13

Immersive Virtual Environments and the Classrooms of Tomorrow

Cody O. Karutz and Jeremy N. Bailenson
Virtual Human Interaction Lab, Stanford University, Stanford, CA, USA

Introduction

Imagine you are sitting in a traditional university lecture hall. Even though the room has a 200 seat capacity, only half are occupied by other students. At closer glace, the others around are mostly distracted, checking various social media platforms on their mobile devices. You find that this distracts you from focusing on the professor that is attempting to lecture on stage about climate change science. His monotone voice drones on about carbon emissions, fossil fuels, and glacier melt timelines. What is worse is that the professor is not even using an interactive slideshow. Instead, he is using an almost unreadable ancient transparency overhead machine with tiny text. You realize that you have nothing in common with this professor, and despite his established credentials you find this lecture incredibly unengaging. But suddenly, this entire unengaging scene starts to change. The students around you all simultaneously put away their electronic devices and pay full attention to the professor, taking diligent notes while smiling complacently. Next, the professor morphs into Mark Ruffalo, the animated actor and environmental advocate that you admire. He kicks over the transparency machine, to the cheers of the audience, and explains that instead of lecturing about climate change, he is going to show it directly. The lecture hall rumbles with an earthquake-like magnitude, the walls cave in, and water gushes into the previously dry room. You look around, and realize you are now on a glacier, in the arctic north. Fully alert and awake, you remind yourself that although this is a completely virtual environment it feels incredibly real.

Compare the two versions of the previous imagined learning scenario. In the beginning, a traditional large-format university lecture was described, with disinterested students and a professor lacking public speaking pizazz. The second version of the scenario, however, brought the students to full attention with a lecturer that was

The Handbook of the Psychology of Communication Technology, First Edition. Edited by S. Shyam Sundar.

more entertaining and a visual environment that was both vivid and relevant to the lesson material. Although this fictional depiction of an educational setting might seem like science fiction, recent technological advances have catapulted *immersive virtual environments* (IVEs) out of expensive research labs and into both living rooms and classrooms (Blascovich & Bailenson, 2011).

Virtual environments are already consuming more and more of the population's time spent online. A user study revealed that in 2011, 21 million users spent almost 1.3 billion collective hours playing League of Legends, a popular online video game (Gaudiosi, 2012). In second place was World of Warcraft at over 600 million hours. A comprehensive digital media consumption study that surveyed daily trends of 8–18 year-olds found that on average children spend 7 hr and 28 min a day using digital media (Kaiser Family Foundation, 2010). Of those hours, 1 hr and 13 min are spent in video games on various platforms. The power of IVEs lie in their allowance of control, since everything is customizable and anything can be tweaked to construct a virtual classroom that is not only a near replication of a real one, but can outperform its physical counterpart in certain ways. What would such a virtual learning environment look like, and how would it work?

Enter the *massive open online course* (MOOC), a digital trend that has swept many of the nation's universities in the recent years to make educational material, the same that current students pay hefty tuition for, available for free online. This shift represents a bold move in bringing content to a platform that universities have traditionally been conservative about openly embracing: the internet. But because this format is accessible to as many students as there is interest, many problems still exist with the model. For example, how does assessment work for a class that has 50,000 students but only 10 teaching assistants? With such a large class size, how can education still feel personal or individualized for each student? Despite these issues, the MOOC model is gaining tremendous momentum. As the economist Thomas Friedman notes, "the MOOCs revolution, which will go through many growing pains, is here and is real" (Friedman, 2013).

MOOCs

The term MOOC was first introduced by George Siemens and Stephen Downes in 2008 to describe their online course *Connectivism and Connective Knowledge* (CCK08) taught through the University of Manitoba (Fini, 2009). Although it certainly was not the first online course to attempt to open up its course material in an accessible way for anyone, CCK08 succeeded in defining a new trend of education by building a network of learners of various educational backgrounds that self-organized to learn from an expert using various online resources and tools (McAuley, Stewart, Siemens, & Cormier, 2010). Unlike physical university classes, which have enrollment capacities, MOOCs are open to all users with an internet connection and a willingness to not necessary complete the course, but to engage in as little or as much learning as they like.

Through various measures, the MOOC model has already proved extremely successful. For achieving high enrollment numbers, an artificial intelligence course at

Stanford University registered 160,000 students, of which approximately 23,000 successfully completed the course (Martin, 2012; Rodriguez, 2012). Adopting the platform can also increase student performance, such as an electrical engineering course at San Jose State University that increased pass rates from 55% to 91% when it switched to a MOOC platform (Fowler, 2013). It has also been argued that MOOCs represent a larger economical movement where users are engaging in lifelong learning that increases their marketable skills and shifts the population from knowledge scarcity to knowledge abundance (McAuley et al., 2010). This is especially important for parts of the world that might not have access to traditional educational institutions but do have limited access to the internet, allowing them to still to learn through a MOOC platform for free.

This new network of learners that are in control of their own educational pace and goals provides challenges for traditional models. Thorough assessment becomes an issue when grading moves beyond simple multiple choice answers and onto more complex computer science problem sets or projects with qualitative elements (Cooper & Sahami, 2013). Additional assessment problems deal with validation and plagiarism, where it becomes difficult for administrators of a MOOC to both verify work and detect when a student is cheating (Cooper & Sahami, 2013). Especially puzzling are accountability issues, such as the high attrition rates (Kizilcec, Piech, & Schneider, 2013) and the behaviors of *lurkers,* who are students in a MOOC that observe content in a course but do not actively participate (Rodriguez, 2012). Hybrid models such as the *flipped classroom* attempt to find a way to strike a balance between digital optimizations and impersonal interactions by combining video content of MOOCs with physical classroom discussion to tackle personalization issues (Cooper & Sahami, 2013). Due to geographic location or time constraints, not all students have the opportunity to engage in flipped classroom models. Is there a way to capitalize on the operational advantages of the MOOC with the high emotional interactivity of an IVE to create a model that creates a more personal and individualized educational platform?

MOOVE Overview

This chapter aims to propose a new theoretical hybrid classroom model called the *massive open online virtual environment* (MOOVE) that capitalizes on the existing research on IVEs and applies them to the MOOC to present solutions for its current issues of assessment, accountability, and personalization. In order to do this, the literature surrounding IVEs is thoroughly reviewed through a social science lens. First, the hardware systems required to run IVEs are detailed, and new technologies are highlighted that are making components more affordable to average consumers. Research methods are explicated, where IVEs offer certain advantages over traditional social science experiments, such as collecting massive amounts of behavioral data about a user in a noninvasive way. Three theories are then outlined and reviewed, all with specific applications to the proposed MOOVE model. Transformed social interaction leverages unique characteristics of an IVE to disrupt the tracking and rendering cycle to change behavioral outcomes of an interaction. Social learning theory is reviewed, applying its literature to three new IVE research avenues where users view versions of their digital selves. Lastly, embodied cognition theory looks at the effects of actively moving body limbs on higher order cognition, such as solving a difficult physics equation. Conclusions drawn from the IVE literature offer an enticing expansion of the current MOOC model to create a new hybrid educational platform that leverages unique IVE affordances with MOOC accessibility and popularity. Ethical and philosophical issues with aspects of this technology are finally mentioned, along with suggested future research directions.

IVE Hardware Systems

What makes IVEs different than other types of virtual environments? Technologically speaking, IVEs are a dynamic feedback loop between tracking a user's movements and updating a rendered virtual scene. Physical motions are tracked, and a user is presented with a multimodal sensory experience that replaces physical stimuli with digital ones (Biocca, 1997; Loomis, 1992) creating a psychological experience of forgetting that the user is in a virtual environment at all (Witmer & Singer, 1998). On the lower end of the immersive spectrum, tracking involves using a mouse or keyboard to move a viewpoint or character around a virtual scene. Traditional video game consoles, such as the Microsoft Xbox 360, often use game controllers with joysticks and buttons to track user movements. However, those systems traditionally involve rendering to more passive display technologies, such as a desktop monitor or a television. Fully immersive setups rely on more accurate locomotion tracking systems, as well as multisensory rendering devices.

Tracking a user with extreme accuracy and precision requires a dedicated space with properly calibrated camera equipment designed to scan for certain light sources. One example of such a system is an *active optical* tracking system, where lights, such as infrared, are attached to various parts of a user and are then triangulated by multiple cameras to provide a reliable x, y, and z position in Cartesian space (Meyer, Applewhite, & Biocca, 1992; Welch, 2009). Additionally, *accelerometers* can be used to track the yaw, pitch, and roll of a user's head. This movement is especially important for an IVE where the user employs a first-person perspective and physical head movements correspond to moving a virtual viewpoint. *Passive optical* systems offer alternative and more portable solutions for tracking in a space that might not allow for designated cameras. One popular passive system is Microsoft's Kinect sensor, which uses an infrared emitter to process depth information about a physical scene to track a user without having to attach any lights (Suma, Lange, Rizzo, Krum, & Bolas, 2011; Wang, Stolka, Boctor, Hager, & Choti, 2012). Passive sensors are typically more cost-efficient (the Kinect currently sells for around $100) but operate with higher latency and lower resolutions, creating less-reliable tracking systems. At the time of this writing, new tracking products are circulating in the consumer electronic market, offering new ways to control interfaces with gesture recognition instead of traditional input devices such as mice and keyboards. Although these devices are meant to be used in less immersive applications, such as scrolling through pictures using a flick of

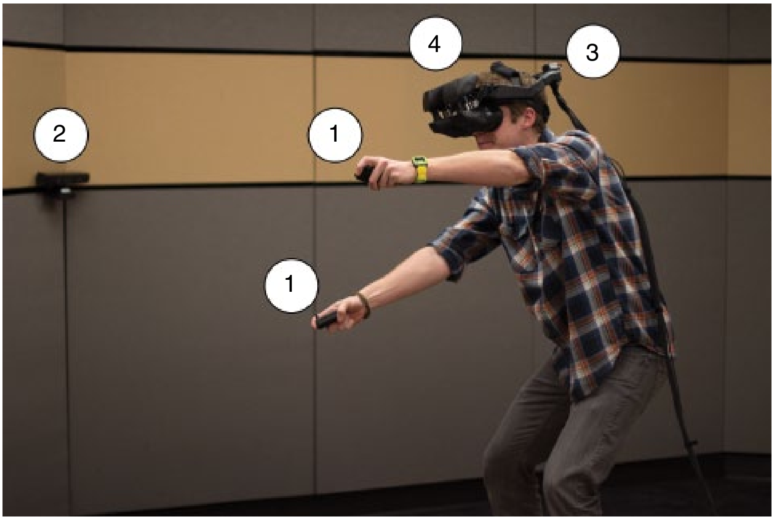

Figure 13.1 A user in an IVE pretends to fly using tracking and rendering equipment. Hands are tracked by active infrared sensors (1). Nonverbal behavior is collected by a passive infrared Microsoft Kinect device (2). Head movements are tracked by an accelerometer (3). The virtual scene is rendered from all of the tracking data and shown to the user in 3D with a head-mounted display (4).

the hand, they offer appealing applications to IVEs. One such product, the Leap Motion, offers reliable tracking of all 10 fingers simultaneously with an accuracy of 1/100th of a millimeter, which is planned to be included in select retail computers (Alzieu, 2013). If paired with an IVE, a gesture tracker such as the Leap Motion could potentially offer a more accurate and affordable passive tracking solution.

Multimodal rendering is the next step in the IVE system, utilizing sensory channels to create virtual stimuli. For sight, *head-mounted displays* (HMDs) use LCD displays that are displaced in front of a user's eyes and then aligned with binocular overlap to create stereoscopic depth for a rendered environment (Chung et al., 1989; Furness, 1987). HMD technologies have traditionally been utilized in research labs and large-scale simulation training, such as military flight simulators, partly due to their enormous price tags and limited market competition. For an example of tracking and rendering equipment, see Figure 13.1. However, Mark Bolas and the MxR division of the University of Southern California's Institute for Creative Technologies have developed a lens attachment that once printed, will attach to smartphones and tablets to transform them into portable HMDs. This option is especially enticing since smartphones and tablets pervade most of the consumer market and already have self-inclusive tracking systems, such as accelerometers. USC's HMD system is called VR2Go, and uses open-source software applications to create a completely mobile IVE system (Hoberman, Krum, Suma, & Bolas, 2012; Olson, Krum, Suma, & Bolas, 2011). Similarly, an HMD backing by commercial video game developers called the Oculus Rift is targeted for consumer users at a cost of around $300. Both VR2GO and the Oculus Rift have the potential to finally provide an inclusive and affordable piece of IVE hardware that consumers can comfortably use wirelessly or in their own homes.

Visual rendering is also achieved through other hardware means, such as using three-dimensional (3D) projectors or televisions. Dedicated rooms can project images on all surfaces, such as a *computer-assisted virtual environment* (CAVE®) that still tracks a user using optical systems but does not block out self-stimuli such as the hands or body (Cruz-Neira, Sandin, Defanti, Kenyon, & Hart, 1992; Sutcliffe, Gault, Fernando, & Tan, 2006). Recently, auto-stereoscopic technologies have developed to allow for a complete 3D viewing experience but without the need for any glasses at all (Woods, 2009), such as the Alioscopy lenticular television and the Nintendo 3DS handheld game console. With 3D entertainment still proving economically successful, other electronic companies are similarly building consumer-level products that maximize the immersive viewing experience but minimize the inconvenience of wearing extra devices such as 3D glasses.

Beyond visual stimuli, IVEs also utilize modalities such as *spatialized,* or virtual sound, channels that use either headphones or carefully placed speakers to create completely 3D sound experiences. In an IVE, virtual objects with attached sounds can move in 3D space, causing sounds to change based on a user's tracked movements. For example, sound volumes of an object can increase when approached by a user. Past research has shown that fully utilizing immersive sound channels can increase the immersive qualities of an IVE (Loomis, Herbert, & Cicinelli, 1990; Zahorik, 2002). H*aptic feedback*, or virtual touch, can also contribute to an IVE by providing forces or resistance with a physical device that resists a physical hand or finger. These devices can range in intricacy and price, but are usually meant to interact with the hands in some way (Basdogan, Ho, Srinivasan, & Slater, 2000; Lanier, 1992, 1997; Tan & Pentland, 1997). Vibration motors in smartphones and tablets can also be seen as a rudimentary form of haptic feedback. Olfactory senses are sometimes used in IVEs (Richard, Tijou, Richard, & Ferrier, 2006) but play less of a role in research due to their intricate and sometimes impractical device designs. One Japanese company plans to release a device that spatially moves smells around a television display with a fan system (Matsukura, Yoneda, & Ishida, 2013).

IVE Research Methods

Since its inception as a new technological tool that early pioneers projected would create an entirely new type of social space (Lanier, 1992; Rheingold, 1991), IVEs have since permeated many different research areas. This chapter focuses on reviewing the literature that uses IVEs in a social science context as a tool to not only study traditional social phenomena and theories (Loomis, Blascovich, & Beall, 1999) but to also examine the new types of experiences that IVEs create that would never have existed otherwise.

As a research tool, IVEs offer many advantages to social scientists over traditional lab-based experimental research that psychology labs have used for decades. Early work by Blascovich outlines three advantages that IVEs offer over their real-world counterparts: the mundane realism tradeoff, representative sampling, and experimental replication (Blascovich et al., 2002). The first advantage, the mundane realism tradeoff, deals with providing authentic stimuli in an IVE, as opposed to asking users to visualize these events or experiences (Blascovich et al., 2002). For example, in an IVE a virtual shark can approach a user in a threatening way, an experience that might be difficult for participants that have never physically seen a real shark. Another advantage that IVEs offer is solving nonrepresentative sampling issues by networking experiments across geographic bounds, including participants from multiple universities, states, or even countries (Blascovich et al., 2002). Recently, the online retailer Amazon has released a platform for crowdsourcing tasks called Mechanical Turk, which allows users to select specific demographic traits of online workers, such as age, native language, or educational background. Although this platform is more intended to collect data such as self-report surveys, some tasks involve navigating virtual worlds or playing an online game. One can imagine a future where it becomes even easier to recruit participants that own IVE technology at home using VR2GO or an Oculus Rift. The last advantage that Blascovich offers is ease of experimental replication, where IVEs can guarantee a consistent experience between participants, solving internal validity problems that social science experiments sometimes experience (Blascovich et al., 2002). This is especially important when dealing with *confederates*, or trained human actors, which can sometimes lack consistency based on the intricacy of the deception. Virtual actors, however, can be programmed specifically to behave the exact same way each time (Bailenson, Blascovich, Beall, & Loomis, 2001). Additionally, an IVE can transport a user to an environment that would be almost impossible to create in a traditional laboratory setting, such as an ocean, redwood forest, or even a different historical time period. These IVEs maintain consistency between uses. For example, a user that walks through a busy city sidewalk can encounter virtual agents in a completely replicated manner that would be extremely difficult, if not impossible, to achieve in a real-world setting without certain interference (Fox, Arena, & Bailenson, 2009).

In our current world, where users are constantly being tracked by browsers and smartphone applications, all actions online leave a *digital footprint* that can be used to build elaborate predictive algorithms about those users (Blascovich & Bailenson, 2011). Similarly, everything that a user does in an IVE can be recorded and output to a massive data file, allowing for more precise data analysis that can examine nonverbal behavioral variables such as spatial movement patterns, gaze, and gestures (Bailenson et al., 2001; Bailenson, Blascovich, Beall, & Loomis, 2003; Bente, Petersen, Krämer, & Ruier, 2001). For example, a study that analyzed participant proximity behaviors between *avatars,* virtual representations controlled and animated by physical humans, and *agents*, virtual representations programmed with a static set of animations or behaviors, found differences in tracking data where self-report yielded none (Bailenson, Aharoni et al., 2004). This format of large-scale data collection, a new digital trend called *big data*, is garnering attention from major companies like Amazon, Google, and Netflix that aim to track spending and browsing habits online to better predict what products users are likely to purchase next. One study looked at this in an experimental setting, where facial features of participants were tracked and processed through algorithm classifiers that predicted buyer intent above chance (Ahn, Jabon, & Bailenson, 2008). Other virtual environments on bigger scales, such *massively multiplayer online* games (MMOs), allow for custom programming scripts that can track users' gaming habits and behaviors (Friedman, Steed, & Slater, 2007; Yee & Bailenson, 2008; Yee, Bailenson, Urbanek, Chang, & Merget, 2007). One study collected massive amounts of data over a period of 10 weeks in the MMO Second Life to show the decline of user engagement over time (Harris, Bailenson, Nielsen, & Yee, 2009). The movement in a digital space for big data has much promise for educational models that seek to better understand and predict success in a more comprehensive way than traditional standardized testing, such as the SAT, but must collect data in a way that feels natural to the user. IVEs offer a solution to this in that users are often unaware that they are being tracked at all due to the engaging nature of the technology.

The big data and digital footprint models utilized in IVEs present possible solutions toward assessment problems that MOOC's face. Instead of merely assessing students based on problem sets or quizzes, machine learning can be utilized as a better predictor on how students arrive at answers based on their work (Piech, Sahami, Koller, Cooper, & Blikstein, 2012). In this technique, massive amounts of data are collected about students and then algorithms are constructed to better predict which students will struggle with the material. Because IVE constructs allow for collection of many more rich variables, such as nonverbal behavior, additional inputs can train an even better assessment method. Students in a MOOVE would capitalize on this data-driven strategy, receiving continual feedback about their performance based on not just their answers, but their problem solving methods. This approach also provides a solution to plagiarism in that digital footprint strategies are able to collect much continuous data about a user and verify that the students logging into a MOOVE are who they claim. One example of such a detection device is the Microsoft Kinect sensor, which can already detect gender based on the nonverbal data it collects about a user (Won, Yu, Janssen, & Bailenson, 2012). Tracking sensors and machine learning algorithms implemented in a MOOVE could potentially detect subtle nuances in physical movements or word syntax that would flag administrators of plagiarism. Obviously this data-driven approach is not perfect, and there is a potential for error in that students could be falsely accused of plagiarism for unexplained deviances in the collected measures. Still, big data and digital footprint measures offer potential solutions for current assessment problems in MOOCs.

Transformed Social Interaction

Because IVEs deal with a feedback loop between tracking and rendering, it is possible to intercept that process and manipulate elements in a way that a user is unaware of the changes. *Transformed social interaction* (TSI) is an area of research that examines the new social constructs this process creates, offering new situations that would not be possible in the real world (Bailenson, 2006; Bailenson, Beall, Blascovich, Loomis, & Turk, 2005; Bailenson, Beall, Loomis, Blascovich, & Turk, 2004; Bailenson, Yee, Blascovich, & Guadagno, 2008). This unique disruption of a computer-mediated process like an IVE allows for three advantages over traditional real-world interactions: enhancing normal perceptions, manipulating time and space, and identity capture of a speaker.

The first advantage TSI leverages is the ability of an IVE to augment the information of other users in the environment, such as displaying names of students or a quantified score of their current engagement level (Bailenson & Beall, 2006). A consumer example of this is a new project called Google Glass, which uses *augmented reality* (AR) to add a virtual heads-up display layer over glass frames that users wear. By connecting to the internet, wearable computing such as this provides the ability to combine facial recognition technology with available social media information to provide a real-time information system that enhances users' perceptions to recall others' names, interests, or even relationship statuses. Additionally, an IVE can allow for *multilateral perspective taking*, where a user can move to different spots in the environment (Bailenson & Beall, 2006), which can be especially useful in a lecture hall or a classroom where a student might prefer a certain location (McCall, Bailenson, Blascovich, & Beall, 2009). A user in an IVE teaching role can benefit from this enhanced sensory process, such as using an algorithm that changes the visual opaqueness of students in an IVE based on how much eye gaze is delivered to other students. As a user fails to make eye contact with other students, their opacities would decrease, reminding that user to spread gaze more evenly (Bailenson, Yee, Blascovich, Beall, et al., 2008).

The second advantage of TSI in an IVE is manipulation of time and space. For example, student users in an IVE can pause, slow down, or fast forward the speed of the content to process more difficult material at an individualized pace (Bailenson & Beall, 2006). If a lecture is entirely prerecorded, then users in hypothetical MOOVE could completely fast forward through the material, similar to current video lecture formats. If the lecture in the MOOVE is live, it can be paused and then sped up to the current broadcast point, similar to how current cable television controls work. This feature is especially important for courses with complex material and limited prerequisites, where students come from a myriad of educational backgrounds. For example, a huge computer-science MOOVE course could contain both highly technical students with intentions to thoroughly learn all aspects of the content and beginning students that aim to only learn the fundamentals. Space manipulations allow for users in an IVE to control both the environment of a classroom or the appearance of other rendered co-learners. Each individual user might choose to change the rendered environment to appear either like a large open lecture hall with hundreds of other students, or a small intimate classroom with only a dozen other students, all based on personal preference or learning style. The manipulation of virtual agents between attentive and distracted animations has been shown to affect the amount of material learned in an IVE lecture, where participants absorbed more material in a setting with other attentive co-learners (McCall et al., 2009). TSI components allow for users of all skill levels to process and control the material and environment in an efficient and individualized way to maximize learning.

In the introduction of this chapter, a learning scenario was proposed where a dull teacher was transformed into an animated and entertaining one. The third advantage of TSI, identity capture, is that this is entirely possible, allowing for digital manipulations from a teacher that other student users can then customize to fit their learning style (Bailenson & Beall, 2006). This means that attributes from a teacher such as voice pitch, volume, or even language translation are all possible in an IVE. Even further, the user's physical appearance can be subtly captured using available photographs and morphed into another user's face in an IVE without conscious recognition of the change, increasing the likability of the morphed individual (Bailenson, Garland, Iyengar, & Yee, 2006; Bailenson, Iyengar, Yee, & Collins, 2008). Although this action brings up ethical implications of persuasion, it offers additional benefits of simple changes that can change learning outcomes of interactions in a digital space.

Thus far, TSI has been shown to provide many unique opportunities to the IVE tracking and rendering process, but there are other similar technologies in place that resemble these interactions. Google has a service called Hangouts, which uses multiple webcams from users and aligns them side-by-side to allow for a live multiuser visual conference call. Other research has looked at replicating an experience like this in an IVE with avatars (Benford, Greenhalgh, Rodden, & Pycock, 2001; Joslin, Di Giacomo, & Magnenat-Thalmann, 2004; Reeves, Malone, & O'Driscoll, 2008). Already on the consumer market is a free application developed for the Microsoft Xbox 360 called Avatar Kinect that utilizes a Kinect sensor to track users' gestures, and places them in a virtual conference room where they can chat with friends. Environments can be changed, avatars can be customized, and multimedia elements such as sounds and objects can be added to enhance the communication experience. Although Avatar Kinect does not allow for complete control over the rendering process that is required to fully utilize TSI elements, it presents a novel example of a less immersive technology system already available for console owners. Discussion sections, an important element of most physical university classes where students meet in person to expand on lecture material, could use similar IVE technology to host virtual sections where users control avatars and go over course material in an engaging way. A version of a MOOVE could even expand to consoles, meaning devices like the Microsoft Xbox 360 and Kinect could be heavily utilized to track users and construct a more interactive and customizable learning platform.

When it comes to TSI, certain affordances of an IVE also offer solutions for accountability and personalization issues in MOOCs. In a current MOOC platform, students interact passively with lectures and do so fairly anonymously. However, in a hybrid MOOVE platform students could partake in a lecture by using IVE equipment. The rendering and tracking decoupling that TSI creates allows each student in the virtual lecture receive a personal callout from the lecturer, such as addressing the student by his or her name and asking an essential question. Lecturers are not able to respond to all students simultaneously, but a MOOVE could play back a collection of standardized responses based on the student's response. This unique interaction allows for students to engage with the material in a way that would be impossible in the current MOOC model, possibly solving high attrition rates and making the learning environment feel more personal.

Social Learning Theory

As humans, we often look to others to model what behaviors are acceptable for ourselves. *Social cognitive theory* conjectures that when a person refers to a model, similarity between the two can determine how likely behavior change is to occur (Bandura, 2001; Bandura & Huston, 1961). Characteristics such as gender (Bussey & Perry, 1982), age (Kazdin, 1976), skill aptitude (Meichenbaum, 1971), background similarity (Hilmert, Kulick, & Christenfeld, 2006), and prior behaviors (Andsager, Bemker, Choi, & Torwel, 2006) all can contribute toward the chance that a model will be effective in creating behavior change. For example, an individual watching a video of oneself can be a useful tool in using the self as a model but is limited to actions the individual has already completed, making it difficult to provide models for previously uncompleted or impossible actions (Dowrick, 1999). More specifically, *social learning theory* expands on this notion by detailing three types of effective models that can lead to behavior change: a live model, such as a physical person performing an action; a verbal instruction model, such as explaining a set of actions to someone; or a symbolic model, such as a digital character performing an action through a technology device (Bandura, 1977). For example, if a person is watching a public service announcement commercial on television, the extent to which that person feels similar to the character giving the announcement will predict if a behavior change occurs (Bandura, 1977). In an IVE, the social learning theory has been studied through three manipulation techniques called the Proteus effect, the chameleon effect, and doppelgangers, all of which offer opportunities to leverage affordances of the digital platform to enhance learning and provide more effective models.

The Proteus effect

Self-perception theory has shown that attitudes and beliefs are formed by examining behaviors of the self, instead of forming behaviors from those initial attitudes (Bem, 1967). *The Proteus effect*, inspired by self-perception theory and named after the Greek god Proteus that could change his form, encompasses an area of research that examines the behavioral effects of changing a user's embodied avatar in an IVE (Yee & Bailenson, 2007; Yee, Bailenson, & Ducheneaut, 2009). For example, when a user wears an avatar that is more attractive or taller, that user is more willing to reveal personal details and decrease interpersonal distance when interacting with a confederate (Yee & Bailenson, 2007). Other studies show that embodying an older avatar decreases stereotypes about elderly groups (Yee & Bailenson, 2006) and increases retirement savings allocations (Hershfield et al., 2011). Additionally, female users that embody or view sexualized avatars, meaning more scantily clad in dress, reported more body-related thoughts (Fox & Bailenson, 2009b; Fox, Bailenson, & Tricase, 2013).

Applications for the Proteus effect in MOOVE's where users are allowed to customize their digital selves are numerous. For example, an older student could embody a younger avatar to feel more comfortable in a virtual classroom dominated by other younger students. Women users in science, technology, engineering, and math

(STEM) courses, commonly dominated by male students, could similarly embody avatars of the opposite gender to decrease the barriers of stereotype threat. There are some dangers in this customizable option, however, since some studies have also shown that embodying an avatar of another race can actually increase implicit racial bias (Groom, Bailenson, & Nass, 2009). Still, the benefits that the Proteus effect offer for MOOVEs creates an exciting possibility of a virtual classroom where no student has to feel disadvantaged due to physical appearances.

Digital chameleons

Nonverbal cues in social interactions between humans show to be important drivers in communication interactions. When confederates in a virtual social interaction mimicked the nonverbal behaviors of an individual, that confederate was reported to be more likable (Chartrand & Bargh, 1999). In an IVE setting, *the chameleon effect* continued this finding to show that a virtual agent mimicking a user's tracked head movements at a 4 s delay was more persuasive and received more positive trait ratings than control conditions (Bailenson & Yee, 2005). Morphing a user's face into other virtual agents to increase facial similarity, similar to the TSI work explained earlier, increased problem-solving task performance (Bailenson & Yee, 2006). This effect also extends to other actions, such a virtual handshake where users reported agents that mimicked their handshakes as more likeable (Bailenson & Yee, 2007).

Similar to TSI applications outlined earlier, utilizing this digital chameleon effect in an IVE is easily done since a user's actions are very accurately tracked and recorded. Leveraging this in a MOOVE would allow for enhanced teacher ability, where a student's tracked movements could be mimicked at an undetectable delay, creating a more likable and persuasive lecturer. Facial similarity morphing could also be leveraged in a MOOVE so that a student user's face could morph not only into the teacher, but other attending students, as well. Again, these bring up ethical implications of swaying a user to more easily accept material without their consent of the manipulation. Still, the potential for creating a more successful learning environment for students that might be more introverted could benefit from such a manipulation in an IVE, allowing for better collaborations on peer assignments or group work.

Doppelgangers

The *doppelganger* is a virtual agent modeled with a user's captured visual identity, which can be animated asynchronously from the user's actual physical movements. This allows for expansion of the social learning theory, constructing virtual behaviors and actions that a user might not be able to actually physically perform. Users that interacted in front of their doppelganger in an IVE were more willing to perform embarrassing acts in front of that character as opposed to a dissimilar agent (Bailenson, Beall, Blascovich, Weisbuch, & Raimmundo, 2001; Bailenson, Yee, Blascovich, & Guadagno, 2008) and rated those agents with higher attractiveness and liking (Bailenson et al., 2008). Similar effects also translate to pro-social behavior change, where users in an IVE shown their doppelgangers exercising actually performed more physical exercise the following day (Fox & Bailenson, 2009). However, when a user's doppelganger endorsed a product in an IVE, the user later rated that product with higher association and more positive ratings (Ahn & Bailenson, 2011), leading to a potentially influencing opportunity for advertising giants to exploit the digital chameleon effect for profit. Children are also particularly vulnerable to this effect. For example, a study found that elementary children constructed false memories from an IVE where they saw their doppelganger swim with orca, thinking that they later thought they had actually encountered real orca whales (Segovia & Bailenson, 2009).

In a potential MOOVE, doppelgangers have the opportunity to create both positive and negative outcomes in an educational context. On the one hand, a doppelganger can be used virtually to encourage pro-social habits such as the effects of eating healthy in a lesson on nutrition. Users in a MOOVE listening to a lecture on proper nutrition could view how certain behaviors such as eating junk food or smoking cigarettes affect the body, by vividly and personally showing those changes on a virtual self. To boost confidence, users giving a speech in a MOOVE could also have the option to change every character in the audience to be a doppelganger, decreasing the anxiety of performing an embarrassing act in front of a crowd. Users could also choose to change the teacher in a lesson to be their doppelgangers, essentially receiving a lecture from their digital selves. All of these IVE affordances make a MOOVE feel more personal to the student's own learning style. This is the ultimate extension of the social learning theory, constructing a virtual model of the self that enables the user to be confident that they too can become an expert at the learning material.

Embodied Cognition Theory

Recent technologies such as the Microsoft Kinect and the Nintendo Wii signal a trend of commercial video games that encourages users to interactively move their bodies. Past research has looked at the role bodily states and actions play in perceptual processes (Barsalou, 2008). *Embodied cognition* looks at the effects that active body movements have on higher-order cognition, where perceptual information creates certain mental schemas. For example, past research has shown that nodding while listening causes people to more likely agree with statements (Wells & Petty, 1980) and that sitting upright as opposed to slumping causes more pride in achievement when people receive performance feedback (Stepper & Strack, 1993).

In an IVE, the multisensory and highly active nature of the technology allows for complex tracking and haptic systems to test embodied experiences. When receiving stimuli, users in an IVE can actively move around interact with those stimuli. For example, users that controlled a haptic device in an IVE to saw down a virtual tree changed their conservation behaviors by reducing measured paper usage as opposed to just reading about deforestation (Ahn, 2011). In another study, users in an IVE that took the perspective of a colorblind individual and performed a difficult task with a haptic device were more willing to volunteer their time later to help a confederate pretending to be colorblind (Ahn, Le, & Bailenson, 2013). This altruistic finding also extended to a study where users that embodied a superhero by actively moving their arms were more willing to help the researcher clean up from an accident (Rosenberg, Baughman, & Bailenson, 2013).

Embodied cognition findings also extend to education. When participants actively swung their arms in a manner that resembled the solution to a physics problem, those participants were more likely to come up with the correct answer than those that just stretched randomly (Thomas & Lleras, 2009). In a proposed MOOVE, limb tracking and active movement can be digitally integrated in a way that is beneficial for the type of educational content. For example, if students are learning about ocean currents in an environmental science lecture, they can use their hands to change current direction and speeds of an interactive model, all while viewing effects on the underwater ecosystems. Similar to the superhero experiment, students can also choose to navigate through the virtual environment by swimming with their hands, increasing the realism and making the MOOVE lesson more engaging. Since users are being tracked, feedback systems can be built to dynamically encourage user behaviors, such as physically sitting up straight or nodding along with the teacher, to maximize learning effectiveness. In an earlier TSI example, one where a student was actually called on personally by a lecturer, would have the chance to respond with voice recognition software. This act of using the voice to talk is one that is sparse in current MOOC models and has been shown to actually increase feelings of presence in an IVE (Aymerich-Frank, Karutz & Bailenson, 2012). If a student was able to respond to a question in a MOOVE, it could keep that student more engaged and accountable for fully completing a course.

Conclusion

The balance between positive and negative outcomes of digitally mediated technologies is what Blascovich and Bailenson (2011) call the "virtual yin and yang," referring to a confluence of forces that can both help and harm. IVEs are the same way, when used appropriately they offer physically impossible advantages, such as traveling to a virtual scene that a user may never experience otherwise. Yet when used to exploit, IVEs can also offer a platform for subtle mind control, which propaganda media have utilized historically to sway the public on certain issues. Imagine the danger if certain extremist political groups were able to leverage IVE findings to persuade users of radical agendas. One solution to the negative possibilities IVEs create is awareness. Blascovich and Bailenson advocate this (2011) by encouraging the public to watch their digital footprint and reconsider things like posting high-resolution photos online in social media or other platforms where user behavior is closely tracked. Like all things, healthy media consumption is a balance between analog and digital technologies, especially when it comes to more realistic media such as IVEs. As this immersive technology becomes more ubiquitous with devices like wireless smartphone HMDs and infrared tracking sensors, it is important to be mindful of the possibility of addiction. If an IVE is easily accessible by a device such as a smartphone or a tablet, what is to stop users from choosing to spend more and more time in an extremely engaging and vivid virtual world? New immersive video game devices such as the Nintendo 3DS handheld encourage users to take breaks every 30 min to avoid becoming sick (Nunneley, 2011). But addiction is a powerful force, and merely encouraging users to take breaks might not be enough.

Digital balance also applies to virtual selves. Since eternal digital life is entirely feasible through an avatar and user identity capture, what are the implications for a virtual self that never ages or dies? New technologies such as Kinect Fusion, which uses the Kinect sensor as a 3D scanner, can cheaply and quickly construct a lifelike 3D model of a person. Used positively, this could allow for children to interact virtually with grandparents that have long since passed away, or to preserve especially talented professors digitally. Although those professors might waver in their ability to give an effective lecture in reality, their digital doppelgangers can live on to lecture undergraduates forever. But postmortem, users need to consider the consequences regarding who has the rights to their digital doppelgangers. At Coachella in 2011, a popular music festival, the deceased rapper Tupac's doppelganger was digitally constructed and used to give a live performance, an experience that both excited and chilled viewers (Bailenson, 2012). Similarly, Orville Redenbacher's doppelganger has been featured in many of the company's commercials to endorse popcorn (Blascovich & Bailenson, 2011). Even now, Google is catching on to this eternal digital data, offering a new service called Inactive Account Manager that handles who owns the rights to users' data after they die (Rosen, 2013).

Studying the psychological effects behind these emergent technologies is incredibly difficult since social scientists have to work at following the blistering pace at which they develop. Future research directions still need to examine the longitudinal effects of IVEs, as well as how healthy new technologies such as VR2GO or the Oculus Rift are for users. Effects found for much of the research reviewed in this chapter look at behavior change from IVEs in a much more immediate context. But when IVE technology becomes more pervasive, how will lasting effects change behaviors many years later, and for better or for worse?

In the context of education, the proposed hybrid MOOVE model offers many new applications of IVE theory, few of which have been studied experimentally in an educational setting. Even the MOOC model, which is still at its nascent state, lacks comprehensive assessment of its effectiveness due to its still sprawling and evolving form. Assessment methods are still formulating, and what follows completion of a MOOC is still in question, such as receiving certifications and badges instead of official university credit. Software is still a challenge with the MOOC model since there is no current universal platform but a handful of startups building their own versions. For example, NovoEd is a startup evolved out of Stanford University that aims to solve currently high attrition rates in MOOCs, which hovers around 5% (Corcoran, 2013), by dividing students up into small groups and keeping them accountable for each other (Empson, 2013). With IVE technology, student collaboration in this manor could be improved even further. Tackling universal hardware across students is also another challenge. With so many devices to choose from, how can students in a MOOVE ensure that they have a similar experience? Especially when many areas of the world still lack high speed internet, IVE's require a system of low latency sensors and fast rendering rates in order to avoid making users sick.

Regardless of the technological challenges, the goal to radically change traditional educational environments is established and growing. As MOOCs find success and failure in universities, students will be the driving force in choosing just how they want their education delivered. Customizability and individualized education in an online platform provides an enticing package that public schools will have a challenging time replicating with continued budget woes. As IVE technology becomes cheaper and more widespread, users will become more and more comfortable interacting in multisensory virtual worlds. It makes sense that the marriage of the two technologies, MOOCs and IVEs, has the potential to provide an extremely high-quality and affordable educational platform. One where your professor, be it Mark Ruffalo's avatar or your digital doppelganger, might end up teaching future generations in the classrooms of tomorrow.

References

Ahn, S. J. (2011). *Embodied experiences in immersive virtual environments: Effects on pro-environmental attitude and behavior* (Doctoral dissertation). Stanford University, Stanford, CA.

Ahn, S. J., & Bailenson, J. N. (2011). Self-endorsing versus other-endorsing in virtual environments: The effect on brand attitude and purchase intention. *Journal of Advertising*, *40*(2), 93–106.

Ahn, S. J., Jabon, M. E., & Bailenson, J. N. (2008). Facial expressions as predictors of online buying intention. *Proceedings of the 58th Annual International Communication Association Conference*, May 22–26. Montreal, Canada.

Ahn, S. J., Le, A. M. T., & Bailenson, J. N. (2013). The effect of embodied experiences on self-other merging, attitude, and helping behavior. *Media Psychology, 16,* 17–38.

Alzieu, V. (2013). *Leap motion controller coming to HP computers. Digital Versus.* Retrieved from http://www.digitalversus.com/motion-sensors/leap-motion-the-leap-p15766/leap-motion-controller-coming-hp-computers-n29173.html

Andsager, J. L., Bemker, V., Choi, H. L., & Torwel, V. (2006). Perceived similarity of exemplar traits and behavior effects on message evaluation. *Communication Research*, *33*(1), 3–18.

Aymerich-Franch, L., Karutz, C., & Bailenson, J. N. (2012). Effects of facial and voice similarity on presence in a public speaking virtual environment. *Proceedings of the International Society for Presence Research Annual Conference*, October 24–26. Philadelphia, PA.

Bailenson, J. N. (2006). Transformed social interaction in collaborative virtual environments. In P. Messaris, & L. Humphreys (Eds.), *Digital media: Transformations in human communication* (pp. 255–264). New York, NY: Peter Lang.

Bailenson, J. N. (2012). *Holograms are here, from Tupac to Marilyn Monroe. Will you be next? The Washington Post.* Retrieved from http://www.washingtonpost.com/opinions/holograms-are-here-from-tupac-to-marilyn-monroe-will-you-be-next/2012/11/30/92ff5d02-38d3-11e2-8a97-363b0f9a0ab3_story.html

Bailenson, J. N., Aharoni, E., Beall, A. C., Guadagno, R. E., Dimov, A., & Blascovich, J. (2004). Comparing behavioral and self-report measures of embodied agents' social presence in immersive virtual environments. *Proceedings of the 7th Annual International Workshop on PRESENCE*, Valencia, Spain.

Bailenson, J. N., & Beall, A. C. (2006). Transformed social interaction: Exploring the digital plasticity of avatars. In R. Schroeder, & A.-S. Axelsson, (Eds.), *Avatars at work and play: Collaboration and interaction in shared virtual environments* (pp. 1–16). Dordrecht, The Netherlands: Springer-Verlag.

Bailenson, J. N., Beall, A. C., Blascovich, J., Loomis, J., & Turk, M. (2005). Transformed social interaction, augmented gaze, and social influence in immersive virtual environments. *Human Communication Research*, *31*, 511–537.

Bailenson, J. N., Beall, A. C., Blascovich, J., Weisbuch, M., & Raimmundo, R. (2001). Intelligent agents who wear your face: Users' reactions to the virtual self. *Lecture Notes in Artificial Intelligence*, *2190*, 86–99.

Bailenson, J. N., Beall, A. C., Loomis, J., Blascovich, J., & Turk, M. (2004). Transformed social interaction: Decoupling representation from behavior and form in collaborative virtual environments. *Presence: Teleoperators and Virtual Environments*, *13*(4), 428–441.

Bailenson, J. N., Blascovich, J., Beall, A. C., & Loomis, J. M. (2001). Equilibrium theory revisited: Mutual gaze and personal space in virtual environments. *Presence: Teleoperators and Virtual Environments*, *10*, 583–598.

Bailenson, J. N., Blascovich, J., Beall, A. C., & Loomis, J. M. (2003). Interpersonal distance in immersive virtual environments. *Personality & Social Psychology Bulletin*, *29*, 819–833.

Bailenson, J. N., Garland, P., Iyengar, S., & Yee, N. (2006). Transformed facial similarity as a political cue: A preliminary investigation. *Political Psychology*, *27*, 373–386.

Bailenson, J. N., Iyengar, S., Yee, N., & Collins, N. (2008). Facial similarity between voters and candidates causes influence. *Public Opinion Quarterly*, *72*(5), 935–961.

Bailenson, J. N., & Yee, N. (2005). Digital chameleons: Automatic assimilation of nonverbal gestures in immersive virtual environments. *Psychological Science*, *16*, 814–819.

Bailenson, J. N., & Yee, N. (2006). A longitudinal study of task performance, head movements, subjective report, simulator sickness, and transformed social interaction in collaborative virtual environments. *Presence: Teleoperators and Virtual Environments*, *15*(6), 699–716.

Bailenson, J. N., & Yee, N. (2007). Virtual interpersonal touch and digital chameleons. *Journal of Nonverbal Behavior*, *31*, 225–242.

Bailenson, J. N., Yee, N., Blascovich, J., Beall, A. C., Lundblad, N., & Jin, M. (2008). The use of immersive virtual reality in the learning sciences: Digital transformations of teachers, students, and social context. *The Journal of the Learning Sciences, 17*, 102–141.

Bailenson, J. N., Yee, N., Blascovich, J., & Guadagno, R. E. (2008). Transformed social interaction in mediated interpersonal communication. In E. Konijn, M. Tanis, S. Utz, & A. Linden (Eds.), *Mediated interpersonal communication* (pp. 77–99). New York (NY): Lawrence Erlbaum Associates.

Bandura, A. (1977). *Social learning theory.* Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (2001). Social cognitive theory of mass communication. *Media Psychology, 3*, 265–299.

Bandura, A., & Huston, A. C. (1961). Identification as a process of incidental learning. *Journal of Abnormal and Social Psychology*, *63*(2), 311–318.

Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology*, *59*, 617–645.

Basdogan, C., Ho, C.-H., Srinivasan, M. A., & Slater, M. (2000). An experimental study on the role of touch in virtual environments. *ACM Transactions on Computer-Human Interaction*, *7*, 443–460.

Bem, D. J. (1967). Self-perception: An alternative interpretation of cognitive dissonance phenomena. *Psychological Review*, *74*(3), 183–200.

Benford, S., Greenhalgh, C., Rodden, T., & Pycock, J. (2001). Collaborative virtual environments. *Communications of the ACM*, *44*(7), 79–85.

Bente, G., Petersen, A., Krämer, N. C., & de Ruiter, J. P. (2001). Transcript-based computer animation of movement: Evaluating a new tool for nonverbal behavior research. *Behavior Research Methods, Instruments, & Computers*, *33*, 303–310.

Biocca, F. (1997, August). The cyborg's dilemma: Embodiment in virtual environments. In J. P. Marsh (Ed.), *Proceedings of the Second International Conference on Cognitive Technology, 1997, Humanizing the Information Age,* August 25–28, 1997, Aizu-Wakamatsu City, Japan (pp. 12–26). Los Alamitos, CA: IEEE.

Blascovich, J., & Bailenson, J. N. (2011). *Infinite reality—Avatars, eternal life, new worlds, and the dawn of the virtual revolution*. New York, NY: William Morrow.

Blascovich, J., Loomis, J., Beall, A. C., Swinth, K. R., Hoyt, C. L., & Bailenson, J. N. (2002). Immersive virtual environment technology as a methodological tool for social psychology. *Psychological Inquiry*, *13*, 103–124.8–9.

Bussey, K., & Perry, D. G. (1982). Same-sex imitation: The avoidance of cross-sex models or the acceptance of same-sex models? *Sex Roles*, *8*(7), 773–784.

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception-behavior link and social interaction. *Journal of Personality & Social Psychology*, *76*, 893–910.

Chung, J. C., Harris, M. R., Brooks, F. P., Fuchs, H., Kelley, M. T., Hughes, J., … Pique, M. (1989). Exploring virtual worlds with headmounted displays. *Proceedings of SPIE*, *1083*, 42–52.

Cooper, S., & Sahami, M. (2013). Reflections on Stanford's MOOCs. *Communications of the ACM*, *56*(2), 28–30.

Corcoran, B. (2013). *Adding collaboration to massive online courses. edSurge*. Retrieved from https://www.edsurge.com/n/2013-04-15-adding-collaboration-to-massive-online-courses

Cruz-Neira, C., Sandin, D. J., DeFanti, T. A., Kenyon, R. V., & Hart, J. C. (1992). The CAVE: Audio visual experience automatic virtual environment. *Communications of the ACM*, *35*(6), 64–72.

Dowrick, P. W. (1999). A review of self modelling and related interventions. *Applied & Prevention Psychology*, *8*, 23–39.

Empson, R. (2013). *Stanford's NovoEd brings collaboration and group learning to MOOCs to help fight attrition. TechCrunch*. Retrieved from http://techcrunch.com/2013/04/15/stanfords-novoed-brings-collaboration-and-group-learning-to-moocs-to-help-fight-attrition/

Fini, A. (2009). The technological dimension of a massive open online course: The case of the CCK08 course tools. *The International Review of Research in Open and Distance Learning*, *10*(5), 1–26.

Fowler, G. (2013). *Online education lifts pass rates at university. The Wall Street Journal*. Retrieved from http://online.wsj.com/article_email/SB10001424127887323741004578414861572832182-lMyQjAxMTAzMDEwMDExNDAyWj.html

Fox, J., Arena, D., & Bailenson, J. N. (2009). Virtual reality: A survival guide for the social scientist. *Journal of Media Psychology*, *21*(3), 95–113.

Fox, J., & Bailenson, J. N. (2009a). Virtual self-modeling: The effects of vicarious reinforcement and identification on exercise behaviors. *Media Psychology*, *12*, 1–25.

Fox, J., & Bailenson, J. N. (2009b). Virtual virgins and vamps: The effects of exposure to female characters' sexualized appearance and gaze in an immersive virtual environment. *Sex Roles*, *61*(3–4), 147–157.

Fox, J., Bailenson, J. N., & Tricase, L. (2013). The embodiment of sexualized virtual selves: The Proteus effect and experiences of self-objectification via avatars. *Computers in Human Behavior*, *29*, 930–938.

Friedman, D., Steed, A., & Slater, M. (2007). Spatial social behavior in second life. In C. Pelachaud (Ed.), *Intelligent virtual agents* (pp. 252–263). New York, NY: Springer.

Friedman, T. (2013). *The professors' big stage. The New York Times.* Retrieved from http://www.nytimes.com/2013/03/06/opinion/friedman-the-professors-big-stage.html?_r=0

Furness, T. (1987). Designing in virtual space. In W. B. Rouse & K. R. Boff (Eds.), *System design: Behavioral perspectives on designers, tools, & organization* (pp. 127–143). New York, NY: North-Holland.

Gaudiosi, J. (2012). *Riot games' league of legends officially becomes most played PC game in the World. Forbes.* Retrieved from http://www.forbes.com/sites/johngaudiosi/2012/07/11/riot-games-league-of-legends-officially-becomes-most-played-pc-game-in-the-world/

Groom, V., Bailenson, J. N., & Nass, C. (2009). The influence of racial embodiment on racial bias in immersive virtual environments. *Social Influence*, *4*(1), 1–18.

Harris, H., Bailenson, J. N., Nielsen, A., & Yee, N. (2009). The evolution of social behavior over time in second life. *Presence: Teleoperators & Virtual Environments*, *18*(6), 294–303.

Hershfield, H. E., Goldstein, D. G., Sharpe, W. F., Fox, J., Yeykelis, L., Carstensen, L. L., & Bailenson, J. N. (2011). Increasing saving behavior through age-progressed renderings of the future self. *Journal of Marketing Research*, *48*, S23–S37.

Hilmert, C. J., Kulik, J. A., & Christenfeld, N. J. (2006). Positive and negative opinion modeling: The influence of another's similarity and dissimilarity. *Journal of Personality and Social Psychology*, *90*(3), 440–452.

Hoberman, P., Krum, D. M., Suma, E. A., & Bolas, M. (2012, March). Immersive training games for smartphone-based head mounted displays. In *Virtual Reality Short Papers and Posters (VRW), 2012 IEEE* (pp. 151–152). IEEE.

Joslin, C., Di Giacomo, T., & Magnenat-Thalmann, N. (2004). Collaborative virtual environments: From birth to standardization. *IEEE Communications*, *42*(4), 28–33.

Kaiser Family Foundation. (2010). *Generation M2: Media in the lives of 8–18-year olds.* Menlo Park, CA: Rideout, V., Foehr, U., & Roberts, D.

Kazdin, A. E. (1976). Effects of covert modeling, multiple models, and model reinforcement on assertive behavior. *Behavior Therapy*, *7*(2), 211–222.

Kizilcec, R. F., Piech, C., & Schneider, E. (2013). Deconstructing disengagement: Analyzing learner subpopulations in massive open online courses. In D. Suthers, K. Verbert, E. Duval, & X. Ochoa (Eds.), *Proceedings of the Third International Conference on Learning Analytics and Knowledge* (pp. 170–179). New York, NY: ACM.

Lanier, J. (1992). Virtual reality: The promise of the future. *Interactive Learning International*, *8*, 275–279.

Lanier, J. (1997). Beyond goggles and gloves. *Byte*, *22*(9), 32.

Loomis, J. M. (1992) Distal attribution and presence. *Presence: Teleoperators and Virtual Environments*, *1*, 113–119.

Loomis, J. M., Blascovich, J. J., & Beall, A. C. (1999). Immersive virtual environment technology as a basic research tool in psychology. *Behavior Research Methods, Instruments, and Computers*, *31*, 557–564.

Loomis, J. M., Hebert, C., & Cicinelli, J. G. (1990). Active localization of virtual sounds. *Journal of the Acoustical Society of America*, *88*, 1757–1764.

Martin, F. G. (2012). Will massive open online courses change how we teach? *Communications of the ACM*, *55*(8), 26–28.

Matsukura, H., Yoneda, T., & Ishida, H. (2013). Smelling screen: Development and evaluation of an olfactory display system for presenting a virtual odor source. *Visualization and Computer Graphics, IEEE Transactions on*, *19*(4), 606–615.

McAuley, A., Stewart, B., Siemens, G., & Cormier, D. (2010). *The MOOC model for digital practice*. Retrieved from, http://www.elearnspace.org/Articles/MOOC_Final.pdf

McCall, C., Bailenson, J. N., Blascovich, J., & Beall, A. C. (2009). Leveraging collaborative virtual environment technology for inter-population research on persuasion in a classroom setting. *Presence: Teleoperators & Virtual Environments*, *18*(5), 361–369.

Meichenbaum, D. H. (1971). Examination of model characteristics in reducing avoidance behavior. *Journal of Personality and Social Psychology*, *17*(3), 298.

Meyer, K., Applewhite, H. L., & Biocca, F. A. (1992). A survey of position trackers. *Presence: Teleoperators and Virtual Environments*, *1*(2), 173–200. (ISSN 1054-7460).

Nunneley, S. (2011). *3DS: Nintendo recommends a break every 30-minutes when playing games on the handheld*. *VG24/7*. Retrieved from http://www.vg247.com/2011/02/23/3ds-nintendo-recommends-a-break-every-30-minutes-when-playing-games-on-the-handheld/?

Olson, J. L., Krum, D. M., Suma, E. A., & Bolas, M. (2011, March). A design for a smartphone-based head mounted display. In *Virtual Reality Conference (VR)*, 2011 IEEE (pp. 233–234). New York, NY: IEEE.

Piech, C., Sahami, M., Koller, D., Cooper, S., & Blikstein, P. (2012, February). Modeling how students learn to program. In L. A. Smith King, D. R. Musicant, T. Camp, & P. T. Tymann (Eds.), *Proceedings of the 43rd ACM Technical Symposium on Computer Science Education* (pp. 153–160). New York, NY: ACM.

Reeves, B., Malone, T. W., & O'Driscoll, T. (2008). Leadership's online labs. *Harvard Business Review*, *86*(5), 58–66.

Rheingold, H. (1991). *Virtual reality*. New York, NY: Simon & Schuster.

Richard, E., Tijou, A., Richard, P., & Ferrier, J. L. (2006). Multi-modal virtual environments for education with haptic and olfactory feedback. *Virtual Reality*, *10*(3), 207–225.

Rodriguez, C. O. (2012). *MOOCs and the AI-Stanford like Courses: Two Successful and Distinct Course Formats for Massive Open Online Courses. European Journal of Open and Distance Learning, 15.* Retrieved March 10, 2013 from http://www.eurodl.org/index.php?p=current&article=516

Rosen, R. (2013). *Google death: A tool to take care of your Gmail when you're gone. The Atlantic.* Retrieved from http://www.theatlantic.com/technology/archive/2013/04/google-death-a-tool-to-take-care-of-your-gmail-when-youre-gone/274934/

Rosenberg, R. S., Baughman, S. L., & Bailenson, J. N. (2013). Virtual superheroes: Using superpowers in virtual reality to encourage prosocial behavior. *PLOS One*, *8*(1), 1–9.

Segovia, K. Y. & Bailenson, J. N. (2009). Virtually true: Children's acquisition of false memories in virtual reality. *Media Psychology*, *12*, 371–393.

Stepper, S., & Strack, F. (1993). Proprioceptive determinants of emotional and nonemotional feelings. *Journal of Personality and Social Psychology*, *64*, 211–211.

Suma, E. A., Lange, B., Rizzo, A., Krum, D. M., & Bolas, M. (2011, March). Faast: The flexible action and articulated skeleton toolkit. In *Virtual Reality Conference (VR)*, 2011 IEEE (pp. 247–248). New York, NY: IEEE.

Sutcliffe, A., Gault, B., Fernando, T., & Tan, K. (2006). Investigating interaction in CAVE virtual environments. *ACM Transactions on Computer-Human Interaction*, *13*, 235–267.

Tan, H. Z., & Pentland, A. (1997). Tactual displays for wearable computing. *Personal Technologies*, *1*, 225–230.

Thomas, L. E., & Lleras, A. (2009). Swinging into thought: Directed movement guides insight in problem solving. *Psychonomic Bulletin & Review*, *16*(4), 719–723.

Wang, X., Stolka, P., Boctor, E., Hager G., & Choti M. (2012). The Kinect as an interventional tracking system. Medical Imaging 2012: Image-guided procedures. *Robotic Interventions, and Modeling*, *8316*, 1–6.

Welch, G. F. (2009). History: The use of the Kalman filter for human motion tracking in virtual reality. *Presence: Teleoperators and Virtual Environments*, *18*(1), 72–91.

Wells, G. L., & Petty, R. E. (1980). The effects of over head movements on persuasion: Compatibility and incompatibility of responses. *Basic and Applied Social Psychology*, *1*(3), 219–230.

Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. *Presence: Teleoperators and Virtual Environments*, *7*(3), 225–240.

Woods, A. (2009). 3-D displays in the home. *Information Display*, *362*, 8–12.

Won, A. S., Yu, L., Janssen, J. H., & Bailenson, J. N. (2012). Tracking gestures to detect gender. *Proceedings of the International Society for Presence Research Annual Conference,* October 24–26. Philadelphia, PA.

Yee, N., & Bailenson, J. N. (2006). Walk a mile in digital shoes: The impact of embodied perspective-taking on the reduction of negative stereotyping in immersive virtual environments. *Proceedings of PRESENCE 2006: The 9th Annual International Workshop on Presence,* August 24 & 26, Cleveland, OH.

Yee, N., & Bailenson, J. N. (2007). The Proteus effect: Self transformations in virtual reality. *Human Communication Research*, *33*, 271–290.

Yee, N., & Bailenson, J. N. (2008). A method for longitudinal behavioral data collection in Second Life. *Presence: Teleoperators and Virtual Environments*, *17*(6), 594–596.

Yee, N., Bailenson, J. N., & Ducheneaut, N. (2009). The Proteus effect: Implications of transformed digital self-representation on online and offline behavior. *Communication Research*, *36*(2), 285–312.

Yee, N., Bailenson, J. N., Urbanek, M., Chang, F., & Merget, D. (2007). The unbearable likeness of being digital: The persistence of nonverbal social norms in online virtual environments. *Cyberpsychology and Behavior*, *10*, 115–121.

Zahorik, P. (2002). Assessing auditory distance perception using virtual acoustics. *Journal of the Acoustical Society of America*, *111*, 1832–1846.