The Value of Inclusively Designed XR Workplace Tools

A Research Report from the Business Cases for Inclusive XR Workstream

Introduction

Background

XR Access' Business Cases for Inclusive XR (bcXR) workstream wanted to explore the connection and potential business value for inclusively designed XR workplace tools and hybrid workplaces. So, the workstream assembled a research team and executed a research project resulting in this report.

Purpose of this Report

This report aims to begin laying out reasons why organizations adopting XR technologies must think about disability inclusion and accessibility as they pivot to hybrid work and maintain business operations.

The increasing adoption of XR technologies for hybrid work

As economies are recovering from the COVID-19 pandemic, successful businesses are adopting hybrid workplace practices. Such practices offer enormous opportunities for people with disabilities to enter or be successful in a variety of workplace settings.

Extended reality (XR) technologies (including virtual, augmented, and mixed reality) have the potential to unlock new opportunities for inclusion and advancement in hybrid workplaces. With inclusive XR, people with and without disabilities can live, work, and interact in new and accessible ways. The key to inclusive XR is that it should be born accessible – meaning that the developers who create it must consider accessibility early and involve people with disabilities in the planning, design, and development of it.

XR technologies are bound to play a huge role in how new working practices are adopted and developed. The numbers also prove this. A recent report (Global VR Collaboration Platform for Enterprise Market Research Report 2022 - Market Size, Current Insights and Development Trends by Maia Research) has in fact highlighted that over 2 million people are utilizing these technologies to work, and this number is fast growing. Therefore, it is imperative for the industry to act now to ensure they are developed with accessibility in mind.

Gaining a competitive edge with disability inclusion

According to a joint paper by the Partnership on Employment & Accessible Technology and the XR Association, organizations that prioritize accessibility in the XR technologies they adopt can gain a

competitive edge in a tight labor market by attracting and hiring from diverse talent pools. Below are just a few of the ways that inclusively-designed XR can provide business value:

- **Inclusion Strengthens Businesses:** Organizations that hire and retain people with disabilities earn 28% higher revenue, two times the net income and 30% higher economic profit margins than their peers, according to Accenture. Greater commitment to disability inclusion and accessibility can help yield better returns.
- **Accessible Technologies Enable Everyone to Succeed:** The flexibility that comes with accessible XR technologies helps employees without disabilities. Usability features such as volume control, captioning and voice commands are just a few examples.
- **XR Technologies Ignite Fast-Growing Jobs:** Some of the fastest-growing jobs in the U.S. are in industries that are rapidly adopting XR technologies (as outlined in the Bipartisan Policy Center's Report "Thinking Ahead About XR: Charting a Course for Virtual, Augmented, and Mixed Reality", 2022). Uses of XR in these fields include warehousing/inventory management, product engineering/design, immersive job training/upskilling, and virtual healthcare patient monitoring.

While the studies above indicate strong business potential for XR in hybrid workplaces, more research needs to be done on the business value of the actual inclusive design and accessibility aspects described in this report's Research Findings, as well as in findings from interviews we conducted with users who identify as having a disability.

Research Methodology

To create this report, the bcXR core research team followed the process outlined below:

- **We determined focus use cases** – The research team chose key enterprise use cases driving XR and immersive technology adoption as its focus areas. These included: job training, meetings and collaboration and large-scale events.

- **We determined technologies to assess** – our team chose to review a variety of mainstream and newer technologies from startups to learn the differentiating factors. The technologies were assessed based solely on the current state of use and accessibility support and we did not consider roadmaps for remediation of accessibility barriers or beta features. The following technologies were included in our research[1]:
    - EngageVR.io
    - Glue.work
    - Meta Horizon Workrooms
    - Moonbeam.ai - Envision
    - Microsoft AltspaceVR
    - Mozilla Hubs
    - Spatial.io

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[1] These assessments resulted from impartial and independent reviews solely for research purposes, and to help understand the current state of these types of tools related to accessibility and inclusive design.

- **We developed a rubric and set of questions**
  - Questions used to assess each immersive platform are adapted from the [PEAT Inclusive XR & Hybrid Work Toolkit](#) and formatted into a rubric.
  - We focused on questions in different topic areas such as: general access, seeing, hearing, speaking, movement, interacting, thinking and cognitive.

- **We assembled a diverse research team** – our team included XR Access members with disclosed disabilities (sensory, physical, and cognitive) as well as diverse lived experiences related to race and gender.

- **We each conducted independent research** – the team used tethered and untethered head-mounted displays (HMDs) where possible, but also employed desktop or laptop computers where the immersive technologies could be accessed via a web browser.

- **We interviewed people with disabilities about XR technologies, and discussed research limitations**, which included:
  - Not all immersive platforms have desktop support that provides an equal experience.
  - Not all XR technologies could be included in the research.
  - In some cases, online videos were required to understand context and to conduct interviews with people with disabilities. We did this by compiling a curated selection of YouTube videos that described how XR technologies were being used as workplace tools and interviewed participants about how they thought these tools could benefit them.
  - The research was conducted by a team that was entirely remote and global. This meant we were unable to test the hardware and platforms with our interviewees. It also meant that the interviewees and researchers needed to own the technology to test it.
  - The research was conducted on a volunteer basis and without a budget.
  - The research verified that many people interviewed would require more orientation and assistance on how to use the technologies so they could overcome barriers to entry.

- **We consolidated our findings into this report.** There are two major sections in this report:
  - [Research Findings](#) which synthesize findings across interviews and other research; and
  - [Interview Findings](#) which concentrate on input from specific interview subjects.

Research Findings

The findings from our research are summarized below, organized by different topic areas we explored.

Topic 1: General Access

The following functions were reviewed because they provide benefits to all users and provide flexibility when interacting with XR, especially when users interact with the technologies in different environments like a bright worksite or loud factory floor. In addition, users with physical, cognitive, and learning disabilities may need to interact at different paces.

Research Questions related to General Access

- **How do the platforms handle undo, redo, saving and bypass functions?** We reviewed the undo and redo functions, action confirmations, ability to bypass actions and save progress. These functions allow users to correct or avoid mistakes. A few products (Moonbeam, Horizon, some of Glue) offered options for undo and redo and being able to save progress, and functionality varied slightly between the VR and desktop version.
- **How do the platforms offer ways to remove or reduce visual details and audio from virtual environments?** None of the platforms assessed currently offer these options.
- **How do the platforms handle a user's decision-making speed?** We reviewed whether a user could reduce the program's speed and if they could increase the time allotted for them to make decisions. This feature was rarely included as an option in the applications we looked at but would be useful.

Recommendations for General Access

Below are general access recommendations that were referenced from the W3C XR Accessibility User Requirements (XAUR), a note from the W3C Accessible Platform Architectures (APA) Working Group, which lists user needs and requirements for people with disabilities when using virtual reality or immersive environments, augmented or mixed reality and other related technologies:

- Allow users to change the speed they can travel or perform interactions.
- Provide options to remove or reduce visible background details and audio.
- Provide different display options to distinguish in-app information such as shapes or symbols, texture and meaningful color selections for users who are colorblind.
- Allow timings for interactions or critical inputs to be modified or extended.
- Provide help for users with a cognitive or learning disability.
- Provide clear start and stop mechanisms.

Topic 2: Sight & Visual Considerations

In this assessment area, we reviewed the use of shapes, symbols, meaningful colors, textures, and more visual cues. These can help users distinguish information within the platform and can be impactful for people who are blind, have low vision or are using XR in conditions where situational vision challenges can occur like a bright outdoor space.

Research Questions related to Sight & Visual Considerations

- **How do the platforms enable adjustment of brightness, color/contrast, and offer adjustments for people who have colorblindness?** Some collaboration platforms (Glue & Moonbeam) have more options for changing brightness levels and colorblind adjustments. One platform (Mozilla Hubs) allows users to change the foreground and background colors of text.
- **How do the platforms handle object magnification?** Some platforms (Spatial, Mozilla Hubs and Workrooms) allow magnification of objects, especially on the HMD versions of the app.

Recommendations for Sight & Visual Consideration

We recommend that platforms explore the following accessibility barriers and suggested features:

- More research needs to be done on how to best textually or audibly describe 3D-rendered scenes using a screen reader or text-to-speech. Due to the non-linear nature of many immersive applications and experiences, this can be challenging.
    - o Metadata about 3D objects should be accessible to screen reader users. Consider including, available at the user's discretion, metadata such as: an object's name, short description, long description, traits (e.g. textures, etc.), role, state, parent-child relationships, etc.
    - o XR Access is exploring this challenge in its Accessibility Object Model collaboration with XR Association, including working directly with blind and low vision users for direct input and understanding of their needs and ideas.
    - o Spaces and structures should be labeled to help users understand and navigate around virtual spaces. Specific elements such as chairs can offer additional metadata about whether they are occupied and can communicate this via screen reader. These elements could also include information about who is seated in each space.
- Offer options to adjust brightness, adjust color/contrast of background and foreground text, and adjust views to optimize visual access by people who are colorblind.
- Offer options to allow magnification or zooming to help users with low vision access content.

Topic 3: Hearing & Speaking Considerations

Research Questions related to Subtitles & Captions

Captions help users who cannot hear audio content, and subtitles are designed to help users who may or may not hear well, or who communicate in different languages, to understand audio content[2]. They can be used to convey audio content from real-time, human speech and communication (e.g., avatars or live participants in immersive video conferences, etc.), significant ambient audio, and audio in pre-recorded media. Many users benefit from captions and subtitles including people who are d/Deaf or hard of hearing, language learners, people with temporary hearing loss or when apps are used in loud or quiet environments, users with ADHD, users with reading disabilities and users who cannot have the sound on for any reason. Statistics show that 80% of people use social media with the sound off, meaning that subtitles are incredibly important[3]. In addition, transcripts of a whole conversation or media object can be offered to benefit all users, and for other purposes such as text mining, conversation analysis or task identification.

How do the platforms support subtitles for spoken conversations?
- One platform offers subtitles for multilingual collaboration.
- Three other platforms are implementing subtitles/captions to support both users who have hearing challenges as well as users who speak different languages.
- Many platforms support screen sharing which could include sharing a web-based video conference window to display subtitles or sharing a media object like a video or presentation that includes captions or subtitles.
- No platform offered specific, documented techniques to integrate human-generated captions (CART Captions) into the platform.
- Most of the platforms that offer captions or subtitles generate them using automated methods such as speech-to-text.
- One product offers a running conversation transcript.

Recommendations for Subtitles & Captions
- Ensure that the number of participants in a world or app does not impact the quality or function of features. For example, in one case it was reported that subtitles would crash on a platform when more than 30 people were in a world.
- Consider evolving practices such as those being researched by the W3C Immersive Captions Community Group (ICCG) – Initial Findings Report. The ICCG is exploring the accessibility of audio and spoken content in immersive technologies.
- Ensure that people with disabilities are not required to pay extra for subtitles or captions.
- Make sure subtitles and captions identify speakers, are synchronized with the visual information, indicate spatialized audio sources, and are properly designed for readability and visual clarity, including not obscuring important visual content.

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[2] 3Play Media, "Captions vs. Subtitles: Do You Know the Difference?", 26-Aug-2021.
[3] 3Play Media, "Verizon Media and Publicis Media Find Viewers Want Captions", 19-July-2019.

- Offer an option for captions to provide text equivalents of non-speech elements such as significant ambient audio.
- Make subtitles or captions an option up front when a user sets up meetings, events, and training sessions.
- Offer a way to integrate human-generated captions (CART) into the platform.
- Provide transcripts of spoken dialogue or media audio content to benefit all users, and for other purposes such as text mining, conversation analysis or task identification.
- Avoid supporting only audio, video, or avatar-based communication. Instead, ensure there is a way to communicate using text like a chat.

Research Questions related to Video Interpreter & Remote Assist

Platforms can allow users to view a video display of sign language interpreters to translate spoken conversation into sign language. This video display could also be used for remote assist. Many users benefit from this feature, including people who are d/Deaf, people who speak sign language, and all people who might receive remote assistance.

How do these platforms support incorporation of a video interpreter?
- While none of the platforms explicitly supported a video interpreter, many platforms do allow placement of a video feed or videoconference software player embedded in the environment, which could display an interpreter.

Recommendations for Video Interpreter & Remote Assist
- Offer users the option to have video assist or communication.
- Offer the ability to alter the video placement based on the interaction such as a small meeting, large event, or individual work activity with remote assist.
- Explore the interconnection between video and captions to support fluid multiplex communications.

Topic 4: Mobility & Dexterity Considerations

Platforms can allow users to interact with the technology from a seated, reclining, or stationary position and to support the use of alternate or separate controllers and sensors. They can also allow users to remap controls on a standard controller or onto alternate controllers, sensors, or keyboards. Many people benefit from these options including people who have limited locomotion, use wheelchairs, have limited dexterity, wish to use XR in a stationary position or are unable to use their hands for any reason.

Research Questions related to Mobility & Dexterity
- **How do the platforms handle movement?** One platform (Mozilla Hubs) allows users to type commands in the chat and move within the space.
- **How do the platforms handle control mapping?**
  - Two platforms (Glue and Workrooms) offer the ability to use alternate or separate controllers.
  - Two platforms (Moonbeam and Mozilla Hubs) offer the ability to remap controls in the desktop versions.

- **Do the platforms allow for a range of positions?** Operation from a seated position is offered on most platforms.

Recommendations for Mobility & Dexterity
- Consider including wrist and hand turning gestures and eye tracking controls.
- Make sure apps can be used one-handed instead of requiring two handed interactions.
- Provide task completion assistance.
- Employ dynamic foveated rendering on head-mounted displays by utilizing eye tracking to boost the visual resolution where the user is looking and reduce it on the peripheral of their vision. This not only reduces processing requirements on the system itself but is also similar to how the human eye/brain works.

Topic 5: Cognitive Considerations

It is important to adapt content output methods to include both visual and audio options, for example, giving users the ability to turn off background audio. Users also benefit from practicing within the platform before fully using it and having important information distinguished in some way. Additionally, all tutorials should be written in plain language using a scaffolding method from simple to complex. Everyone who uses a new system will benefit from a platform that is clear and easy to understand. These considerations will support users with developmental disabilities and those who identify as neurodivergent.

Research Questions related to Cognitive
How do the platforms handle tutorials?
- One platform (AltspaceVR) offers interactive tutorials that encourage users to experiment before entering worlds.
- A few other platforms have 2D or plain language tutorials.
- Several platforms do not offer a tutorial.
- One platform (Transfr) was found to be accessible to people with cognitive disabilities.

Recommendations for Cognitive
- Offer 2D or interactive tutorials using plain language.
- Consider ways that adapting or simplifying content display or audio output can help with focus.
- Offer ways to allow users to set up or practice functionality before using it.

Interview Findings

As part of the research, it was also important to gain more in-depth information about how people with lived experience perceive the current XR workplace tools and the potential they may have in the future. Interviewees had a mixture of experience in XR – from early adopters of the technology to those who had not tried it yet (due to lack of accessibility) but knew about the possibilities XR presents. The findings of those interviews are summarized below.

Do people with disabilities see potential in workplace XR?

Throughout our interviews, we learned that even if a person with a disability had not tried XR yet, they still felt it had potential. Specifically, they felt that the technology could give them more freedom to complete tasks they typically found cumbersome. Many people we interviewed put a great deal of time and effort into learning new technologies to assist them in their work. For example, a person with low vision may spend a considerable amount of time taking remote classes to learn how to use screen readers. These tools must be accessible to support workers with and without disabilities.

"I can't do many things, it takes me a long time to get ready in the morning, but the things that I can do are massively amplified by technology."
– Interviewee

What barriers stand in the way of people with disabilities using XR?

If a user has access to XR, they often must find workarounds. For example, a user with low vision noted that to look at menus, they had to point their headset at the menu, record a video, send the video to their computer, remove the HMD, and zoom the video on their computer to see what it said. Then, they had to memorize the button position and go back into VR to select what they needed from the menu. These barriers cause disappointment and if users do not see any improvement over time, they will abandon the technology.

"I got tired of not seeing any consumer facing accessibility improvements - why should I have to continuously find workarounds just to access content?"
– Interviewee

What will happen if XR is not accessible?

Our interviewees all felt that if XR does not seriously focus on accessibility features, they will likely abandon the technology. Much of the content available in XR is not accessible. For example, captions are not offered in many apps even if the platform supports them. Often, our interviewees felt that more research was being done on XR accessibility, but it was not translating to consumer-facing improvements.

"I have become frustrated, and I have stopped using VR as much because of the barriers that I continuously experience."
– Interviewee

What accessibility features should developers focus on including?

Generally, the key thing to consider is that there must be multiple interaction methods for people to communicate, collaborate and contribute. To have truly accessible interaction methods, people with disabilities need to be included in the design and testing of XR. Also, the industry needs to provide more entry points for people with disabilities to gain accessible XR education, for example, virtual classes that are screen reader compatible.

Below are the features that were suggested by our interviewees.
- There should be the ability to screen share.
- There should be automated transcription or note taking capabilities.
- There should be options for text to speech, haptics and voice commands and these features should be integrated so that users with and without vision can use them and collaborate in immersive spaces.
- Virtual meeting spaces should provide spatialized descriptions with immersive audio and haptics.
- There should be the ability to mirror a desktop computer in XR, as many interviewees noted this was helpful.
- There should be the option to use a Bluetooth keyboard.
- Developers should consider using the Accessibility Object model for metadata descriptions.
- Flat screen apps that accompany headset apps have the potential to solve access issues. Manufacturers and content makers should consider how they can use flat screen apps to make their hardware more accessible.
- Manufacturers should be aware that screen readers pick up content in a very linear way, which can be a barrier to interactive content.

What's Next?

Our research only scratches the surface of defining the business value for inclusively-designed XR in hybrid workplaces. More research needs to be done on the business value of the actual inclusive design and accessibility recommendations described in this report's findings. We implore developers, designers, and manufacturers to hire, collaborate and engage with people who have lived experience of disability, to inclusively design XR platforms, applications and experiences. This is the best way to ensure that all employees can be fully engaged and included in the hybrid workplaces that utilize XR technologies, as well as to build workplace technologies that are usable by the broadest user base, instead of becoming obsolete.

You can get involved and improve the state of XR in the following ways:
- Contribute to the XR Accessibility Project GitHub
- Connect with disability advocacy organizations and accessibility consultants, and ensure you compensate them for their contributions to your technology development or implementation.
- Run workshops that highlight how inclusive design and accessibility can remove barriers to entry for disabled users, as well as provide a better user experience for everyone.

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bcXR Core Research Team

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XR Access Needs Your Support

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