# Evaluation of Technology Accessibility and User Sentiment in Learning Through Virtual Reality Modality

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## Abstract

*How would your organization's employees respond to a deployment of virtual reality-based training? Would they be excited, inspired, or perhaps intimidated by new technology?*

We tested the accessibility of virtual reality (VR) as a modality for training PricewaterhouseCoopers (PwC) employees, and we observed negative and positive sentiments associated with various approaches to VR engagement.


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This case study presents our efforts to improve VR headset onboarding and game play experience by analyzing user experience from the time they show up for the VR learning experience to the time they leave. We describe learner capabilities and skills required to interact with the headset and voice-recognition technology in a simulation based learning experience, the methods we used to identify user sentiments and infer causes, as well as our efforts to address user needs by adjusting our VR learner experience design.

In selecting our test user population, we attempted to represent the diversity of PwC learner demographics, including gender, ethnicity, employee role / function, practice group within PwC, and other characteristics that could have had a material impact on VR equipment use, such as prior experience with VR, use of eyeglasses, and presence of various accents when speaking. Our heterogenous group of testers pushed us to acknowledge user sensitivities, which we had previously underestimated. We changed our VR onboarding protocol in order to mitigate reticence to learning in VR.

We believe that as the technology becomes more prevalent in the enterprise and more employees experience the value VR brings to the training experience, the overall sentiment toward VR will continue to improve. We hope our study motivates continued research to improve accessibility of VR technology, enterprise implementation of VR, user-interface design, and voice recognition technologies used in gameplay.

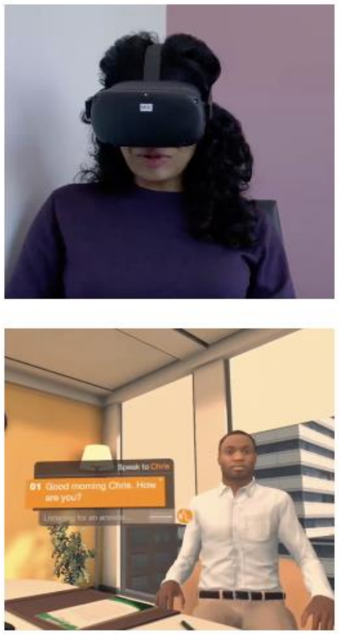

**Figure 1:** Image of PwC learner in virtual reality headset, and companion image of view from inside the headset.

**Author Keywords**
Virtual Reality; User Experience Test; UX Test Design; Sentiment Surveys; Diversity and Inclusion; Accessibility; Inclusive Leadership; Virtual Human; Virtual Reality Learners; Gaze; Voice recognition

## CCS Concepts

• Human-centered computing ~Interaction Paradigms; Virtual Reality;
• Human-centered computing ~ Accessibility; Accessibility Design and Evaluation Methods

## Introduction

Virtual reality affords professionals an immersive training environment wherein they may practice job skills by engaging with the virtual environment much like they might engage with a physical world, through seeing, hearing, speaking, and even manipulating objects with their hands. Because of the kinesthetic learning available through VR, job-skills practiced in VR are supposedly more quickly mastered and better retained than through traditional training methods such as reading or lecture.

To test these results, in 2019, PwC ran a comparative study of classroom, online, and VR based learning efficacy and cost efficiency [1]. This case study focuses specifically on the preparation and testing of the VR learner experience to improve accessibility in advance of that research. Note that we define "accessibility of VR learning" as the ease of utilizing VR as a learning modality. Accessibility is achieved through consideration of physical, mental, or emotional barriers to learning in VR.

To share how our user testing influenced design of VR onboarding protocol and experience design, first, we will provide a brief description of the VR inclusive leadership training we created. Then we will outline user capabilities and skills required to engage in our training. Next, we share our user experience testing methods. Finally, we report the top issues identified by sentiment indicators and how we increased accessibility and improved sentiment.

## Inclusive Leadership Training in VR

The VR training course we produced and tested trains PwC employees on applying inclusive leadership behaviors at work. In the VR simulation, headset wearers (learners) find themselves in a virtual office representative of actual PwC offices speaking to a group of virtual characters representative of PwC colleagues. Learners play themselves as they carry out realistic professional conversations relating to "who to hire", "who to staff", and "who to promote."

In a choose-your-own-adventure-style experience, the learner speaks to virtual characters, choosing dialogue from a list of options. Virtual human characters then react to what a learner says and the conversation progresses with more options for the learner. Each branch track is designed to allow learners to observe and practice every inclusive leadership behavior identified by PwC's Office of Diversity and Inclusion for this training. During the course of the conversations, learners may, for example, state that another character is showing bias for a particular candidate, ask questions to collect information about how to be objective, and/or share their own opinions and recommendations, just to name a few.

After each conversation the learner can then review their dialogue choices. Weak and neutral options selected by the user are highlighted and wording reflective of more inclusive behaviors are provided, along with explanations as to why the recommended dialogue is more inclusive. Learners are allowed to repeat and practice each scenario as many times as desired.

## Equipment Requirements

The visuals in our training took advantage of recent device improvements. A VR device with at least a 72hz refresh rate, offering high resolution of 1,440 by 1,600 pixels per eye, would have previous required a VR headset to be tethered via several cables to a powerful computer with an expensive video graphics card. Our experience leveraged a newer VR equipment model that was simpler to set up. Our deployment was of self-contained headsets, completely wireless (no tether) and the headset contained all the necessary components. Our experience also did not require the use of hand controllers.

With the more complicated setup in the past, other researchers have expressed concerns around feasibility of VR based learning [2]. Selecting a simpler hardware setup, VR was more accessible to our population at scale, but we still needed to prepare for some onboarding to the tech.

## User Capability and Skill Requirements

As a baseline for accessibility we knew the learning in VR would require the following capabilities:

- Vision
- Hearing
- Eye movement
- Neck mobility

Any learner that did not possess these capabilities was exempt from participation in learning in the VR modality, and instead was recommended for classroom or e-learning course on the same topic.

Additionally, as a baseline, we expected all our learners to have the following necessary skills:

- Literacy
- Verbal communication in American English

To complete the VR experience, learners would need instruction on how to do the following:

- Adjust headset straps for head-mounted fit
- Adjust lens distance for visual focus
- Select interface options using gaze (A visual dot indicates where the learner is looking, based on head position. When the dot aligns with target areas in the interface for a set number of seconds a scene action initiates)
- Select interface options using speech (voice to text commands initiate scene actions)

For a completely self-service training experience, a learner would also need to be able to do the following:

- Identify a safe location for experiencing VR, free of physical hazards
- Turn on / off or restart headset
- Launch *Inclusive Leadership Behavior Training* application
- Recharge battery on headset
- Connect headset to local wifi network
- Properly clean and store headset

During the summer we tested several VR onboarding methods that attempted to educate the user on how to use a VR headset.

## User Sentiment Survey and Analysis

We used UX testing to ascertain the accessibility of VR to our population. When presented test users with the VR equipment and some basic instructions, we were able to observe the user testers' VR navigation skills and know-how.

We gained a further understanding of the populations' receptivity of VR learning by identifying the learners' sentiments at each step of the user journey. Identifying sentiments drew our attention to steps in the user journey that were particularly positive or negative for learners.

To collect this information, we administered sentiment surveys at predetermined intervals in our user tests (e.g., when the user first walks into the training room, after handling the equipment for the first time, after completing in-headset training modules, etc.). These surveys documented user energy levels and emotional states. Reports of low energy levels and negative user sentiments in these surveys directed our attention to areas where learners struggled with core VR skills or with the gameplay.

We collected baseline user sentiment as step one of our UX tests. We surveyed learners using the sentiment collection tool illustrated in Figure 2, which captures the intensity of ten emotional states that co-exist during select phases of their VR training experience. Users were asked to mark with a highlighter a sentiment in each row, which they felt during that phase of the journey. At the end of each user experience test, we had a complete data set documenting every learner's sentiments along each step in their VR training journey.

We compiled all sentiment data into a spreadsheet. We assigned numerical values to each of the five options users could select from in each of ten rows of emotional states learners reported on. This enabled us to quantify the degree of positive / negative sentiments users experienced. Our scoring methodology is as follows for each of five possible user responses in each row:

- "A little [negative sentiment]" received a score of (-1)
- "Somewhat [positive sentiment]" received a score of (1)
- "Very [positive sentiment]" received a score of (2)
- "Very [negative sentiment]" received a score of (-2)
- "Can't identify" received a score of (0)

To arrive at an aggregate score representative of user's outstanding sentiment at each phase of their VR training journey, we found the average of the scores for each of the 10 sentiment ranges for each user at each timepoint. If this average score was above (1.5) or below (0) for any given sentiment in a phase of the user journey, the user sentiment at this point in time was considered as "remarkable."

By identifying remarkable user sentiments along the learner's journey and collecting interview feedback on the underlying drivers associated with these emotions, we were able to narrow our focus to parts of the VR training journey that needed revisions to our user experience design. We characterized remarkable sentiment change by considering quotes captured from follow-up interviews.

When I **entered the event room** today I felt...

| | | | | | |
|---|---|---|---|---|---|
| 1 | A little distracted | Somewhat engaged | Very engaged | Very distracted | Can't identify |
| 2 | A little confused | Somewhat confident | Very confident | Very confused | Can't identify |
| 3 | A little self-conscious | Somewhat relaxed | Very relaxed | Very self-conscious | Can't identify |
| 4 | A little apathetic | Somewhat empathetic | Lots of empathy | Very apathetic | Can't identify |
| 5 | A little bored | Somewhat entertained | Very entertained | Very bored | Can't identify |
| 6 | A little irritated | Somewhat grateful | Very grateful | Very irritated | Can't identify |
| 7 | A little fatigued | Somewhat energized | Very energized | Very fatigued | Can't identify |
| 8 | A little dizziness | Somewhat grounded | Very grounded | Very dizzy | Can't identify |
| 9 | A little discouraged | Somewhat inspired | Very inspired | Very discouraged | Can't identify |
| 10 | A little indifferent | Somewhat hyped | Very hyped | Very indifferent | Can't identify |

**Figure 2**: To indicate how testers felt during the stated phase of the user journey, they were asked to highlight one sentiment on each of ten rows of emotional states. This image shows an example of an unmarked survey tool used to collect baseline sentiments when the learner entered the event room.

## VR Onboarding and Experience Design Tips

Some of the negative sentiments manifested in our studies are as follows:

- Learners felt bored and distracted while being instructed on core VR skills
- Learners felt self-conscious and discouraged without validation that they were engaging with VR equipment and technology as intended
- Learners felt disoriented / dizzy from repeated side-to-side head movements to explore in-headset fields of view
- Learners felt uncomfortable or disinclined to put on the headset because they were concerned about transferring makeup and / or hair product to the headset
- Learners felt self-conscious wearing the headset in conspicuous settings.

- Learners did not feel comfortable using voice during VR gameplay in office areas where they could be overheard (and potentially disrupt coworkers)

Identifying these pain points guided us in making the following adjustments to the user experience:

- Change our feedback delivery methodology and content to enable learners to see the "best choice" of inclusive behavior options juxtaposed to their selected choice elicited feelings of inspiration and call to action vs. feelings of discouragement
- Reposition characters and text more narrowly in the learners' field of view to reduce the need for head movements and resulting dizziness
- Allow learners to take training in a private room to reduce self-consciousness
- Send learners a "what to expect" email communication helped learners feel less self-conscious and more hyped about the experience

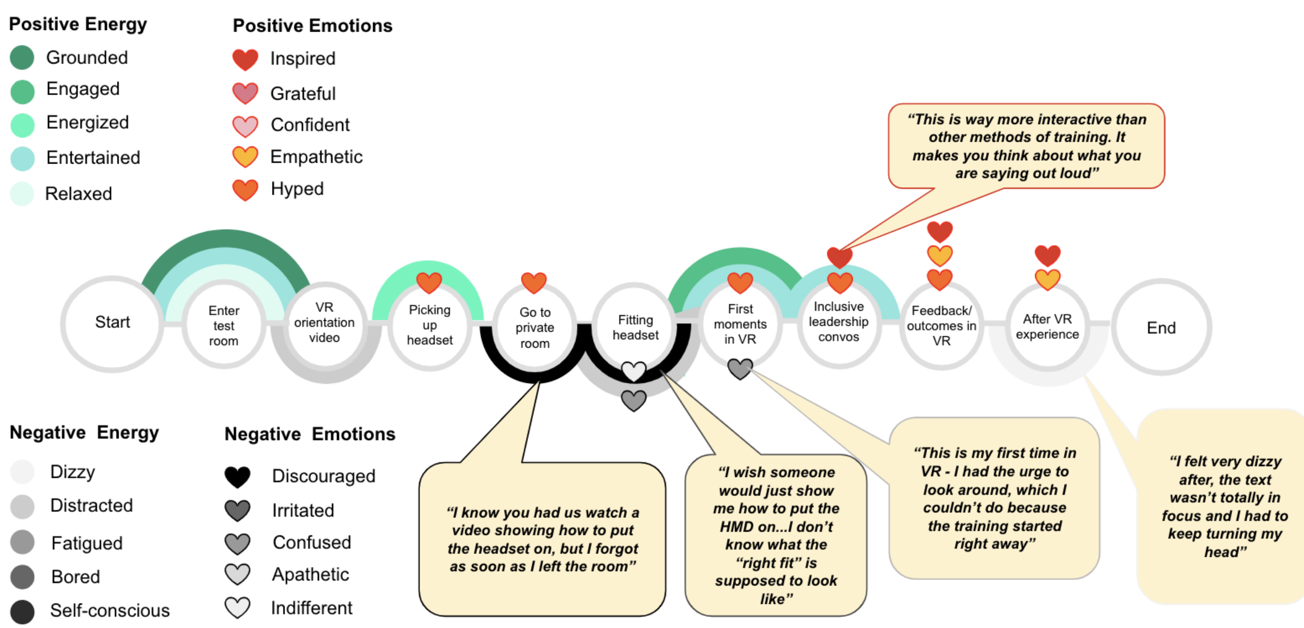


**Figure 3**: Illustrated above is an example visualization of sentiments gathered along users' VR training journeys. Remarkable positive sentiments reported are visualized above the user journey line, and remarkable negative sentiments are depicted below the user journey line.

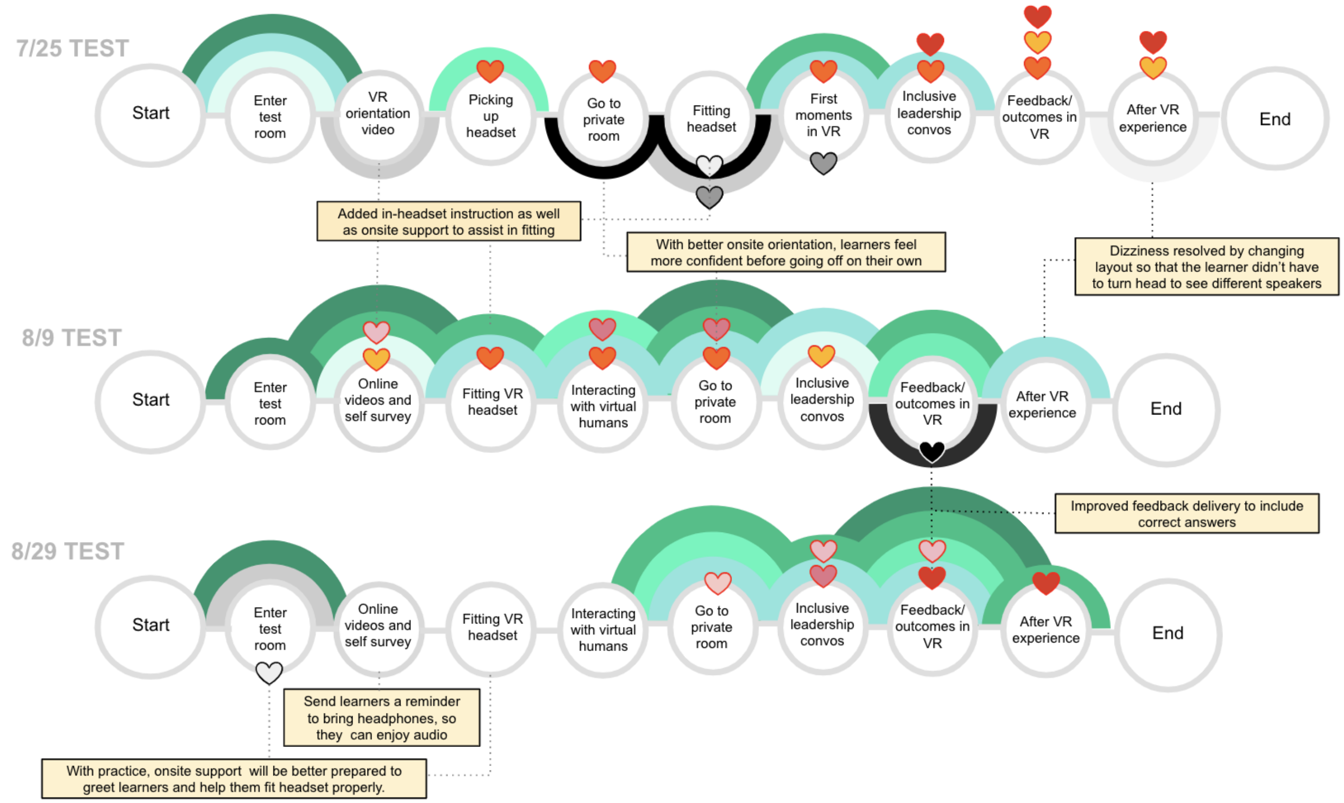


**Figure 4**: Illustrated above is a summary visualization of iterative improvements between UX tests. Tests at later dates show improved sentiment averages in the VR portion of the experience. Improvement notes indicate how the user experience was adjusted in the next test to try and improve sentiment.

## Conclusions

Our UX testing highlighted that the use of VR headsets for the average learner is not yet simple enough to be a self-service device for the first time user. Out-of-headset video demonstrations and pictorial instructions alone were ineffective in teaching how to adjust for fit and focus. The most successful approach was to provide in-headset guidance and feedback on these skills. Our in-headset orientation also included a short virtual human interaction that enabled users to practice voice and gaze interactions prior to entering the simulation.

Furthermore, we were able to reduce the number of skills required of the learner by leveraging specially trained onsite support personnel and enterprise level VR management tools. The headsets used in our study were pre-programmed to automatically connect to an office wifi network compliant with corporate IT security policies. They were also set to "kiosk" mode. This enables user orientation and the Inclusive Leadership Behavior Training application to be launched immediately after headsets are turned on. It also prevented users from unintentionally existing the application, launching other applications, disabling access to the internet, or otherwise using the headsets for purposes outside of training.

Ultimately, after our VR training accessibility was refined by UX tests as illustrated in Figure 4, the inclusive leadership behavior training was deployed to 12 locations through 100 headsets. PwC compared effectiveness and cost effectiveness of VR to traditional training. VR learning was rated by learners as most effective at meeting the course learning objectives and teaching inclusive leadership behaviors. 75% of our participants surveyed said that the VR training helped them identify situations in the past where they were not as inclusive as they previously believed. Most learners rated VR and classroom training as a preferred/acceptable modality.

We were glad to see that our UX tests had enabled an immersive learning experience, where learners were not distracted by learning a new technology. Many learners reported making choices in VR instinctively based on what they would do in real life. 78% of VR learners surveyed said they would like to take more VR based learning.

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