Case Study

Understanding Virtual Reality: Presence, Embodiment, and Professional Practice

—JASON THAM, ANN HILL DUIN, LAURA GEE, NATHAN ERNST, BILAL ABDELQADER, AND MEGAN MCGRATH

***Abstract*—Introduction:** *Virtual reality (VR) has gained popularity across industries for its ability to engage users on a level unprecedented by print or 2-D media; however, few guidelines exist for the use of VR technologies in technical and professional communication (TPC) curricula. To address this need, this experience report details the study of a recognizable and adopted set of VR devices to promote understanding of the ways in which emerging VR technologies provide new approaches to pedagogy.* **Literature review:** *Drawing from literature in computer science, communication studies, and anthropology, as well as embodiment and phenomenology, the authors provide a historical account of VR development.* **About the study:** *Using three concurrent case studies and qualitative interviews, the authors share their deployment of three low-end to high-end VR devices: Google Cardboard, Google Daydream View, and HTC Vive. Using a modified heuristic, the authors assess the functions, features, and uses of the devices; showcase current or potential deployments; and for triangulation, provide a user study of two devices.* **Results/discussion:** *VR immersion can provide students with a deeper understanding of course content; immersion in future workplaces can give students an initial vision of their project and profession; concepts can be seen from new vantage points; and user themes include felt experience, sense and sensibility, agency and autonomy, and constant identities. Together, these themes provide an entry into discussions of designing VR content for technical and professional communication.* **Conclusion:** *The authors discuss limitations to VR integration and provide resources so practitioners might implement VR in engaging and relevant ways.*

Index Terms*—Embodiment, pedagogy, practice, presence, technical and professional communication, virtual reality.*

Once a fictitious element in sci-fi stories, virtual reality (VR) technology is now becoming commonplace in an age of pervasive information and immersive computing. With the rise of wearable technology and networked computing (e.g., cloud computing, the Internet of Things), human–computer interaction has evolved from screen-based to sensory-based interfaces, transforming how we communicate between humans, machines, and data. Amid these transformations, VR has gained notable popularity across various industries for its ability to engage users on a level unprecedented by traditional print or 2-D screen media.

The New York Times, for instance, partnered with Google in October 2015 to organize a massive giveaway of the Google Cardboard device, shipping a million of the do-it-yourself virtual reality headsets alongside a *New York Times* VR app [1]. Since the giveaway, the *Times* has continued to produce immersive stories that push the envelope of print journalism through its use of 360° videos and interactive content. Other global ventures, including Facebook (which acquired VR tech manufacturer Oculus VR) and Swedish home furnishing giant IKEA (which partnered with the smartphone network company HTC to launch a VR shopping experience app [2]), are leading the market in VR acquisition with the common goal of creating engaged user experiences, where digital and physical worlds collide. Most recently, one can learn how to tile using Lowe's home improvement VR [3], and marketers declared 2017 as the year when VR will bring "unprecedented immersion" to content marketing [4].

Practitioners of technical and professional communication (TPC) have begun to discuss the impact of such virtual and augmented reality along with wearable technology and the Internet of Things [5]. Technical communicators, information designers, and those who work to communicate complex information find that they need more knowledge about these emerging technologies. Training examples are found in the 2016 North America Content Management System and Darwin Information Typing Architecture seminars

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Practitioner Takeaway

- This experience report details the study of a recognizable and adopted set of VR devices to promote understanding of the ways in which emerging VR technologies provide new approaches to pedagogy.
- Three case studies and qualitative interviews demonstrate the deployment of three low- to high-end devices. The authors assess the functions, features, and uses of the devices; showcase deployments; and for triangulation, provide a user study of two devices.
- VR immersion can provide students with a deeper understanding of course content; immersion in future workplaces can give students an initial vision of their project and profession; and concepts can be seen from new vantage points.

sponsored by the Center for Information-Development Management [6] and online seminars such as talks on Techevents.online regarding augmented reality in technical communication [7]. While the industry is blazing trails with these professional development opportunities, few if any pedagogical guidelines exist for the use of VR technologies in technical and professional communication curricula in higher education.

Recognizing this void, scholars in the Writing Studies department at the University of Minnesota have established the Wearables Research Collaboratory (WRC, http://wrcollab.umn.edu) to address this very issue. There, students and faculty explore specific new technologies for their influence on technical and professional communication. During the 2016–2017 academic year, WRC researchers focused on three recognizable low-end to high-end VR devices (see Fig. 1): Google Cardboard, Google Daydream View, and HTC Vive. These devices were selected for their popularity in the VR market as well as the range of price and experience they offer.

In this experience report, we share our experiences with these devices as a means to promote understanding of how new and emerging VR technologies are changing our approaches to TPC pedagogy, with special attention to presence, embodiment, and professional practice. Our work is informed by a unique cross-cultural collaboration model through the WRC in which undergraduate research assistants, graduate students, and faculty members work together to explore emerging technologies through design-thinking methodology [8]. In this paper, we exemplify this practice through shared authorship between undergraduate researchers, graduate students, and a faculty member. Particularly, the distinctive device assessments in the first three case studies are written mainly by our undergraduate researcher coauthors, given their extensive use and knowledge of the devices. The case studies were conducted simultaneously as each undergraduate researcher focused on one specific device and its deployment in a pedagogical setting.

In this paper, we begin with a literature review of studies from computer science, communication studies, and anthropology, as well as literature on embodiment and phenomenology, as a way to define VR across the spectrum of reality. We present a historical account of the development of VR technologies and their influence in socio-technical industries, including technical communication. Then, through three case studies and qualitative interviews, we share our deployment of these devices.

The three case studies focus primarily on educational scenarios. We provide information on the devices' basic features and functions, detail on how to use each device, and discussion of the opportunities and challenges encountered across deployments in TPC courses. Using a modified heuristic, we assess the functions, features, and uses of the devices, and showcase their deployments through the three case studies. The fourth study provides a report of user interviews for two of the devices: Google Cardboard and HTC Vive. Although we worked to ensure accurate representations of these devices and their capabilities, we have been constrained by the state of the art of these technologies in 2017 when this article was written. By the time of publication, these devices are likely to have been upgraded with greater functionality. Following the results from the case studies and interviews, our conclusion includes integration of findings regarding VR presence, embodiment, and professional practice, as well as implications for TPC practitioners.

Literature Review

Most existing literature on VR is located across computer science, communication studies, and anthropology scholarship. We have selected literature by premier thought leaders in these fields to provide a historical account of the development

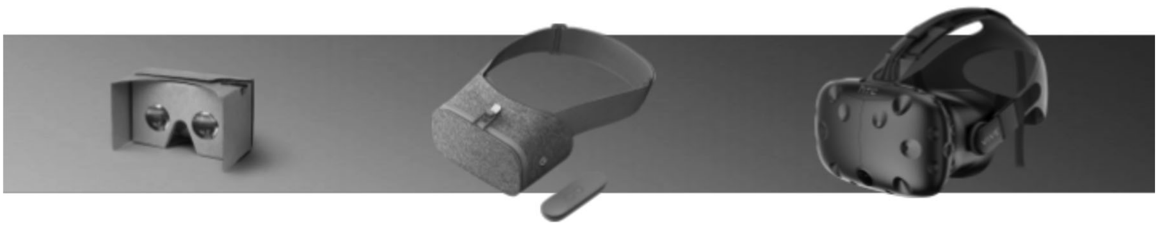

Fig. 1. VR hardware landscape, from low end (left) to high end (right): Google Cardboard, Google Daydream View, and HTC Vive. Graphic created by Jason Tham.

Fig. 2. French VR artist Nicole Stenger demonstrates wearing a VR headset and glove developed by VPL Research, 1992 [55].

of VR technologies, as well as the socio-technological effects that these technologies bring to TPC practice.

Defining Virtual Reality VR is typically defined in terms of the technological hardware that creates the dimensions of experience affording different levels of vividness and interactivity in an immersive or para-reality environment. Early models of VR relied heavily on human eyes and hands to create a sense of presence in virtual spaces. Lanier, who is credited as the first to popularize the term in the late 1980s, defined VR as “three-dimensional realities implemented with stereo viewing goggles and reality gloves” [9, p. xiii]. He is also the founder of Visual Programming Languages Research, a pioneering company that developed and sold VR products in Palo Alto, CA (see Fig. 2).

VR for Creating a Realistic-Looking World VR is often known for its functionality in setting apart the real and the fabricated. In *Becoming Virtual*, Levy approached the concept of “the virtual” as a juxtaposition against “the real,” “the actual,” and the “possible” [10]. In a similar fashion, Milgram et al. compared VR to other forms of mediated

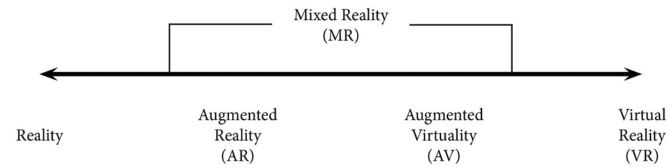

Fig. 3. Spectrum of reality. Adapted from [11].

reality (augmented reality and augmented virtuality) to highlight VR’s simulation feature, where artificial environments are built based on real-world imagery [11] (see Fig. 3).

Milgram et al. [11] defined the various levels of reality as follows:

- **Reality:** Substantial interactions bounded by space, time, and material conditions of the physical world (e.g., using a traditional compass to read and navigate directions)
- **Augmented reality:** Computer-generated enhancements of and atop an existing reality that blend digital components into the analog world (e.g., getting a real-time, synchronous navigational display that is projected onto the existing road being travelled)
- **Augmented virtuality:** Virtual environments controlled by real-world, analog information (e.g., videoconferencing through a webcam)
- **Virtual reality:** Artificial simulations, usually recreation of a real-life environment, that enhance an imagery reality or situation (e.g., impersonating a character in a Minecraft game adventure)
- **Mixed reality:** Augmented reality and augmented virtuality; any merging of real-world objects or information into the virtual world

Note the definition of VR as “artificial simulations, usually recreation of a real-life environment, that enhance an imagery reality or situation” [11, p. 283]. In simpler words, Burdea and Coiffet define VR as “a simulation in which computer graphics are used to create a realistic-looking world” [12, p. 2].

Fig. 4. User wearing and maneuvering an HTC Vive [56].

VR for Providing Real-Time Interactivity
Another defining feature of VR is its real-time interactivity. In their definition of VR, Aukstakalnis et al. highlight the notion of interaction between a user and a computer in VR environments: "Virtual Reality is a way for humans to visualize, manipulate, and interact with computers and extremely complex data" [13, p. 7]. Information is presented both through displays for the eyes and through tactile and auditory user feedback. Wearers are able to view what appears to be a life size, three-dimensional (3-D) virtual environment without the boundaries that they usually associate with TV or computer screens. This device is called a head-tracking system—whichever way the wearers look, the screen mounted to their face follows them. To create input for simulation, VR headset wearers use either tethered or wireless controllers with built-in sensors to track hand movements (see Fig. 4). In the case of devices similar to HTC Vive (e.g., Sony PlayStation VR, Oculus Rift, and Oculus Touch), wearers hold two controllers and use buttons, thumbsticks, and triggers to register actions within VR simulations. Wearers are also able to see their hands in the display through the headset.

VR in Terms of Human Presence Steuer argues that Lanier's definition of VR limits its analysis to particular hardware instantiation, thus reducing its potential for variance [14]. Steuer suggests a conceptualization of VR in terms of human experience rather than technological hardware—that is, presence. Presence, by Steuer's definition, is

> the experience of one's physical environment; it refers not to one's surroundings as they exist in the physical world, but to the perception of those surroundings as mediated by both automatic and controlled mental processes. [14, p. 75]

For VR, the feeling of presence determines the overall mediated experience [15]. As a result, the concept of presence has great practical relevance to the design, evolution, and evaluation of VR technologies.

In attempts to operationalize presence in the context of VR, Lombard and Ditton surveyed the literature on presence and found that other researchers had conceptualized presence as the result of a combination of one or all of a number of factors [16]. Their summary indicates that an increased sense of presence can result from a combination of all or some of the following factors: quality of social interaction; realism in the environment (graphics, sound, etc.) from the effect of "transportation" and from the degree of immersiveness generated by the interface; the user's ability to accomplish significant actions within the environment and the social impact of what occurs in the environment; and the user's response to the computer itself as an intelligent, social agent [16]. Table I provides the description for each factor.

Elsewhere, Heim has provided similar definitions and categorization of virtual presence [17]. According to Heim, there are seven elements of VR: simulation, interaction, artificiality, immersion, telepresence, full-body immersion, and networked communications [17]. In immersive VR systems, the sensation of presence is conveyed by minimizing the contact of the user with the external real world, thus differentiating these systems from web-based VR applications that are normally manipulated through a mouse and the computer screen display. Some of Heim's elements, such as interaction and immersion, are referenced in Lombard and Ditton's classification of presence [17]. However, as Lee demonstrates, different fields use different terms to refer to the notion of presence in mediated environments, and its conceptualization lacks coherence [15]. Moreover, the rapid advancement of technological hardware (microchips, nanoprocessors, global positioning system (GPS) transceivers, touchscreen controllers, etc.) to enhance user interactivity with the device further complicates the notion of presence.

The rise of wearable computers and portable augmented-reality (AR) technology adds even more complex expressions of presence through VR spaces. Again, as part of the Wearables Research Collaboratory, we have studied the rhetorical

TABLE I
TYPES AND DESCRIPTIONS OF PRESENCE, ADAPTED FROM [16]

Types of presence	Description of presence
Conveyance of social cues	The degree to which any given medium has the capacity to transmit information that is perceived by a participant and used in the interpretation of the message.
Fidelity of representation	The degree to which a communication medium creates imagery and other sensory input that has high fidelity relative to the target person, place, or thing that is the focus of communication.
A transport mechanism	The degree to which a medium can give users a sense that they are transported elsewhere (i.e., "you are there") or bring a place or objects to a user's location (i.e., "it is here").
Immersion in a space	Either physical immersion (i.e., immersing sensory organs into physical devices like head mount displays and headphones) or psychological immersion (i.e., creating a sense that one is inside the space).
Social actor in a medium	When an observer treats a character in a medium as a social actor regardless of whether that actor can respond or is controlled by a human actor (e.g., watching and talking back to a TV anchor).
Computers as social actors	When people treat inanimate objects that do not resemble human actors (e.g., computers) in a socially sound manner.

nature of real-time or synchronous stimulation of virtual information in semantic contexts of the physical world. Duin et al. theorize a "third space for constructions of social presence" that complicates the boundaries between physical and virtual reality, namely, wearable presence [18]. They contend that portable virtual environments, made possible by wearable computers, close the proximity between virtual spaces and the human mind. In effect, wearers of such devices enter a hybrid space, where physical presence and virtual presence can be switched and suspended intermittently. Such instances complicate the rhetorical situation and expressions of persuasion since the persuasive mechanism now involves an unusual coordination of the wearer's physical and cognitive energy [18].

Based on definitions by Steuer [14], Lombard and Ditton [16], Heim [17], and Duin et al. [18], we define presence as a psychological state of existence within an environment. However, without physical attributions, presence itself cannot fully represent the sense of being that one perceives when experiencing immersive virtual environments. As a result, we turn to the notion of embodiment to supplement the cognitive awareness of one's manifestation of the self with the corporeal representation of the body.

Conceptualizations of Embodiment One thing that all humans share is the fact that our lived experience is profoundly affected by our awareness of a body—physical or not. While theories of embodiment are relevant to many fields, it is most commonly defined as "how culture 'gets under the skin,' or the relationship of how sociocultural dynamics become translated into biological realities in the body," according to anthropologist Anderson-Fye [19, p. 16].

Embodiment has also been discussed in relation to presence in virtual environments [20], [21], especially since there is evidence to suggest that a virtual body in the context of a head-mounted, display-based virtual reality is a critical contributor to the sense of being in the virtual location [22]. Kilteni et al. state that exploitation of immersive virtual reality has allowed a reframing of the question of felt embodiment to whether it is possible to experience the same sensations toward a virtual body inside an immersive virtual environment as toward the biological body and, if so, to what extent [23]. They offer a working definition that states that a sense of embodiment consists of three subcomponents: the sense of self-location, the sense of agency, and the sense of body ownership [23].

Certainly, our perception of embodied reality can be further complicated by our experience of the world. The next section highlights some theories related to the experiential and metaphysical aspects of embodiment.

Embodiment as Culture and Experience As noted by Csordas,

> If embodiment is an existential condition in which the body is the subjective source or

> inter-subjective ground of experience, then studies under the rubric of embodiment are not about the body per se. Instead they are about culture and experience insofar as these can be understood from the standpoint of bodily being-in-the-world. [24, p. 143]

This notion of embodiment is particularly pertinent to the context of human–computer interaction research, where the relationship between actors highlights interdependencies, interactions, and support networks that grow and occur as a result of new forms of interaction. Within tangible or physical computing, gesture is also considered an extensive and important aspect that supports observable discussion and explanation of embodiment [25]. Manipulation of objects is seen as a gestural precursor, where physical arrangement, participants, and artifacts provide the support necessary to achieve communicative competence [26].

Where many embodiment theorists diverge is in their (dis)agreement about the separation of the body from mental abstraction. This results in varying conceptualizations for intelligent agents in computers such as artificial intelligence. Nonetheless, although embodiment is widely contested across different disciplines, they all contribute to the emergence of embodiment theories that are helpful lenses in understanding the ways that we interact with virtual systems.

Phenomenology of Virtual Experience Both presence and embodiment have a phenomenological sense, which can refer to the things we consciously notice about the role of our bodies in shaping our self-perception and identities through conscious introspection and deliberate reflection on our experience [27]–[29]. Phenomenology concentrates on the consciousness of the subject on its object in direct experience. Since consciousness is susceptible to bodily as well as mental sensations, VR researchers often adopt phenomenological approaches to studying user experience in immersive environments [30]–[32].

Following a phenomenological methodology, Dourish theorizes an understanding of embodied interaction organized in terms of the creation, manipulation and communication of meaning, and the establishment and maintenance of design practices [33]. Dourish stipulates that “the technologies of embodied action participate in the world they represent,” as opposed to computational artifacts that simulate virtual worlds [33, p. 177]. Dourish combines social computing and tangible (“off-the-screen” interface) computing, explaining that design (as persuasion) should concentrate on interaction between humans and their virtual worlds, with a focus on ubiquity, tangibility, and most of all, shared awareness, intimacy, and emotions. Dourish finds that VR and AR designers create new metaphors of computer interaction using human physical skills and interaction with tangible objects.

Therefore, as a means to promote understanding of the ways in which emerging VR technologies provide new approaches to TPC pedagogy, we apply a phenomenological approach in interviewing amateur VR users and gathering their lived experiences, as a way to identify how VR mediates the notions of presence, embodiment, phenomenology, and ambience. This user study is presented in the qualitative interview portion of this report.

About the Study

This paper reports on three case studies and qualitative interviews in which we focused on VR devices that are among the most recognizable and adopted by technical professionals and consumers in the VR market: Google Cardboard, HTC Vive, and Google Daydream View. These devices were selected for evaluation for two reasons. First, the authors have all experienced these devices firsthand and used them for research and pedagogical activities. Therefore, we are comfortable studying these devices rather than those that we have yet to explore or experiment with, but that are emerging in VR.

Another reason to focus on these VR headsets is their *virtual* reality capabilities rather than AR features. Unlike Microsoft Hololens [34], or the now-retired Google Glass Explorer Edition [35], the VR devices examined here do not augment but rather simulate reality with the help of computer-generated content. We consider AR to be a different technology from VR, and our goal here is to promote understanding of the ways in which emerging VR technologies provide new approaches to TPC pedagogy.

The three case studies and the interviews reported here were completed independently from one another, each led by different coauthors of this paper who were part of the Wearables Research Collaboratory at the University of Minnesota—Twin Cities. While each of us has developed advanced knowledge on specific VR devices, collectively we collaborate to provide constructive critiques of their use and our perceptions of their implications for TPC pedagogy [8]. This paper represents a collaborative effort to reporting our findings.

APPROACH

For the three case studies, we employed a modified heuristic approach to evaluate the VR devices. A heuristic approach, according to Squires, is a predictive evaluation “usually done by teachers when they are making purchasing decisions or preparing lessons and by review agencies” [36]. For these three case studies, we begin with an overview of each device followed by its unique features, functions, and uses. We then focus on each device’s quality, potential, and actual use in TPC pedagogy scenarios.

While we acknowledge that this study focuses mainly on VR technology applications in TPC classrooms and that such cases are contextually limited [37], we applied triangulation by speaking to student users directly. This effort is presented in the qualitative interviews section of this paper. We spoke with three users of two of the devices, summarizing common themes in user experience. We employed a phenomenological framework when collecting and analyzing these users’ narratives. Our goal was to extract the bodily experience that three users had with the VR devices being studied by recording their descriptions of these VR experiences. Users were encouraged to provide full descriptions of their experiences, including their thoughts, feelings, images, sensations, and memories.

CASE STUDY 1: GOOGLE CARDBOARD

Google Cardboard (see Fig. 5) is a low-cost ($5–$15 USD), low-fidelity, fold-out cardboard viewer that lets viewers turn their smartphones into VR headsets. Utilizing a pair of 40 mm focal distance lenses, users can view specific applications and interact with immersive content that reacts to the user’s actual position in space (using the smartphone’s built-in accelerometer, gyroscope, and GPS). Google Cardboard users experiment with applications such as Google Street View [38], the *New York Times* VR (YouTube demo) [39], and the Google Cardboard demo suite [40].

Google Cardboard was created as a way to spark interest in the world of virtual reality [41]. It was introduced at the Google I/O 2014 developers conference where a Google Cardboard viewer was given away to all attendees. The current version is compatible with any Android and iPhone with a screen width of six inches (or less). As of March 2017, more than 10 million Google Cardboards had been sold and 160 million VR apps downloaded.

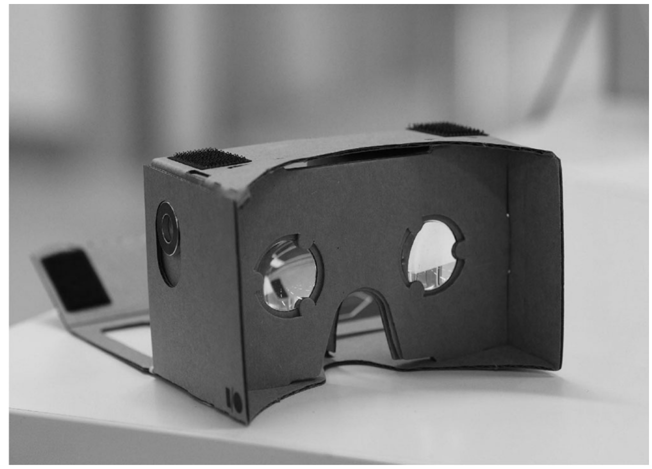

Fig. 5. Assembled Google Cardboard [57].

Features, Functions, and Use Prior to operating this device, a Google Cardboard app must be downloaded to the user’s smartphone via the Apple App Store, Google Play, or Microsoft Store. Alternatively, a 360° video can be viewed through a video-streaming app like YouTube. Using the velcro on the Google Cardboard, a user can affix the smartphone to the device. Then, the user can view the display by looking into the lenses by holding the Google Cardboard and rotating his or her head in any direction. The gyroscope sensors in the smartphone can detect the orientation of the device and provide corresponding playback or viewing to the user. While the phone screen displays a split screen, the Google Cardboard viewer will show the user a stereoscopic, panorama view. A button on the top right corner of the Google Cardboard allows the user to click and move through the immersive environment. Some apps also allow users to interact with their content by letting the user click through different options. Most Google Cardboard apps are free to download.

Course Deployment Ann Hill Duin deployed Google Cardboard in an online course on international and professional communication as a means for students to “immerse” themselves in course content (or cultural dimensions) as opposed to relying on student reading of articles, links, or resources as the primary delivery tool for information. With more than 20 years of teaching online, Duin has tried a number of approaches to engage students in online discussion (e.g., role playing, discussion leadership, use of video clips, group instant messages, use of Twitter, concept quizzes, and rubrics for improving discussion forums). Despite these efforts, she has found online discussion postings to often be a regurgitation of the course materials. Therefore, this pedagogical deployment was designed to prompt student “viewers” of cultures to become “interactors” with cultures through the use of the Google Cardboard device.

During Spring 2017, Duin required her 20 online students to purchase a Google Cardboard device or to use the device at a university lab. She also required the students to download the *New York Times* VR application for their iPhone or Android smartphone device. No student reported any issue with access to a smartphone or to the Google Cardboard device.

Exercises at four points throughout the course—weeks 3, 6, 9, and 12—required students to use Google Cardboard to view 360° videos

- To examine cultural dimensions
- To explore nonverbal communication, that is, eye contact, vocal qualifiers, facial expressions, gestures, timing in spoken exchanges, touching, the language of space, appearance, and silence
- To examine cross-cultural communication effectiveness (that is, to view how relationships are being developed), exchange of information and positions, persuasion and argumentation, and concessions and agreement
- To consider cross-cultural technology design in terms of perception and use of the Google Cardboard devices across cultures [42]

For each exercise, students were given specific directions and then asked to share their thoughts regarding cultural dimensions present in the VR recordings that they experienced.

Results/Discussion All students were able to locate relevant recordings and discuss these in terms of each week’s theme. Upon their first limited exposure to the use of a low-end VR device for viewing another culture, students wrote of their presence and their psychological state of existence within these new cultural environments. The following quote illustrates initial student responses to their use of the Google Cardboard device for examining cultural dimensions:

> I went a little crazy with the virtual reality as this was the first time I experienced anything like it. I first watched a short film called *Policing Flint*, which tracks the current state of Flint, Michigan’s struggling police department. I spent the first five minutes trying to figure out why I could only see the inside of their patrol car, and then it occurred to me that I actually needed to physically turn myself around to look out of the windshield. This was a revelation to be sure. I then spent more than an hour experiencing a variety of places such as Shanghai, the plains of North Dakota, as well as Iraq. Some of the cultural dimensions that I quickly picked up on while watching the 360VR videos include the “doing” culture in China’s major cities. The pace of life seems to move just as fast as it does in New York, for example, and efficiency is highly valued.

Later in the term, student use of the device as a means to explore nonverbal communication resulted in increased understanding and consciousness of culture and experience; for example, one student wrote the following:

> One of the videos that I watched this week was called *Pilgrimage* . . . . The video looked to show the rise in commercialism around Islam’s holiest site in Mecca. Inadvertently, it also showed how Muslims communicate non-verbally. I noticed that the need for personal space is not a priority within the culture, especially when it comes to prayer . . . . It is one thing to read about a culture from a textbook, but the power to experience it through virtual reality makes it that much more real. I can see for myself, in other words, what the culture is like and begin to make my own assessments of it.

Students also discussed human presence and embodiment; for example, another student wrote the following:

> A VR viewer makes me feel invested by somewhat cancelling the reality around me . . . . When my senses are redirected to a place of immersion, I can *become* someone there and experience firsthand the interactions of others from that culture. Since we are a culture of visual learners—as many are—this gives us a huge advantage by letting us see and *then* do. It’s the concept of theory and practice. We can read about cultures all day, but nothing will be as realistic as an actual physical immersion within one. In this case, VR is the closest we can get to experiencing it in person. In this sense, by experiencing cultures nonverbally (or verbally) in a “safe space,” we can learn the mistakes *before* they even occur, and go into the culture more

> deeply informed and aware having had that "in their shoes" experience.

As the course continued, students discussed more issues related to the device. The following quotes are from four students.

> [VR devices] do seem likely to fall prey to a certain "design flaw": not in the VR itself, but rather, in the reality which it depicts. It will be interesting to see, as this technology becomes more widespread, how technical communicators try to "gussy up" the medium.

> In Google Cardboard's current state, there's a huge gap between this idea of the outgoing, active user and the actual realistic uses of the technology. When you put on a Google Cardboard device, you are entering an imaginary world with a population of one. It couldn't be more solitary.

> The overall design of Google Cardboard across cultures can be found as compelling and useful, or on the other hand uninteresting and possibly offensive . . . . Cultures that value privacy may like the fact that others can't see what they're viewing, whereas in China, people expect to communicate face-to-face and may find it offensive if people's faces are covered by a Cardboard device.

> I think what we'll start seeing in the near future is a more encompassing notion of presence and cultural experience . . . . Once VR improves and you can literally jump into the venue and look around at the people who are actually there, the distinction that one did not attend the event becomes increasingly tenuous.

To our knowledge, this case study represents the first such investigation of the use of Google Cardboard in a TPC course. As an initial study, it is exploratory and represents an initial report of this experience rather than a more detailed research study. Students found Google Cardboard to be more helpful than traditional texts for learning about other cultures. Despite the fact that this was the low-end VR device, students found that the embodiment experience brought them to a completely different place and that they began to develop deeper cultural understanding.

CASE STUDY 2: GOOGLE DAYDREAM VIEW

The Google Daydream View device (see Fig. 6) was released in November 2016, retails for up to $99 USD, and offers some major improvements over Google Cardboard. It was designed to bring higher quality, more absorbing VR experiences to users. *Daydream* is a virtual reality platform developed by Google that is built into smartphones with the Android Nougat 7.1 and later mobile operating system. *View* is Google's VR headset made for Daydream use [43]. As of May 2017, 260,000 units had been sold, with future growth expected [44].

Fig. 6. Google Daydream View [58].

Features, Functions, and Use For the second case study, we examined this device's features, functions, and use, and considered specific benefits for technical and professional communicators. Before one straps the phone in, the Google Daydream View application must be downloaded and opened. The user can then interact with Google Daydream View by putting on the headset and picking up the Google Daydream View controller.

Unlike Google Cardboard, Google Daydream View is currently compatible with a limited set of smartphones: Google's Pixel 2 and Pixel 2 XL; Samsung's Galaxy S8 and S8+; ASUS's ZenFone AR; LG's V30; Axon 7; Mate 9 Pro; and Moto Z and Z2. Apple iPhones are also compatible; however, features are limited to those more similar to Google Cardboard. As with Google Cardboard, the user does not have to connect or plug in anything; the user places the smartphone inside, and the smartphone detects the viewer using near-field communication. The viewer has two capacitive nubs on the inside of the headset that the smartphone senses to align the screen image correctly.

Google Daydream View also has a companion device, the controller. The controller is motion tracked and has a home button, back button, trackpad or clicker, and volume control. One uses the controller to navigate in Google Daydream View, and because the device is motion tracked, the user sees a virtual representation of the controller.

Google Daydream View also has a head strap that allows its users to wear the viewer on their heads, thus freeing up their hands (versus Google Cardboard where users have to hold the viewer to their face); as a result, it creates a more immersive experience for users. Users can manipulate the VR content using the Google Daydream View controller rather than by head movement only, as with Google Cardboard. This advantage, according to Biocca and Levy [20], [21], creates a more realistic simulation for users because it decreases the dissociating experience of the body in the “real” and the “virtual” by eliminating the consciousness of physical activity outside the virtual simulation (such as the hands that hold the viewer).

Course Deployment The real-time interactivity and heightened sense of presence that users experience using Google Daydream View has the potential to improve instruction over traditional user manuals or instruction sets. Google Daydream View could enhance the experience of users’ physical environment by altering their visual, auditory, and mental perceptions of their surroundings. Altering a user’s sense of presence, even when it is not a full-body immersion, has a potential benefit for technical and professional communicators.

For example, instead of writing a technical description for a product, a technical or professional communicator could create a technical description for virtual reality. A technical description in virtual reality would visually show users what the product is and take them through an immersive exploration of all of the major and minor parts. Instead of reading a technical description about a product, the user would actually interact virtually with the product. A user would be able to virtually test the major and minor parts of a product in Google Daydream View, use the clicker to select specific parts, and then zoom in or isolate a specific part to learn more about it. Not only could the information in a technical description be displayed visually with VR, but tactile and auditory elements could also be included. Using Google Daydream View, a user could slip on the View headset and be guided through an interactive, virtual training session on how to perform the task. In addition, it could be used to test instruction sets and videos.

Results/Discussion Although we have not deployed Google Daydream View for all students in a single classroom, as part of this case study, individual students from a number of courses experimented with it. As part of this effort, we learned that 360° videos are currently the only content that users can easily create for VR. Instructions for creating content for Google Daydream View are geared toward developers, so a technical and professional communicator would have to devote time to learning and using one of the content development platforms: Android, Unity, Unreal, or iOS [45].

VR content for education is more robust in quantity and development, partially because of the availability of 360° videos. Allowing students to watch 360° videos through VR to learn about a subject is a new and exciting way that Google Daydream View can be used to better prepare students for careers in technical and professional communication. Google Daydream View is suited for classroom use because it is lightweight, easy to use, and easy to slip on and off; it requires very little setup time; and the learning curve for use is much lower than that for use of HTC Vive.

In a technical and professional writing class taught by one of us, the final project was to conduct an interview with someone at a company in the student’s field of interest and write an analytical report based on the interview. The first task was to write a project proposal, with the audience being the human resources unit of the company. Writing a project proposal for an imaginary company and an imaginary human resources employee proved difficult for students who lacked previous knowledge of the field. Instead of jumping right to the project proposal, a first task could be to identify a workplace of interest, locate a 360° video of that or a similar workplace, and watch it via Google Daydream View. Aside from the chance to visit the workplace in person, seeing the workplace through VR, along with Google Daydream View’s HD quality, would provide students with a more accessible and practical start to their project. Just that critical first step, immersing themselves in their future workplace through VR, would give students an initial vision of their workplace and their project, and potentially prepare them for their profession in the long run.

Overall, the Google Daydream Viewer is more embodied than Google Cardboard; it functions like an extension of the user’s body—specifically the eyes and hands—with minimal interruption to the

Fig. 7. HTC Vive [59].

existing capabilities of the body. This embodiment experience with the device may lead to a greater experience of virtual presence. We further investigate this level of presence in the user interviews about the use of Google Cardboard and HTC Vive.

Case Study 3: HTC Vive

HTC Vive (see Fig. 7) is a virtual reality headset that uses "room-scale" tracking technology to allow the user to move in 3-D space while interacting with objects in the virtual environment [46]. It costs $599 USD from the Microsoft Store. It includes an adjustable headset and wireless controllers designed for seamless, intuitive interaction with immersive content. Most of the current VR applications for HTC Vive are available on SteamVR, a VR system built by HTC's partner company, Valve [47]. The simulations used in our investigation included Budget Cuts [48], The Lab [49], and Google Tilt Brush [50].

HTC Vive's accuracy shows itself when users become completely immersed in its virtual magic. Users have even tried to lean on a virtual table or sit in a virtual chair. The main difference between the Vive and Google Cardboard or Google Daydream View is that the Vive has handheld and head motion tracking. It follows all of a user's movements, in turn, creating a very realistic virtual self. Most software currently developed for the Vive is in the world of gaming.

Features, Functions, and Use For this case study, one of us examined the HTC Vive's features, functions, and use. We found that the HTC Vive has specific features that differentiate it from lower-end VR devices such as Cardboard and Daydream View. Specifically, it is not run from a smartphone; rather, it connects to a computer (preferably a higher-end computer) through the headset. This headset is heavier and works in the same way as the smartphone-based VR devices, except that the smartphone is replaced with two 1080×1200 screens, one for each eye. The Vive uses many different sensors such as accelerometers, gyroscopes, and position sensors. This device functions as a creativity tool. Through gaming, art, and storytelling, users are able to experience and create their own virtual worlds.

Classroom Deployment Due to its immersive user experience and specific engagement of the body, we believed that the HTC Vive, in conjunction with Google Tilt Brush, showed particular promise for a course that one of us teaches on technical and professional presentations. The Vive's body-technology relationship highlights just how dynamic, complex, and embodied communication is, regardless of the specific tools being used at a given time. A live presentation is an embodied *experience* that transcends the boundaries of speech and slides. But when students were asked to outline a presentation before delivering it for this course, traditional outlining and concept-mapping seemed to make capturing the dynamism of presentations difficult, ignoring or shortchanging the presentation's rich extra-textual elements. When doing some preliminary research on immersive educational tools, we discovered a *New York Times* article that argued that, with Google Tilt Brush, "The edges of the paper are no longer there" [51]. Therefore, our classroom deployment was motivated by a curiosity about what a "page-less" medium might afford students as they brainstormed, outlined, and mapped out a presentation.

This presentation was a group assignment that asked students to propose a new product or improve an existing one. Students were encouraged to experiment with Tilt Brush to first get a feel for its interface and to get acquainted with its range of drawing features. Since students were still in an exploratory phase, we suggested uses for Tilt Brush—as a way to brainstorm, work through tensions, map out main content, or sketch out potential directions—but precisely how students used the technology was left up to them. Although only one person could use the Vive device at a time, a projection screen allowed the remaining group members to follow along by displaying what would have otherwise been an individual experience.

Results/Discussion Initial experimentation with the device indicated that Tilt Brush was more useful when students had identified their content rather than to brainstorm topic ideas. As one student noted,

> As a mapping tool, it allows people to arrange their thoughts in a . . . unique way by moving through them, zooming in on them and being able to expand upon them. Other tools might be more useful with writing words but don't let an image literally come off of the page.

Another student marveled at the ability to be physically inside the outline, allowing the group to actually see their concept from a different vantage point. As much as Tilt Brush was expansive, it was also constraining—both physically, and conceptually. First, although the Tilt Brush interface seems limitless, the room in which it is used is not. The page may feel "page-less," but the room is not wall-less.

Furthermore, VR headsets tend to isolate users from those around them. One student pointed out that

> As a presenter, the virtual reality blocks you from direct engagement with the audience. You could draw and talk at the same time, but then you still are wearing the headset and that would be distracting for the audience. This limit could be worked around by pre-recording the drawings, or having one person do the drawings while another presents.

In addition, the Vive requires users to be able-bodied, and the virtual reality component can make some users feel dizzy. Somewhat ironically, the freedom of Tilt Brush indicated just how married we still are to the familiarity of the page, bullet points, and other linear, tried-and-true learning tools—and, therefore, how important it is to encourage students out of these comfort zones by exposing them to alternative ways of knowing, being, and doing. One student who had gotten familiar with the Tilt Brush interface and began trying to brainstorm asked, "How do I think in 3D?"—a provocative question that points to the two-way, interanimating relationship between technology and knowledge construction.

Through the use of Tilt Brush, students have experienced a new dimension of presence that was not available before HTC Vive's immersive affordance. The technology also presents new concerns about embodiment issues in what we know as "writing"—the mind working as a part of the human body to accomplish communicative tasks. As the student comment above reveals, the struggle to "think in 3D" is a new cognitive dissonance that comes from challenging conventional composing processes. This makes the connections between the act of constructing a communication artifact and the communicator even more visible through the consideration of the body. The observations from the Tilt Brush exercise pose an invitation to further research on embodied cognition and embodied communicative processes. To this end, we conducted a small qualitative interview study to investigate users' sense of embodied representation in low-end versus high-end immersive experiences. The next section documents our findings.

Qualitative Interviews

To triangulate our findings, we conducted one-on-one interviews with three undergraduate research assistants (X, A, and N in the comments below) in a lab where HTC Vive and Google Cardboard were readily available for use during the interviews. (Google Daydream View was not yet available when the interviews were conducted.) We asked the users how they experienced a virtual bodily representation within the immersive virtual environment when using devices like HTC Vive and Google Cardboard. We specifically looked for expressions of these users' sense of presence, control, body, and self.

Once narrative data had been collected from our participants about their VR experience, we abstracted collective themes essential to the meanings of their experience. We found four major collective themes.

Embodiment as Felt Experience Parallel to existing literature, our users unanimously described embodiment in VR as a felt sense of being. Furthermore, all three users identified the notion of embodiment in VR as an *experience* rather than a mere *state of existence*. This felt sense of embodiment supports and advances Kilteni et al.'s [23] concept of VR embodiment by highlighting the importance of fidelity in VR simulations. All three users reported that they feel more present in the VR environment if the environment gives them rich sensory stimulations (audio, visual, tactile feedback).

X: It can take away my sense of immersiveness if the sound and visual effects are lacking.
A: Google Cardboard and its applications really need to get over the "quality" bump in order to gain traction.
N: After the simulation, I actually need to recalibrate my body for the actual real world.

In other words, higher fidelity leads participants into a greater sense of embodiment in VR. For them, reality is how the VR hardware makes any given scenario convincing to their senses. In this case, participants regarded HTC Vive as providing a more vivid sense of presence than Google Cardboard because of the richer sensory stimulations that HTC Vive provides.

Sense and Sensibility While physical sensory stimulations play a big part in creating immersive experiences for VR users, Biocca [21] and Lee [15] have reminded us that cognitive consciousness is also crucial to the quality of the embodiment experiences. Our users all reported that they felt positive emotions, such as excitement and playfulness, when entering the VR simulation.

A: It is fun. I always feel like I haven't spent enough time being in the simulation.
X: I always feel like I am exploring something new . . . and have to keep going through stuff and stay engaged.
N: I feel mostly excited and motivated to *do* something in the simulation.

While the sensory input could have been cues for their cognitive experience during the simulation, the participants described how their feelings of curiosity, adventure, and sometimes horror helped shape their sense of immersiveness in the VR world. This affective notion of embodiment remains an area of study underexplored by current scholarship.

Agency and Autonomy Certainly, the notion of user control is a key area of inquiry for HCI researchers, such as Goldin-Meadow [25]. Kilteni et al. [23] included agency and body ownership as two of the subcomponents in sensing virtual embodiment. Our narrative data are aligned to this observation. In describing their embodiment experiences, our participants used the term "control" to indicate their sense of body and presence. The participants expressed that the sense of presence was greater when they knew that they were in control of the VR simulation. They also declared that they wanted to remain in control of their experience and not leave it to the manipulation of the VR system. This sense of autonomy also gives rise to a sense of agency, as these users noted that the greater the control that they perceived themselves to have over the VR content, the more likely that they were to feel motivated to engage the content.

A: All of the games I have played here have an escape function so I always feel that I am in control.
N: I have a good sense of control because nothing random is happening in here.
X: Once I have gained control, I know I can complete my mission [in the simulation].

Constant Identities Our users also mentioned that they remained in charge of their identities and sense of self even when they were represented differently in VR simulations. For instance, in most HTC Vive games, users may not see their own bodies other than their hands, which often appear as a digitalized controller or giant, cartoon-like gloves. These representations of themselves did not change the way that the participants perceived their identities.

A: It's interesting because the only part of your body that's rendered are your hands. The ways the hands are simulated are very intuitive. I can feel my fingers tensing up when grabbing things in the simulation.
X: I know that my body is in there . . . . it is really hard to convince someone that they are not themselves in the game.
N: I cannot see myself but I know I am myself.

Comparing HTC Vive and Google Cardboard, our participants noted that they have more control and greater sense of self in the HTC Vive experience than with Google Cardboard, since the latter has only one button for clicking and, thus, very limited interactions between the user and the VR content are possible.

Taken together, the themes that emerged from user narratives provide insights to senses of embodiment that could help expand our overall understanding of embodiment. These themes also provide an entry point into the discussions of designing VR content for technical and professional communication.

Discussion and Implications

In this paper, we have explored theories of embodiment and presence as ways of understanding immersive VR experience. These theories are updated by the new features and potential uses of new VR technologies such as Google Cardboard, Google Daydream View, and HTC Vive, especially in TPC classrooms. In the three case studies, we showcased deployment examples and scenarios in which TPC students could benefit from exposure to new immersive VR technologies. To demonstrate how a user's sense of embodiment and presence is felt when using VR, we provided a report of qualitative interviews with three users of HTC Vive and Google Cardboard, working to capture common themes in the narratives about virtual bodily experience. These themes correspond to existing frameworks for understanding embodiment and presence, but they need further explication to encapsulate the features and capacity of emerging VR technologies.

The rise of wearable computers and portable augmented reality technology will continue to add even more complex expressions of presence through VR spaces. We believe that portable virtual environments, made possible by wearable computers, close the gap between virtual spaces and the human mind. In effect, users may experience a hybrid space where physical presence and virtual presence can be switched and suspended intermittently.

As Steuer [14] argued to expand conceptualization of VR in terms of human experience, the case studies reported here add to our knowledge and understanding of perception and presence in VR-mediated experience. Our results further indicate that an increased sense of presence can result from the realism of each VR environment, the effect of "transportation" and increased degree of immersiveness with each device, and (as shown in the qualitative interviews) the user's response to the VR itself as an intelligent social agent.

Future study of VR might further explore the seven elements of VR that Heim [17] proposed: simulation, interaction, artificiality, immersion, telepresence, full-body immersion, and networked communications. We must continue to study embodied interaction in terms of the new forms of presence and interaction brought about by VR technologies—that is, what users notice about the role of bodies in shaping perception and presence. As TPC professionals, we play a central role in framing VR and designing its associated content.

VR Presence, Embodiment, and Professional Practice: Implications for Technical Communication To summarize, we offer a grid (see Table II) of the three VR devices examined in these case studies with detail regarding each device's presence, embodiment, and implications for professional practice.

Conceptualizing the opportunities of VR often falls outside the current technology's capabilities. For TPC, VR may be the future of understanding and interacting with physical objects in a virtual space. For example, a technical communicator working on an engine for a vehicle needs to understand all parts of the engine and how they work. With advancements in VR software, the technical communicator could interact with the engine in a virtual space, taking it apart and putting it back together, with each part labeled with its respective name and function. However, this scenario requires that the engine be specifically designed with VR applications in mind. Most 3-D models of products today are created using computer-aided design (CAD) software. This application begs the question whether CAD programs will adapt to function with VR devices and, if so, whether they will be easy for technical communicators to use.

As another example, during the timeframe of this study, our team met with leaders of the University of Minnesota's Medical Devices Center [52], where, after 3-D prototyping is done (e.g., of a person's heart following an MRI), surgeons use a virtual prototyping conference room [53] to "test" various devices (e.g., heart valve replacements) as a means to identify which is best to use for a patient. In fact, surgeons and medical professionals at the University of Minnesota Masonic Children's Hospital have utilized such a VR simulation to explore a 3-D model of the heart of conjoined twins, which enabled them to successfully separate the twins in May 2017 [54]. In future scenarios, technical communicators need to understand the technology, interact with it, and translate and transfer this complex information to patients.

Technical communicators who employ VR technologies to deliver or present complex information need an awareness of VR users' immersive experience. Such an endeavor requires them to equip themselves with current theories of presence and embodiment. Though it is not news

TABLE II
SUMMARY GRID OF VR PRESENCE, EMBODIMENT, AND PRACTICE WITH GOOGLE CARDBOARD, GOOGLE DAYDREAM VIEW, AND HTC VIVE

	Presence	Embodiment	Practice
Google Cardboard	Immerses the brain more than the body, but is not as immersive as Google Daydream View. Users will feel the experience of virtual reality but will not remove themselves from reality entirely. Physical use of the device detracts from the immersive goals. Google Cardboard is more like a viewer than an immersive experience.	Immerses the user from the shoulders up, but they will still be very aware of their body in real space. With a more immersive device such as Google Daydream View or the HTC Vive, the user won't think about how they are moving outside of the VR headset.	Can be used for immersing students in different environments through the use of 360° videos. Google Cardboard is an excellent tool for first time VR users to learn how to use VR and conceptualize how it can be expanded upon. Empathy can be achieved through any level of VR, making this device a good choice for learning from a budget.
Google Daydream View	Alters users' perception of their surroundings as mediated by both automatic and controlled mental processes (visual, auditory, mental). Offers less contact of the user with the external world than Google Cardboard, not as little as HTC Vive. Immerses the brain more than the body.	Offers greater sense of embodiment than Google Cardboard (head strap, controller), but not as much as HTC Vive. Fails to immerse the whole body in a virtual environment, only immerses from your shoulders up.	Possible uses in: education, instructions and training content, 360° videos for learning about new environments, creating new ways to envision documentation such as technical descriptions and project reports.
HTC Vive	The user in the Vive is still able to hear the surrounding noises, if they are not wearing earplugs which could impact the presence of the virtual experience. If the user has the headset and earphones in, they are completely not present visually, auditorily, and mentally in the surrounding real world environment.	This device has the power to completely immerse the user in a virtual reality. Even when the user is completely aware of their surroundings, the virtual aspects of the Vive can be so realistic that the user will.	The largest use of the HTC Vive is for gaming and storytelling for the user. It's specifically branded as a gaming device for high end computers. Even though gaming and storytelling are thought of as a leisure hobby, there are uses for it within education.

to scholars in this field that these theories are important and applicable to technical communication practice, we argue that these theories receive more attention in TCP education. Technical communication students **will** find themselves working with VR technologies as these tools proliferate in the workplace. For educators, the question becomes: How might we determine best practices for creating meaningful VR content for use across TPC courses?

One possibility is to create more open forums for users to contribute ideas. We have held "pop-up" events where the campus community is invited to try out VR and share what individuals envision for design and use in their own fields. Our experience tells us that the user community has plenty to say. Most responses included immersive content for discipline-specific practices, such as preservice patient simulation for nurses, emergency response, police training, and environmental modeling.

Although the possibilities for VR generated by users may seem endless, their development and deployment in the classroom is not as easily implemented as our case studies may suggest. Instructors working with VR at the cusp of its evolution face two major hurdles: finding relevant applications and software for teaching purposes, and making sure that these are engaging for students. Although the material may be briefly engaging for students new to VR, currently available devices lack software well suited for a wide variety of TPC instructors. Moreover, many VR devices are being developed and geared toward use by software development experts.

So what might be the solutions to this issue other than waiting until instructors and students are more adept with VR technology and more software applications are available on the market? One suggestion is to begin developing software that aids in VR creation. Then, instructors and students (without being experts) would be able to develop VR applications that could directly benefit their own classes. As part of the Wearables Research Collaboratory, we have begun to develop 360° videos for such use, providing instructions for doing so on our site.

CONCLUSION

This experience report details the study of some currently available VR devices as a means to promote understanding of the ways in which emerging VR technologies provide new approaches to pedagogy. Drawing from literature in computer science, communication studies, anthropology, embodiment, and phenomenology, we provided a historical account of VR development. Through three case studies and qualitative interviews, we shared insights derived from our deployment of three low- to high-end devices in TPC courses: Google Cardboard, Google Daydream View, and HTC Vive. Using a modified heuristic, we assessed the functions, features, and uses of these devices; showcased deployments; and for triangulation, provided results of qualitative interviews with three users of two of the devices.

We found that TPC students benefited from exposure to VR technologies. VR immersion provided deeper understanding of course content; immersion in future workplaces gave students an initial vision of their project and profession; concepts were seen from new vantage points; and user themes included felt experience, sense and sensibility, agency and autonomy, and constant identities. Together, these themes provide an entry into discussions about designing VR content for TPC pedagogy and training. We discussed these themes and their implications for pedagogical and practical contexts.

Nevertheless, we recognize the limitations of VR devices as a means of immersing students in their future workplace. For instance, there may not be enough 360° video simulation content for all professions, companies may not yet be comfortable with sharing 360° video footage of their office environments, and current content may not yet be configured for use as a classroom set. However, at this point, all three devices studied provide a means for VR experience and potential use across the TPC curriculum, and many resources exist for delving into the world of VR using these devices (see http://wrcollab.umn.edu/resources/vr-resourceshotspots-ieee). These resources are available as of our writing of this paper, and we welcome contributions to the list as the developing world of VR is at its infancy.

We hope that readers of this experience report become inspired and empowered to embrace VR in their own classrooms. We encourage future scholarship on VR presence, embodiment, and professional practice. In partnership with industry, we must leverage the potential of virtual environments for meaningful communication and the creation of useful, purposeful, and engaging content.

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