). https://doi.org/10.1145/3290605.3300341
5. Dudley, J.J., Yin, L., Garaj, V., Kristensson, P.O.: Inclusive immersion: a review of efforts to improve accessibility in Virtual Reality, Augmented Reality and the Metaverse'. Virtual Real. **27**(4), 2989–3020 (2023). https://doi.org/10.1007/s10055-023-00850-8
6. Geerts, D., Vatavu, R.-D., Burova, A., Vinayagamoorthy, V., Mott, M., et al.: Challenges in designing inclusive immersive technologies. In: 20th International Conference on Mobile and Ubiquitous Multimedia, pp. 182–185. ACM, Leuven, Belgium (2021)
7. W3C: Accessibility of Virtual Reality (2017). www.w3.org/WAI/APA/task-forces/research-questions/wiki/Accessibility_of_Virtual_Reality. Accessed 26 Feb. 2024

8. XR Association: Accessibility and inclusive design in immersive experience. Technical report, XR Association (2020)
9. Jain, D., Junuzovic, S., Ofek, E., Sinclair, M., Porter, J.R., et al.: Towards sound accessibility in Virtual Reality. In: ICMI 2021, pp. 80–91 (2021)
10. Maidenbaum, S., Levy-Tzedek, S., Chebat, D.R., Amedi, A.: Increasing accessibility to the blind of virtual environments, using a Virtual Mobility Aid based on the "EyeCane": feasibility study. PLoS ONE **8**(8) (2013)
11. Mott, M., Tang, J., Kane, S., Cutrell, E., et al.: I just went into it assuming that I wouldn't be able to have the full experience: understanding the accessibility of Virtual Reality for people with limited mobility. In: ASSETS'20, NY, USA, pp. 1–13 (2020)
12. Teofilo, M., Lucena, V.F., Nascimento, J., Miyagawa, T., Maciel, F.: Evaluating accessibility features designed for Virtual Reality context. In: 2018 IEEE International Conference on Consumer Electronics (ICCE), pp. 1–6 (2018). IEEE, Las Vegas, NV, USA
13. Creed, C., Al-Kalbani, M., Theil, A., Sarcar, S., Williams I.: Inclusive AR/VR: Accessibility barriers for immersive technologies. Universal Access in the Information Society (2023)
14. Biermann, O.C., Ajisafe, D., Yoon, D.: Interaction design for VR applications: understanding needs for university curricula. In: CHI Conference on Human Factors in Computing Systems Extended Abstracts, pp. 1–7. ACM, New York, NY, USA (2022)
15. Laing, S., Apperley, M.: The relevance of Virtual Reality to communication design. Des. Stud. **71**, 100965 (2020). https://doi.org/10.1016/j.destud.2020.100965
16. Helgert, A., Straßmann, C., Cornelia Eimler, S.: Conceptualizing and designing a Virtual Reality authoring tool for Human-robot interaction studies—learnings and guidance from expert interviews. In: Proceedings of Mensch und Computer 2024, pp. 331–341 (2024). MuC'24. ACM, New York, NY, USA
17. Buruk, O., Petersen Matjeka, L., Mueller, F.: Towards designing playful bodily extensions: learning from expert interviews. In: Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems, pp. 1–20. CHI'23. ACM, New York, NY, USA (2023). https://doi.org/10.1145/3544548.3581165
18. Yargın, G.T., Morosanu Firth, R., Crilly, N.: User requirements for analogical design support tools: learning from practitioners of bio-inspired design. Des. Stud. **58**, 1–35 (2018). https://doi.org/10.1016/j.destud.2017.11.006
19. Van Der Linden, V., Dong, H., Heylighen, A.: Tracing architects' fragile knowing about users in the socio-material environment of design practice. Des. Stud. **63**, 65–91 (2019). https://doi.org/10.1016/j.destud.2019.02.004
20. Braun, V.: Clarke, V: Using thematic analysis in psycho logy. Qual. Res. Psychol. **3**(2), 77–101 (2006). https://doi.org/10.1191/1478088706qp063oa
21. W3C: Web content accessibility guidelines (WCAG) 2.1. (2018), www.w3.org/TR/WCAG21/. Accessed 4 Nov. 2024