Journal of
Virtual Worlds Research

jvwr.net

ISSN: 1941-8477

Assembled 2019

December 2019

Volume 12 No. 3

Volume 12, Number 3

Assembled 2019

December 2019

Cover image: Photo by Mateusz Wyszynski from Pixabay

Journal of Virtual Worlds Research jvwr.net
ISSN: 1941-8477

Volume 12, Number 3
Assembled 2019
December 2019

User Characteristics, Trait vs. State Immersion, and Presence in a First-Person Virtual World

Lynna J. Ausburn
Oklahoma State University

Jon Martens
University of Central Oklahoma

Charles E. Baukal, Jr
John Zink Institute

Ina Agnew
Oklahoma State University Institute of Technology

Robert Dionne
University of Oklahoma

Floyd B. Ausburn
Oklahoma State University

Abstract

Virtual reality and virtual worlds (VWs) are powerful technologies currently helping to define the digital world. These technologies are characterized by user control, immersion, and sense of presence or "being there." They have been examined from a variety of theoretical perspectives, technical and user variables, and psychological approaches. The purpose of this study was to extend VW research by relating the roles of user age and gender directly to the VW-critical features of immersion and perceived presence, an approach that has not been widely addressed in previous research. This study used a photo-real, on-screen, first-person VW in which users "enter" and "walk through" a VW via mouse navigation, viewing it through their own eyes rather than through an avatar. It used a quasi-experimental design with 35 adult subjects who reported their age and gender and were tested for perceived immersion and presence in a VW showing a 360-degree city panorama. Data were analyzed using *t*-tests, chi-squares, Pearson correlations, and interview comments to examine relationships among age and gender, immersion, and presence in the VW. Findings supported conclusions relating to the relevance of age and gender as user variables in VWs and the role of technology characteristics in VWs' effective use. The study also opened a potential new line of inquiry by raising previously unaddressed questions about the importance of the psychological trait *vs.* state nature and measurement of immersion and presence in VWs. Suggestions for further research are offered.

1. Introduction

Fascination with digital technologies is a defining feature of living and learning in the age of cyber-worlds. With its realism and ability to engage, the virtual reality (VR) family of digital representations and their constructions into immersive virtual worlds (VWs) is among the most intriguing and powerful digital technologies (Ausburn & Ausburn, 2014). VR technologies range from high-tech multi-sensory experiences in enclosed CAVE environments with complex headgear and sensory suits, to screen-based environments operated on desktop computers, to inexpensive stereoscopic viewers paired with smartphone apps. These technologies share, across their research base, the general definition of 3D graphic spaces that users can "walk through" in real time, explore at will, and experience with a sense of actually being somewhere rather than just "seeing it." They also share support from a rich variety of theoretical stances that aid in the construction of VWs. These theories include Computers as Social Actors (CASA) theory, anthropomorphism, ethopoeia (putting self in the place of another), homophily (tendency to relate to others like us), appearance and personality, knowledge creation theory, social cognitive theory, wayfinding and navigating, individual differences, culture theory, and presence or "being there" theory (Ausburn, Martens, Dotterer, & Calhoun, 2009; Ausburn & Ausburn, 2014). Another theoretical support from the perspective of multimedia-based learning stems from Dale's (1969) classic Cone of Experience that proposes learning benefits from high levels of concreteness or reality in learning experiences. In a recent re-conceptualization of Dale's Cone, the focus is on new technologies in a *Multimedia Cone of Abstraction.* In this theory update, VR sits at the supporting base of the cone as the most concrete and realistic of media environments (Baukal, Ausburn, & Ausburn 2013).

VR technology and VWs have seen the convergence of increased technical quality and fidelity in representing the real world, more sophisticated user control, greater ease of use, and decreased costs. The result has been a marked increase in VR/VW usage for learning, gaming, experiencing, and just passing time. In the early days of VR, the technology raised concerns about early-use issues such as digital divides, equity of access, physical and psychological effects on users, and ability to facilitate learning. However, as VR has proliferated as a means of experiencing worlds both real and imagined, these early concerns about its basic efficacy have fallen away in the literature, and the technology has generally been accepted to have important potential for a variety of applications when well designed and implemented. An example is using VR for training purposes to simulate a fired heater explosion that would be impossible to demonstrate on an operating heater (Baukal, Olson, & Ernst, 2019). Following the path established by innovation diffusion theory for new technology as it moves from early adaptors through laggards (Moore, 1999; Rogers, 1962, 2003), research on VR has shifted from early simplistic questioning about *whether it works* to complex multivariate examinations of *when, why, how, and for whom it works.*

In all their forms, all VR technologies share the definitional characteristics of real-time user interaction with, and control of, content and operation. These core characteristics set VR apart from other technology-based environments. They have been important components in the now generally-accepted research-based conclusion that VR and VWs can facilitate vivid experiences and learning across a broad range of subject matters, including medicine, biotechnology, aviation, welding, construction, animal care, law enforcement, firefighting and disaster control, hazard detection, and heavy equipment operation; and across numerous types of learning such as environment orientation learning, procedural knowledge, and hands-on simulator training (Ausburn & Ausburn, 2010; Ausburn, Ausburn, Dotterer, Washington, & Kroutter, 2013; Dotterer, 2011; Martens, 2016). VR and VWs present benefits that include not only successful learning performance, but also affective appeal and motivation, transfer to real-world situations, and safe experience in places and situations that are dangerous or even impossible to access in the physical world. Importantly, they remove locational walls and allow learning and experience to become uncoupled from traditional institutional settings and methods (Gabriel, Wiebe, & MacDonald, 2009; Project Tomorrow, 2010). These key benefits of VWs, which underlie the strong appeal of the technology, were invoked by Ausburn and Ausburn (2008) when they asked:

> Where would you like your students to explore today? Inside an airplane cockpit, a prototype car, a submarine, or a computer? How about an operating room in a large metropolitan hospital, a late-night emergency response location on an isolated country road, an upscale merchandising outlet in Tokyo, a construction site in New York City, an agricultural experimental station in India, a cutting-edge biotech laboratory in Germany, or a crime scene in Los Angeles? (p. 43)

In summary, VR technology and the VWs it creates are currently benefiting from a set of important advancements. The growing acceptance and research-documented learning efficacy of VWs, their transferability, their ability to expand experiences far beyond locational confines, their strong affective appeal, and their cost-effectiveness are driving VW development as a mainstream teaching/learning tool in both education and industry. This situation supports the need for on-going research to establish how best to design and implement VWs to maximize their potential, particularly their ability to create *presence* or a sense of being in a real environment. Spagnolli, Lombard, and Gamberini (2010) supported the need for more research in VR/VWs for learning despite the complexities of such research. These complexities include issues in operationalizing and achieving presence; measuring the nature and intensity of presence; the roles and interactions of media form, content, and user characteristics in the emergence of presence; and assessing the ability of presence to transfer and affect real-world outcomes. Lombard, Ditton, and Weinstein (2009) also called for continued VR/VW research to confirm and understand the presence phenomenon and its effects. The study reported here represents one piece in the progression of this line of inquiry. Specifically, the study addresses the intersection of user immersion, presence, and selected demographic characteristics in orientation and object location in a complex screen-based first-person VW.

2. Purpose, Variables, and Research Questions

The purpose of this study was to examine and describe quantitatively relationships among several interrelated variables as users completed a navigation and location task in a complex screen-based first-person VW. The study's variables included: (1) demographic characteristics of users, specifically their age and gender; (2) self-assessed level of susceptibility to immersion or "immersibility" of users; and (3) perceived sense of presence reported by users as they worked in the virtual world.

The study was guided by the following research questions:

1. What is the relationship between users' self-assessed immersibility and their age and/or gender?
2. What is the relationship between users' perceived VW presence and their age and/or gender?
3. What is the relationship between users' reported immersibility and their perceived sense of presence in a VW?

VW research has frequently included users' age and gender, as well as the VW-critical and ubiquitous characteristics of immersion and presence. However, this study examines a unique set of relationships among this often-investigated set of VW variables. The research questions for this study indicate that its purpose was to address specifically and empirically relationships between VW users' age and gender and their measured general immersibility and perceived sense of presence, as well as the relationship between immersibiliy and presence. This approach has not been common and addresses a gap in VW research.

3. Theoretical Framework and Supporting Literature

This study and its research questions are underpinned by three theoretical strands: presence, immersion, and individual differences. Brief descriptions of these theories and selected supporting literature are presented here.

3.1. Presence in VWs

One of the definitional characteristics of VR and VWs is their ability to create in users the phenomenon known as *presence.* Presence has been defined and discussed for more than a decade by many researchers. Witmer and Singer (1998) defined presence as "… the subjective experience of being in one place or environment, even when one is physically situated in another" (p. 225) and extensively reviewed factors thought to relate to presence. The International Society for Presence Research (ISPR) identified presence as "… a psychological state or subjective perception…" in which a user sets aside awareness that experience is filtered through technology and perceives as though the technology was not involved in the experience (ISPR, 2019). Other researchers have defined presence as the strong sense in VW users of *being there;* being actually inside an environment; the illusion of "non-mediation" or being uncoupled from technology (ISPR, 2019; Lombard & Ditton, 1997); and the sense that they have *actually been somewhere* rather than just seeing it and that what they are doing is actually real (Chen, Toh, & Wan, 2004; Di Blas & Poggi, 2007; Inoue, 2007; Lombard & Ditton, 1997; Mikropoulos, 2006). For Ausburn and Ausburn (2010), presence is simply the *reality* in virtual reality.

The presence construct and understanding its creation and effects in VWs present substantial technical, physical, and psychological difficulties. Ausburn and Ausburn (2010) asserted more than a decade of intensive research has not resolved many of these difficulties or clearly established how to measure presence. One of the most difficult problems has been the failure to establish a universally-accepted presence definition or measurement instrument (Rosakranse & Oh, 2014; van Baren & Ijsselsteijn, 2004). Most attempts to assess presence have been paper-and-pencil and quantitative in nature. These have included multi-item questionnaires (e.g., Chertoff, Goldiez, & LaViola, 2010; Coelho, Tichon, Hine, Wallis, & Riva, 2006; Lombard, Ditton, & Weinstein, 2009; Witmer & Singer, 1998) or single-question scale items (e.g., Bouchard, Robillard, St-Jacques, Dumoulin, Patry, & Ronaud, 2004). Some studies have used physiological measurements to examine presence and other learner affective responses. For example, Baukal, Martens, Ausburn, Dionne, and Agnew (2017) discussed and illustrated the use of electro-dermal activity (EDA) and sensors. Some researchers are now advocating qualitative study of learner comments and narratives to identify the *presence of presence* in VWs (Ausburn, Martens, Washington, Steele, & Washburn, 2009; Kroutter, 2010; Martens, 2016; Washington, 2013).

Given its definitional, measurement and other difficulties, research on presence in VR/VWs and its effects remains elusive. At this point, it can be asserted that researchers understand that presence is a critical attribute of virtual learning environments; can exist in VWs; and may interact with individual technology, task, and user characteristics. However, they do not yet fully understand this phenomenon, its causes, and its effects (Ausburn & Ausburn, 2014; Chapman & Stone, 2010; Lombard et al., 2009; Spagnolli et al., 2010).

3.2. Immersion in VWs

A second theoretical construct that relates to presence in VR/VWs and contributes to the theoretical framework for this study is known as *immersion.* Witmer and Singer (1998) defined immersion as "… a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment …" (p. 227). They asserted that immersion is a matter of individual experience, unlike Slater's view that it is an objective measure of VR technology (Slater, Linakis, Usoh, & Cooper, 1996). Slater and Wilbur (1997) defended the technology-oriented view of immersion by identifying five dimensions of immersion that are clearly tied to the VR technology used to present an environment. These included the technology's ability to be: (1) inclusive (isolating user or shutting out outside world), (2) extensive (stimulating multiple senses), (3) surrounding (presenting wide field of view), (4) vivid (presenting high quality display resolution), and (5) matching (presenting consistency of user's body movements and visual display).

A similar focus on technology characteristics that contribute to VW immersion and presence was presented early in VR research by Waller, Hunt, and Knapp (1998) who used the term *fidelity t*o describe the extent to which a VW and user interaction with it are similar to a physical environment. Blade and Padgett (2002) similarly defined fidelity as the degree to which a VW duplicates the sensory stimulation and operational aspects of the real-world environment being modeled. Ausburn and Ausburn (2014) also felt that technology features were critical to VW effectiveness, including image detail and clarity, smooth zooming and panning, seamless stitching of images into panoramas, and immediacy of computer response time. They suggested that weakness in these technical features diminishes immersion and presence. While Witmer and Singer (1998) viewed VW immersion as an individual psychological experience, they also indicated that technical features of virtual technology influence development of psychological experience, specifically citing the technology's ability to: (1) isolate users from a physical environment, (2) help users perceive self-inclusion in the VW, (3) provide natural modes of interaction and control, and (4) provide the perception of self-movement. They asserted that the *focus and attention* created by VR technology lead to user *involvement,* which they defined as the "psychological state experienced as a consequence of focusing one's energy and attention on a coherent set of stimuli or meaningfully related activities or events" (p. 227).

Several researchers have related technology characteristics and immersion or user engagement to the sensation of presence. Witmer and Singer (1998) stated clearly that "… both involvement and immersion are necessary for experiencing presence" (p. 227). They maintained that immersing users in a simulated environment is what VR is designed to do, and that is, in fact, why VWs can produce presence. Sheridan (2016) concurred, claiming that immersion can lead to presence and that appropriate technology features are required to attain the psychological state of presence. Snelling (2016) also saw a connection in asserting that there is an expectation that more immersive experiences lead to limited distraction and thus to more user engagement with VW content. Kober and Neuper (2013) added user variables to the relationship. They agreed with the individual nature of presence and felt that presence is aided by factors that increase immersion but can also be affected by individual differences. Gutierrez-Maldonado, Alsina-Jurnet, and Rus-Calafell (2009) reviewed factors affecting sense of presence and agreed that personality and abilities were related to the presence experience. This emphasis on individual differences leads directly to the third theoretical pillar for the present study.

3.3. Individual Differences and Performance in VWs

Individual differences have been studied in connection to all emerging learning technologies, and several relationships of learner characteristics to outcomes in VWs have been demonstrated. Gutierrez-Maldonado and Alsina-Jurnet (2010) examined the roles of test anxiety, spatial intelligence, verbal intelligence, personality, and computer experience in the sense of presence in VWs and reported several significant relationships with a greater sense of presence. Other individual difference variables that have demonstrated relationships with VW performance and perceptions include computer gaming experience (Ausburn, 2012; Ausburn et al., 2013; Ausburn, Ausburn, & Kroutter, 2013, 2017), field independent/dependent perceptional style (Kroutter, 2010), and pre-employment state anxiety (Washington, 2013).

Because they are present in nearly all learning situations, the individual difference variables of gender and age are important to examine in relation to virtual environments. Age differences in managing and responding to computer environments in favor of younger users are supported at the theoretical level by both Prensky's (2001) division between younger digital natives and older digital immigrants, and by Howe and Strauss's (2000) description of the computer-skilled and technology-expectant younger Millennial generation. While both these age-related models have been criticized for lack of empirical support, they have been widely cited in the research literature and frequently used to divide younger/older research participants. In both models, the age of approximately 30 establishes a general dividing line between the older and younger groups, providing a results-comparison benchmark across studies. As an example from the VW research, Ausburn (2012) used this age of 30 in a study that directly tested age-related differences in performance in a screen-based first-person VW presenting a technical scene of surgical operating rooms. She found a statistically significant difference in the VW spatial orientation score between younger (age = 18-30) and older (age = >30) college students enrolled in sub-baccalaureate surgical technology programs, with the younger students scoring higher on a measure of spatial orientation within the VW. Similarly, van Dursen, Helsper, and Enyon (2016), used age 30 as an upper limit for the youngest of four age categories (16 to 30, 31 to 45, 46 to 60, and 61 or greater) in the development of scales that measured operational, navigational, social, creating, and mobile Internet skills.

The gender variable has historically been more frequently explored in visual environments. Gender has demonstrated a strong relationship, in favor of males, with spatial skills and visualization (e.g., Linn & Peterson, 1985; Terlecki & Newcombe, 2005; Voyer, Voyer, & Bryden, 1995). The gender link with spatial skills and resultant performance was demonstrated in early VR research to extend to the virtual domain and, in fact, to be exacerbated in virtual spaces (Hunt & Waller, 1999; Sandstrom, Kaufman, & Huettel, 1998; Space, 2001; University of Washington, 200l; Waller, 2000; Waller, Knapp, & Hunt, 1999). Studies of gender and virtual environments have continued to demonstrate links between gender and learner performance and perceptions in VWs (Ausburn, 2012; Ausburn et al., 2009; Kroutter, 2010; Ross, Skelton, & Mueller, 2006). Some studies have indicated these gender-based differences are most observable in VWs that are technical in nature, visually complex, or presented in controlled clinical settings rather than in more flexible and naturalistic ones (Ausburn, Ausburn, & Kroutter, 2013, 2017).

4. Methodology

4.1. Subjects

The recruiting process used for this study involved nonprobability sampling. The sample was intended to represent the non-geriatric general population and, therefore, had an element of purposive sampling. However, to enable use of a relatively complex experimental environment, a fairly lengthy protocol, and the research team's ability to attend testing sessions, it was necessary to limit potential participants to individuals who were accessible to the researchers. This resulted in a sample of convenience (Gay, 1996).

Inclusion criteria for participating subjects were adults aged 18-54 who were members of schools and workplaces that were available to the research team. By reaching out through email and direct contact to professional associates, the investigators recruited 35 suitable adults who voluntarily completed the study. All participants were computer users who were students, faculty, or staff at a technical community college in Oklahoma. Table 1 reports the age and gender demographics for the sample. As shown in Table 1, the sample for this study was somewhat male-biased and relatively equally divided between younger and older ages. They were relatively young as a group, with the males somewhat younger and less variable in age than the females.

Table 1: Demographics of the Sample (N = 35)

VARIABLE Category	*N*	Age Range Included	*M* for Age	*Md* for Age	*SD* for Age	Age Distribution
GENDER						
Male	22					
Female	13					
Total	35					
AGE GROUP						
Indeterminate (near 30)	4	28-32				
Younger	18	18-26				
Older	13	33-54				
Total	35	18-54				
GENDER + AGE						
Male	22	18-45	26.64	23.00	8.16	57% ≤ 30
Female	13	18-54	33.77	34.00	11.85	43% > 30
Total	35	18-54	29.29	26.00	10.14	

4.2. Instruments

Data for this study required assessment of three items related to the use of a VW: (1) learner demographic characteristics; (2) learner susceptibility to immersion, or immersibility; and (3) learner sense of presence within a VW. The operationalization of these variables is presented in this section in order of increasing difficulty.

Learner characteristics. The variables of interest were age and gender. Simple self-response questions allowed participants to indicate on a subject datasheet their gender as male or female and their current age in years.

Learner immersibility. The *Immersive Tendencies Questionnaire* (ITQ) was identified in the literature and reviewed by the investigators for use in this study. The ITQ was developed by Witmer and Singer (1998) specifically to measure general immersion tendencies. They asserted that there are individual tendencies to immerse and that this instrument determines the propensity of individuals to become highly engaged in experiences and to feel their reality. In addition to having been developed specifically to measure immersibility, the ITQ was created by Witmer and Singer (1998) as a companion to their frequently-used presence questionnaire. The relationship between the two instruments was supported when it was found by Bouchard et al. (2004) to have divergent validity with the presence questionnaire. This further supported a link between immersibility and presence, another key variable in this study. Based on these findings in the literature, the ITQ was selected as the measure of immersibility for this study. The ITQ used here is a self-assessment questionnaire comprising 15 Likert-type items on a 5-point scale, for a total possible score of 75. Witmer and Singer (1998) used item and cluster analyses to establish a single-construct structure and an internal consistency reliability coefficient alpha of 0.81 for an 18-item version of the ITQ. Most items have responses addressing the subject's frequency of feelings of involvement in a variety of media and experiences, including books, television shows, movies, video games, sports, and dreams, with response choices ranging from *never (1)* to *all the time (5).* The items focus on capturing subjects' feelings of involvement, identification, and losing track of time or reality.

The instrumentation of immersibility introduced into this study a new concept and line of analysis: the psychological construct of *state vs. trait characteristics*. Since the introduction of psychological traits by Allport and Odbert (1936), the state/trait distinction has been an important concept in psychology. A *state* is typically regarded as an emotional manifestation that is short-term, fleeting, and situational, while a *trait* is more long-term, frequent, and stable. States are temporary emotional reactions to internal or external triggers. They can present various levels of intensity and duration, but when the emotional reactions pass, normal balance returns (Spielberger & Sydeman, 1994). Traits, by contrast, are a more permanent presence of emotions. They represent tendency to consistently feel, think, or behave in a certain way that is present in daily life (Forgays, Forgays, & Spielberger, 1997; Hamaker, Nesselroade, & Molenaar, 2007). With its emphasis on generalized manifestations of immersibility rather than temporary behavior, the ITQ appears to treat this variable as a stable psychological *trait* rather than as a temporary state; thus, as a true individual-difference characteristic rather than a temporary response to a specific technology environment.

Learner presence in a VW. The difficulties in defining and measuring presence have been well documented in the literature. A generally accepted theoretical framework for the assessment of presence has yet to emerge, and there are currently numerous definitions of presence and ways to measure it (Rosakranse & Oh, 2014; van Baren & Ijsselsteijn, 2004). Measures reported in the literature have included multi-item questionnaires, single questions, qualitative interviews, and physiological reactions. Despite the difficulties in measuring presence, it was necessary to find an acceptable instrument in order to operationalize this study.

Regardless of how presence is measured, it appears to be viewed in the literature as a subjective and temporary psychological state. It is frequently assessed using subjective self-assessment post-test questionnaires (Clemente, Rodriguez, Rey, Rodriguez, Banos, Botella, Alcaniz, & Avila, 2011; Meehan, Razzaque, Insko, Whitton, & Brooks, 2005; Rosakranse & Oh, 2014; van Baren & Ijsselsteijn, 2004). In fact, subjective questionnaire was recently reported to be currently the most commonly used method for measuring presence and sensitive enough to find differences in perceived presence (Schwind, Knierim, Hass, & Henze, 2019), even though the ability of such questionnaires to perform this function has been questioned (Slater, 2004). Other options reported in the literature were behavioral measures and physiological measures. However, behavioral measures have been criticized as having excessive difficulty and inadequately-established reliability, and physiological measures have been reported to be promising but potentially causing technical issues that disrupt or destroy presence (Schwind et al., 2019). After weighing both the known operational advantages and the impression/memory disadvantages of post-experience questionnaires (Meehan et al., 2005; van Baren & Ijsselsteijn, 2004), the investigators chose to use this form of instrument to assess presence. Determining which questionnaire to use was then necessary. This choice is dependent on many factors including the researcher's definition of presence and the environment in which the experiment takes place (Rosakranse & Oh, 2014; van Baren & Ijsselsteijn, 2004).

In locating and evaluating potential presence questionnaires, the investigators considered availability and ease of use of the instruments, appropriateness for the study's intended virtual medium, and other basic criteria suggested by Lessiter, Freeman, Keogh, and Davidoff (2001). For this study, three presence questionnaires were evaluated : (1) the Slater, Usoh, and Steed (SUS) questionnaire which was the first to officially measure presence in virtual reality (Slater, Usoh, & Steed, 1994); (2) the Witmer & Singer (1998) presence questionnaire (PQ) which is one of the most widely used presence questionnaires and focuses on immersion and levels of involvement; and, (3) the Igroup Presence Questionnaire (IPQ) which drew items from the previously published PQ and SUS instruments (Schubert, Friedmann, & Regenbrecht, 2001). The IPQ was discarded as the literature indicated that results were questionable due to an absence of information on data quality and psychometric properties that may have led to poor internal validity for the studies in which it was used (Panahi-Shahri, Fathi-Ashtiani, & Azad-Fallah, 2009).

Both the PQ and SUS were attractive instruments for measuring presence. The PQ has a reported internal consistency reliability coefficient alpha of 0.88 (Witmer & Singer, 1998) and is currently the most frequently referenced presence questionnaire in the literature with more than 3500 citations reported (Schwind et al., 2019). The six-item SUS does not have a reported reliability, but it is well respected as the second most frequently referenced presence questionnaire with more than 1300 citations reported (Schwind et al., 2019). To assist with the selection of the questionnaire, the investigators asked doctoral students in a VR research class to review the questions in both instruments. The result was a combined 20-question survey, each with a 5-point Likert-type format with 5 being the most positive response. Each question was unique and non-duplicative; had a correlation with total score of ≥ .40, and a response rating scale with clear meaning statements for each numerical point. The questions addressed VW characteristics such as technical quality and reality, navigation and control, consistency with real world experience and expectations, and sense of involvement. The questions dealt specifically with the VW experienced in this study and did not address broader trait tendencies for presence.

Because the presence instrument was developed by combining items from two existing instruments, there was some concern for its test/retest reliability. This could be addressed because the research design for the study from which the present data were extracted included two administrations of the presence questionnaire (see Procedures section below). This permitted a test/retest correlation of the two presence scores as a stability check, which presented a Pearson correlation of 0.76 which is generally considered acceptable to good. Therefore, the reliability of the presence questionnaire in this study was deemed adequate. The first administration of the questionnaire when participants were naïve and not subject to practice effects was used as the presence measure. Total score out of a possible 100 was designated as the presence score for each subject.

4.3. Virtual World and Learning Task

The two VWs selected for use in this study were based on the GigaPan VR technology platform (www.gigapan.com). GigaPan VWs are 360-degree photo-real panoramas created with a high-resolution camera, a tripod-mounted robotic pan head, and proprietary software for creating panoramas and mounting them online. The worlds are presented on standard desktop computers via a web browser. They are first-person rather than avatar-based in style, with users viewing the photo-real world as if actually entering it personally in the physical world and experiencing it through their own eyes by navigating, panning, and zooming via a standard mouse. Given the age range (18-54; *Md* = 26) and background (computer users in a technical college) of the study's sample, age-related and computer access/experience issues such as mouse functions and control were not considered a potential problem. Such issues should, however, be kept in mind, as they might suggest possible limitations on the extent of the study's external validity.

The two panoramas selected for this study were sourced from the GigaPan web site and presented to subjects in a standard Internet browser. The panoramas depicted the major international cities Monte Carlo and Rio De Janeiro. Both city VWs were highly complex and were judged by the investigators to be equally detailed. The learning task given to subjects was a scavenger-hunt type activity requiring navigating and locating a set of specific landmarks or items within the VW. Dozens of studies since the 1990s have provided examples of use of this type of search and orientation learning task in technical training and other learning-based applications (e.g., Ausburn & Ausburn, 2008, 2010; Ausburn, Ausburn, Dotterer, Washington, & Kroutter, 2013; Ausburn, Ausburn, & Kroutter, 2017; Darken, Allard, & Achille, 1998; James, Humphrey, Vilis, Corrie, Badour, & Goodale, 2002; Ruddle, Payne, & Jones, 1999).

4.4. Procedures

This study's analysis of learner characteristics, immersibility, and perceived presence was extracted from a larger study that comprised several additional variables related to experiences in the GigaPan VWs. This derivation is reflected in the research procedures developed for the larger study and summarized briefly here. The study required experimental manipulation of stimulus presentation variables, but random sampling was not possible. Also, the researchers wanted to establish an environment that was familiar, convenient, and comfortable for subjects and thus chose to bring the study to them with a field-based approach rather than a more artificial laboratory setting that could both introduce uncontrolled anxiety and limit external validity. These factors resulted in the research design being quasi-experimental rather than experimental due to preclusion of probability sampling and laboratory control of the experimental conditions. However, procedures were used to control the conditions in the field environment as much as practical. All testing was conducted by an experienced research team trained to administer a standardized research protocol. Each subject was tested individually by one or two members of the research team, depending on availability. For each subject, the research script was read aloud to ensure that each person received identical instructions.

All 35 selected subjects participated in a GigaPan VW activity set up in a small room in an institute of technology in the United States. One of the goals of the larger study from which the present analysis was extracted was to determine effects of computer display size on VW presence. To facilitate this goal, the study's protocol directed subjects to consecutively use two different configurations of GigaPan VWs to locate designated landmarks. Configurations were distinguished by two variables: (1) the diagonally-measured size of the computer visual display, either large (28") or small (17"), and (2) the depicted city. Initial assignment to display size and city configurations was independently randomized by subject. All subjects eventually saw both the large- and small-screen configurations, but only the data from their initial VW experience was used for the analysis presented here regardless of screen size or VW city.

Prior to performing the landmark search task, subjects' self-reported gender and age were collected, and the *Immersive Tendency Questionnaire (ITQ)* was administered. To enable goals of the larger study, subjects were fitted with an Affectiva Q Sensor (a watch-like device for measuring electro-dermal activity or EDA) on their left wrist and were interviewed twice during the research process. While EDA and detailed interview data were beyond the scope of the present analysis, pieces of the interview data were used here to cross-check quantitative findings. An investigator demonstrated operation of the GigaPan VR system using a city VW of New York and then provided the subject with 15 minutes to practice operation of the system.

After the demonstration and practice session, the subject started the landmark location task on his/her assigned VW system. The subject was given a list of five landmarks and instructed to search the VW to find the landmarks, notifying the investigator when each landmark was found. When the subject identified a potential landmark, the investigator either confirmed that a listed item was found or directed the subject to continue searching. The search task ended when all listed landmarks were found by the subject or when 15 minutes elapsed, whichever came first. Completion times and response accuracy were recorded for use in subsequent analyses. Following the completion of the VW search task, the subject completed the study's *Presence Questionnaire.*

4.5. Data Analysis

All data obtained from the 35 subjects were entered into an SPSS, version 21, file for statistical analyses to address the research questions. Missing data handling procedures were unnecessary as there was no missing data in the data set. All *t*-tests conducted were independent-sample *t*s and all used the equal-variance-assumed model because they yielded non-significant Levene's tests with probabilities ranging from .29 to .67.

To test the relationship between gender and immersibility, two analyses were conducted. First, a chi-square was performed. For this analysis, the immersion scores were divided into three groups: (1) an indeterminate group (n = 5) with scores at the median of 46 on the immersion questionnaire, (2) a high immersion group (n = 17) with scores of 47-64, and (3) a low immersion group (n = 13) with scores of 30-45. These groups, coupled with two gender groups, created a 3 x 2, 2-way contingency table for chi-square analysis. The second analysis used a *t*-test with gender as the independent grouping variable and immersion score as the dependent variable.

To test the relationship between age and immersibility, two analyses were conducted. First, a Pearson correlation was performed using the subjects' age in years and immersion scores. Then the 35 age scores were split into three groups using the commonly-identified division age of 30: (1) an indeterminate group (n = 4) clustered near 30 (28-32), (2) a younger group (n = 18) age 18-26, and (3) an older group (n = 13) age 33-54. This procedure permitted comparability of findings with the many studies using the 30-year age convention and also facilitated the formation of a reasonable extreme-groups statistical design structured near the sample median age of 26. Finally, a *t*-test of the immersion scores was performed using only the younger and older groups (n = 31) with the indeterminate group eliminated to create better separation between the two test groups.

To test the relationship between gender and perceived presence in the VW, a *t*-test was performed using the 35 subjects' gender as the independent grouping variable and their presence scores as the dependent variable. For the age variable's relationship to presence, two tests were used. First, a Pearson correlation was performed with subjects' age in years and their total presence scores (N = 35). Then, a *t*-test was performed using the younger and older age groups (n = 31) as the independent grouping variable and presence scores as the dependent variable.

Finally, the relationship between immersibility and perceived presence was tested using correlation. A Pearson correlation was performed using all subjects' (N = 35) immersibility scores and presence scores.

Before these inferential statistics were applied, simple descriptive statistics were used to examine and describe the sample's demographics and their general performance on the immersibility and perceived presence instruments. Interview data were also reviewed for qualitative alignment with the quantitative data.

5. Results

The immersibility level of this group overall was fairly high, indicating a general tendency toward a willingness to immerse across a variety of media and activities covered by the instrument. This tendency was evidenced by a score range of 30 – 64 on a 75-point total score availability with M = 47.29, Md = 46, and SD = 8.64. The score distribution presented only 20% < 40 and 34% > 50.

Willingness to immerse in the VW in this study was supported by qualitative comments in the subject's interviews. One subject stated that the VW was "…really immersive…" and another said it was "… very interactive…" One person claimed to have felt "… immersed and curious [and] wanted to see what was all in there…" and another claimed to have "… lost the [task] objective … because I was interested in seeing other things…"

The perceived presence scores of the group were also high overall, indicating a generally strong sense of presence in the GigaPan VWs. This sense of presence was evidenced by a score range of 46 – 93 on a 100-point total score available with $M = 76.89$, $Md = 80$, and $SD = 12.20$. The score distribution presented 71% > 70; 46% > 80; and only 29% ≤ 70. Again, confirmation was found in the subjects' interview comments. One subject said the VW was "… almost like you're sitting there looking at it in real life…" Another stated "… I felt like I was close to being there…" A third claimed "… it was almost like you were amongst them" and a fourth said "… it was like you were there." Several subjects linked media properties of the VW to presence by stating it "… felt natural to move around like that…" and "... I could get so close on things…" and "…I liked how I could zoom in really close…" One subject related the interactivity of the VW technology to sense of presence by stating "… when I started really interacting with the picture … it became more realistic … like I was walking in the city." The subjects also indicated a preference for the larger computer screen size and a link with their sense of presence. They claimed the smaller screen "… made it harder for me…" and was "… just not as realistic as the bigger screen." They stated "… the bigger screen was more interactive…," the wider screen … is … a little bit more immersive" and "… you were able to get a lot more into it."

Based on these findings and the demographic data presented in Table 1, the subject group for this study could be generally described as somewhat male-biased, fairly evenly split between younger and older groups, relatively young overall, generally fairly willing to be immersed in media and experiences, and feeling presence in the VW they experienced in this study. They also came from a technical college environment and were computer literate. Findings and conclusions from the study should be interpreted within the framework and external validity limitations of these participant characteristics.

The two statistical tests of the relationship between gender and immersibility each presented the same finding and thus were mutually supportive. A 2-way chi-square test of the distribution of genders across 3 immersion groups (indeterminate, high immersion, and low immersion) yielded a non-significant result ($\chi^2 = 2.34$; $df = 2$; $p = .31$), indicating no significant difference between the obtained distribution and that expected by chance. A *t*-test on all 35 immersion scores was conducted as a follow-up and yielded supportive results. The gender groups had small differences in favor of females ($M = 48.62$; SD = 7.65) over males ($M = 46.50$; $SD = 9.25$). However, the *t*-test found this difference in immersion scores between the genders ($t = .69$; $df = 33$; $p = .49$) was not significant. The chi-square and *t*-test both presented no significant relationship between gender and immersibility.

The two tests of the relationship between age and immersibility were also mutually supportive but of a different finding. A Pearson correlation between age in years and immersion scores yielded a significant relationship ($r = -.34$; $df = 33$; $p = .05$), with the negative correlation indicating that younger ages were significantly associated with higher immersion scores. The coefficient of determination for this test ($r^2 = .12$) indicated that approximately 12% of the common variance of age and immersibility was accounted for by this relationship. The follow-up was a *t*-test on the immersion scores of the younger and older groups only with the indeterminate group eliminated. This test also revealed a significant difference ($t = 2.124$; $df = 29$; $p = .04$) in favor of the younger group ($M = 50.0$; $SD = 7.24$) over the older group ($M = 43.85$; $SD = 8.88$). Both the correlation and the *t*-test indicated a statistically significant relationship between age and immersibility, with the younger group presenting higher immersion scores and less variability.

The relationship between gender and presence scores for the VWs was examined with a *t*-test. There were small observed differences in the perceived presence scores in favor of females (M = 80.38; SD = 12.26) over males (M = 74.82; SD = 11.95). However, the *t*-test presented a non-significant result (t = 1.32; df = 33; p = .20), indicating these differences were not significant, and there was no relationship between gender and presence.

The relationship between age and presence was tested with a correlation followed by a *t*-test. The Pearson correlation between age in years and presence score was non-significant, in fact nearly non-existent (r = -.056; df = 33; p = .75). The *t*-test was also non-significant for the younger/older groups with the indeterminate age group eliminated (t = .48; df =29; p = .63). These results were appropriate for the very small observed presence score differences for the younger (M = 77.89*;* SD = 9.58) and older (M = 79.85; SD = 12.97) groups and presented no significant relationship between age and perceived presence in the VWs.

The relationship between the two scores for immersibility and presence was tested with a Pearson correlation. This correlation was non-significant (r = .18; df = *33;* p = .29). The coefficient of determination (r^2 = .03) indicated that only 3% of the common variance of immersibility and perceived presence was accounted for, showing no appreciable relationship between these variables.

6. Discussion and Conclusions

Several conclusions and recommendations relevant to designers and users of VWs for orientation learning arise from the findings of this study. The conclusions relate to three broad areas of VW usage: (1) the relevance of age and gender as user variables in VWs, (2) the role of technology in effective VW usage, and (3) the nature and measurement of immersion and presence. The conclusions present the introduction of a new line of analysis in VW research, i.e., psychological trait/state theory. They also suggest new approaches to age, gender, immersion, and presence in VW research and theory and for further research and practice as VWs continue their progress towards mainstream technologies for learning.

Conclusion 1. Age may be more relevant than gender to immersibility in VWs

While many studies have examined age and gender differences in *performance* in VWs, this study approached these frequently used variables from the new perspective of their relationships to immersibility as a *trait characteristic*. The result is a potential new line of analysis in VW research. This study found a relatively high degree of willingness in its participants to immerse in media and experiences and a statistically significant difference in immersion scores between younger and older participants, but not between males and females. The instrument used here to assess immersibility treated it as a psychological *trait* rather than a temporary state characteristic, thus encouraging interpretation of the variable as a stable individual difference. If this is the case, the study offers the fresh possibility that immersibility as a psychological trait is not different across genders but is different across ages, with younger people more susceptible than older. The reason for, and extent of, these trait patterns is not addressed by this study and encourage further research. One intriguing possibility is that given the often-reported male advantage in VW performance, this stems from something other than gender-related higher levels of immersibility. An age-based possibility is related to technology and the familiarity and comfort of younger people with newer digital experiences. It may be, despite the irony that much digital interaction occurs as text display on four-inch screens, that younger users who were raised with digital environments make little distinction between digital and "real" experiences, considering the digital world a "normal" place in which to immerse, learn, and communicate. This view of technology has been enhanced by increasing fidelity and technical quality of virtual experiences. The reality phenomenon and its effects on relationships between trait immersibility and performance in VWs, which was not addressed in this study, presents potential for further research and for theory development in individual differences in virtual technology and experiences.

Conclusion 2. Neither gender nor age may be related to perceived presence in VW

In contrast to immersibility, this study treated presence as a temporary psychological *state* rather than a stable trait characteristic. It presented a relatively high level among its participants of perceived presence in the specific VW experienced and no significant differences in presence scores across either age or gender. As with the immersibilty variable, a new line of inquiry emerges that addresses a different aspect of VW presence beyond effects on user performance levels. This finding has relevance to theory-building in the area of individual user differences in virtual environments. It may be that age and gender characteristics, which have figured frequently in research on technology, are less important than other variables in creating VW presence. Perhaps presence is generally attainable and is more a function of *effective use of virtual technology* than of the gender or age of its users. This possibility would have important implications for the expectations of virtual designers and instructors using VR technology to reach users across ages and genders and suggests it might be appropriate to leave behind emphasis on gender and age in further investigation of presence in VWs to seek more relevant characteristics of users and technologies. This leads directly to the study's third conclusion.

Conclusion 3. Technology characteristics and applications appear to be relevant in VW immersion and presence

Available literature and theory regarding immersion and presence in VWs positions various characteristics and features of VR technology as important, even definitional, in creating the "reality" in VWs. This study supports this proposition and thus contributes to theory development in VR research. It suggests that a new systematic line of research should be developed to investigate the effects of various technology characteristics on the perceived sense of immersion and presence in VWs. This research might include such VW features as graphic fidelity, accuracy of environment functionality representation, use of color, speed of computer response, screen size, interface complexity, instructions and guides for users, and general versus technical content as introduced by Ausburn, Ausburn, and Kroutter (2013, 2017). It might also include both better use of older VR technologies and incorporation of emerging technologies such as low-cost cardboard viewers with smartphone apps and new inexpensive "mixed reality" headsets. Such research, properly conceptualized and conducted, may lead to development of a set of design and implementation guidelines that could guide designers and practitioners to effective and consistent use of virtual technologies as mainstream tools to enhance learning and other types of experiences for users with a wide range of characteristics.

Conclusion 4. Distinctions between trait/state nature and measurement of immersion and presence appear to be relevant in virtual environments

Arguably the most unique and most important outcome of this study is its introduction into VW research of the concept of trait *vs*. state psychological characteristics. The study found no relationship between participants' trait level of immersibility and their reported state sense of presence in the VW they experienced. This finding initially appears to contradict the finding of Witmer and Singer (1998) of a small but statistically significant correlation ($r = .24$; $p = .01$) between individual tendencies on the ITQ and scores on the PQ, and their conclusion that immersibility predicted perceived presence. However, a deeper examination of the Witmer and Singer data shows its weakness. Despite its statistical significance, a correlation of .24 has a coefficient of determination (r^2) of only .06, meaning that only 6% of the variance between immersibility and presence scores is common. It can be argued that this is trivial and that the better interpretation is that the two variables have no relationship of practical importance. This interpretation brings the Witmer and Singer finding and the finding of the present study of no significant relationship and $r^2 = .03$ into good alignment.

A finding of no practical relationship between trait immersibility and perceived state presence in a VW raises important new questions that contribute to the theory base of VW research by introducing trait/state psychology into the discussion of immersion and presence. The study has new implications for both the nature and the measurement of these two critical constructs and for their relationship to the technology of VWs.

The first emergent issue is the psychological nature of immersion and presence in VWs. The new question arises: Should these be treated as traits or states in VW research? Literature cited in this paper discusses immersion and presence as being: (1) psychological *states* that are individual in nature, (2) closely interrelated in the creation of the "reality" in VWs, and (3) functions of the specific VW experienced. However, some commonly-used immersion and presence assessment instruments appear to contradict this conceptualization in some studies, including the one reported here. In this study, the presence instrument was clearly *state*-oriented, focusing on users' individual reactions to particular technical and affective aspects of the specific VW they encountered. However, the immersion instrument treated "immersibility" as a *trait,* a generalized measure of "immersive tendencies" across numerous media and experiences. This raises the second immersion/presence issue emerging from this study: appropriate conceptualization and measurement of these two critical variables. Perhaps a state-oriented conceptualization and measurement of immersion in this study might have resulted in a finding of the expected and literature-supported relationship with presence. Perhaps different instrumentation is needed to properly examine immersion and presence in VWs that assesses *state immersion* rather than *trait immersibility*. While trait immersibility may exist, it may be less relevant to developing presence in VWs than is state immersion. It may be that this re-conceptualization and re-instrumentation would reveal the hypothesized relationship between immersion and presence. A starting place for this new line of VW research might be a deep analysis of the individual items on the existing presence instrument, which may already contain sufficient assessment of state immersion to enable empirical establishment of the immersion/presence relationship. It may also be that the key to unlocking the power of both immersion and presence states lies less in user traits than within the effective use of appropriate virtual technology.

7. Final Thoughts

This study examined empirical relationships among users' age and gender, immersibility, and presence in an on-screen first-person virtual world. It presented findings and conclusions that suggest new lines of research and open the door to further analysis of gender and age in VW immersion and presence; relationships between immersion and presence; technology characteristics as critical variables in VW effectiveness; and state vs. trait immersion conceptualization and measurement in VW research. Further research, empirical support, and theory development are recommended to assist the advancement of virtual technologies as effective and reliable tools in the mainstream of teaching, learning, and entertainment in the digital age.

References

Allport, G. W., & Odbert, H. S. (1936). Trait names: A psycho-lexical study. *Psychological Monographs, 47*(1), Whole No. 211.

Ausburn, F. B., & Ausburn, L. J. (2008). Send students anywhere without leaving the classroom: Virtual reality in CTE. *Techniques: Connecting Education and Careers, 83*(7), 43-46.

Ausburn, L. J. (2012). Learner characteristics and performance in a first-person online desktop virtual environment. *International Journal of Online Pedagogy and Course Design, 2*(2), 11-24.

Ausburn, L. J., & Ausburn, F. B. (2010, December). *"Spheres of reality": A conceptualization of desktop virtual environments in career and technical education and an implementation training model*. Paper presented at National Career & Technical Education Research and Professional Development Conference, Las Vegas, NV.

Ausburn, L. J., & Ausburn, F. B. (2014). Technical perspectives on theory in screen-based virtual reality environments: Leading from the future in VHRD. *Advances in Developing Human Resources, 4*, 1-20.

Ausburn, L. J., Ausburn, F .B., Dotterer, G., Washington, A., & Kroutter, P. (2013, December). *Simulation and virtual technologies for workforce learning: Successes from alternate realities.* Paper presented at National Career & Technical Education Research and Professional Development Conference, Las Vegas, NV.

Ausburn, L. J., Ausburn, F. B., & Kroutter P. J. (2013). Influences of gender and computer gaming experience in vocational/technical desktop virtual environments: A cross-case analysis study. *International Journal of Adult Vocational Education and Technology, 4*(4), 1-14. doi:10.4018/ijavet.2013100101

Ausburn, L. J., Ausburn, F. B., & Kroutter, P. J. (2017). Influence of gender and computer gaming experience in occupational desktop virtual environments: A cross-case analysis study. In V.C.X. Wang (Ed.), *Adult education and training in the digital age,* (Chapter 12, pp. 200-216). Hershey, PA: IGI Global Publishers. doi:10.4018/978-1-5225-0929-5.ch012

Ausburn, L. J., Martens, J., Dotterer, G., & Calhoun, P. (2009). Avatars, pedagogical agents, and virtual environments: Social learning systems online. *i-Manager's Journal of Educational Technology, 5*(4), 1-13.

Ausburn, L. J, Martens, J., Washington, A., Steele, D., & Washburn, E. (2009). A cross-case analysis of gender issues in desktop virtual reality learning environments. *Journal of Industrial Teacher Education, 46*(3), 51-89.

Baukal, C., Ausburn, F., & Ausburn, L. (2013). A proposed multimedia cone of abstraction: Updating a classic instructional design theory. *Journal of Educational Technology*, *9*(4), 15-24.

Baukal, C. E., Martens, J., Ausburn, L. J., Dionne, R., & Agnew, I. (2017). Electro-dermal activity (EDA) and sensors: An emerging technology for educational research. *i-Manager's Journal of Educational Technology, 14* (2), 20-33.

Baukal, C., Olson, B., & Ernst, R. (2019, June). *Virtual reality for continuing professional development*. Paper presented at the American Society for Engineering Education, Tampa, FL.

Blade, R. A., & Padgett, M. L. (2002). Virtual environments standards and terminology. In K. M. Stanney (Ed.), *Handbook of virtual environments: Design, implementation, and applications* (pp. 15-27). Mahwah, NJ: Lawrence Erlbaum.

Bouchard, S., Robillard, G., St-Jacques, J., Dumoulin, S., Patry, M.J., & Renaud, P. (2004). Reliability and validity of a single-item measure of presence in VR. In *Proceedings of the 3rd IEEE International Workshop on Haptic, Audio and Visual Environments and Their Applications* (pp. 59-61). Piscataway, NJ: IEEE. doi:10.1109/HAVE.2004.1391882

Chapman, D. D., & Stone, S. J. (2010). Measurement of outcomes in virtual environments. *Advances in Developing Human Resources, 12*, 665-680. doi:10.1177/1523422310394792.

Chen, C. J., Toh, S. C., & Wan, M. F. (2004). The theoretical framework for designing desktop virtual reality-based learning environments. *Journal of Interactive Learning Research, 15*(2), 147-167.

Chertoff, D. B., Goldiez, B., & LaViola, J. J. (2010). Virtual Experience Test: A virtual environment evaluation questionnaire. In B. Lok, G. Klinker, & R. Natatsu (Eds.), *Proceedings of IEEE Virtual Reality 2010* (pp. 103-110). Los Alamitos, CA: IEEE Computer Society. doi:10.1109/VR2010.5444804

Clemente, M., Rodriguez, A., Rey, B., Rodriguez, A., Banos, R., Botella, C., Alcaniz, M., & Avila, C. (2011). Analyzing the level of presence while navigating in a virtual environment during an fMRI Scan. In V. Roto, A. Vermeeren, K. Vaananen, & L. Law (Eds.), *User experience evaluation – Which method to choose* (pp. 475-478). New York, NY: Springer-Verlag.

Coelho, C., Tichon, J., Hine, T. J., Wallis, G., & Riva, G. (2006). Media presence and inner presence: The sense of presence in virtual technologies. In G. Riva, M.T. Anguera, B.K. Wiederhold, & F. Mantovani (Eds.), *From communication to presence: Cognition, emotions and culture towards the ultimate communicative experience* (pp. 25-45). Amsterdam, Netherlands: IOS Press.

Dale, E. (1969). *Audiovisual methods in teaching.* New York, NY: Dryden Press.

Darken, R. P., Allard, T., & Achille, L. B. (1998). Spatial orientation and wayfinding in large-scale virtual environments: An introduction. *Presence: Teleoperators and Virtual Environments, 7*(2), 101-107. doi:10.1162/105474698565604

Di Blas, N., & Poggi, C. (2007). European virtual classrooms: Building effective "virtual" educational experiences. *Virtual Reality, 11,* 129-143.

Dotterer, G. P. (2011). *The effects of multiple-channel technologies and learning styles on proceduralized instruction in a virtual environment* (Unpublished doctoral dissertation). Oklahoma State University, Stillwater, OK.

Forgays, D., Forgays, D. K., & Spielberger, C. (1997). Factor structure of the state-trait anger expression inventory. *Journal of Personality Assessment, 69,* 497-507.

Gabriel, M. A., Weibe, S., & MacDonald, R. J. (2009). Net generation expectations for technology-mediated learning at the university level. In A. Mendez-Vilas, A.S. Martin, J.A.M. Gonzalez, & J.M. Gonzalez (Eds). *Research, reflections, and innovations in integrating ICT in education.* (pp. 996-1000). Badajoz, Spain: FORMATEX.

Gay, L. R. (1996). Educational research: Competencies for analysis and application (5th ed.). Englewood, NJ: Prentice Hall.

Gutierrez-Maldonado, J., & Alsina-Jurnet, I. (2010). Influence of personality and individual abilities in the sense of presence experienced in anxiety triggering virtual environments. *International Journal of Human-Computer Studies, 68*(10), 788-801.

Gutierrez-Maldonado, J., Alsina-Jurnet, I., & Rus-Calafell, M. (2009). Influence of personality and individual abilities on the sense of presence experienced in virtual environments. In L. Lo

Bello & G. Iannizzotto (Eds.), *Proceedings of 2nd International Conference on Human System Interaction.* Piscataway, NJ: IEEE. doi:10.1109/HSI.2009.509097120

Hamaker, E. L., Nesselroade, J. R., & Molenaar, P. C. M. (2007). The integrated trait-state model. *Journal of Research in Personality, 41,* 295-315.

Howe, N., & Strauss, W. (2000). *Millennials rising: The next great generation.* New York, NY: Vintage Books.

Hunt, E., & Waller, D. (1999). *Orientation and wayfinding: A review* (Unpublished manuscript, University of Washington). Retrieved from http://www.cs.umu.se/kurser/TDBD12/HT01/papers/hunt99orientation.pdf

Inoue, Y. (2007). Concepts, applications, and research of virtual reality learning environments. *International Journal of Social Sciences, 2*(1), 1-7.

International Society for Presence Research (2019). *About presence.* Retrieved from http://ispr.info

James, K. H., Humphrey, G. K., Vilis, T., Corrie, B., Baddour, R., & Goodale, M. A. (2002). "Active" and "passive" learning of three-dimensional object structure within an immersive virtual reality environment. *Behavior Research Methods, Instruments, & Computers, 34*(3), 383-390. doi:10.3758/BF03195466

Kober, S. E., & Neuper, C. (2013). Personality and presence in virtual reality: Does their relationship depend on the used presence measure? *International Journal of Human-Computer Interaction, 29*(1), 13-25.

Kroutter, P. J. (2010). *The influence of field dependence/independence, gender, and experience on navigational behavior and configurational knowledge acquisition in a desktop virtual reality environment* (Unpublished doctoral dissertation). Oklahoma State University, Stillwater, OK.

Lessiter, J., Freeman J., Keogh, E., & Davidoff, J. (2001) A cross-media presence questionnaire: The ITC-Sense of Presence Inventory. *Presence: Teleoperators and Virtual Environments, 10*, 282–297. doi:10.1162/105474601300343612

Linn, M. C., & Peterson, A. C. (1985). Emergence and characterization of sex differences in spatial ability: A meta-analysis. *Child Development, 56,* 1479-1498.

Lombard, M., & Ditton, T. B. (1997). At the heart of it all: The concept of presence. *Journal of Computer-Mediated Communication, 3*(2). doi:10.1111/j.1083-6101.1997.tb00072.x

Lombard, M., Ditton, T. B., & Weinstein, L. (2009, November*). Measuring presence: The Temple presence inventory*. Paper presented at Presence 2009: 12th Annual International Workshop on Presence, Los Angeles, CA.

Martens, J. B. (2016). *Foraging for spatial information: Patterns of orientation learning using desktop virtual reality* (Unpublished doctoral dissertation). Oklahoma State University, Stillwater, OK.

Meehan, M., Razzaque, S., Insko, B., Whitton, M., & Brooks Jr., F. P. (2005). Review of four studies on the use of physiological reaction as a measure of presence in stressful virtual environments. *Applied Psychophysiology & Biofeedback, 30*(3), 239-258. doi:10.1007/s10484005-6381-3

Mikropoulos, T. A. (2006). Presence: A unique characteristic in educational virtual environments. *Virtual Reality, 10,* 197-206.

Moore, G. (1999). *Crossing the chasm* (Revised Edition). New York, NY: Harper Business.

Panahi-Shahri, M., Fathi-Ashtiani, A., & Azad-Fallah, P. (2009). Reliability and validity of Igroup Presence Questionnaire (IPQ). *Journal of Behavioral Sciences, 3*(1), 27-34.

Prensky, M. (2001). *Digital natives, digital immigrants: A new way to look at ourselves and our kids.* Retrieved from http://www.marc.prensky.clm/writing/

Project Tomorrow (2010). *Unleashing the future: Educators "speak up" about the use of emerging technologies for learning. Speak UP 2009 national findings.* Retrieved from http://www.tomorrow.org

Rogers, E. (1962). *Diffusion of innovations.* New York, NY: Free Press of Glencoe.

Rogers, E. (2003). *Diffusion of innovations.* (Fifth Edition). New York, NY: Free Press.

Ross, S.P., Skelton, R.W., & Mueller, S.C. (2006). Gender differences in spatial navigation in virtual spaces: Implications when using virtual environments in instruction and assessment. *Virtual Reality.* doi:101007/s10055-006-0041-7

Rosakranse, C., & Oh, S. Y. (2014). Measuring presence: The use trends of five canonical presence questionnaires from 1998-2012. In *Proceedings of the International Society on Presence Research 2014.* ISPR.

Ruddle, R. A., Payne, S. J., Jones, D. M. (1999). The effects of maps on navigation and search strategies in very-large-scale virtual environments. *Journal of Experimental Psychology - Applied, 5*(1), 54-75. doi:10.1037/1076-898X.5.1.54

Sandstrom, N. J., Kaufman, J., & Huettel, S. A. (1998). Males and females use different distal cues in a virtual environment navigation task. *Cognitive Brain Research, 6*(4), 351-360.

Schubert, T., Friedmann, F., & Regenbrecht, H. (2001). The experience of presence: Factor analytic insights. *Presence: Teleoperators and Virtual Environments*, *10*(3), 266-281.

Schwind, V., Knierim, P., Haas, N., & Henze, N. (2019, May*). Using presence questionnaires in virtual reality*. Paper presented at CHI (Computer-Human Interaction) 2019, Conference of the Association for Computing Machinery on Human Factors in Computing Systems, Glasgow, Scotland, UK.

Sheridan, T. B. (2016). Recollections on presence beginnings, and some challenges for augmented and virtual reality. *Presence: Teleoperators and Virtual Environments, 25*(1), 75-77.

Slater, M. (2004). How colorful was your day? Why questionnaires cannot assess presence in virtual environments. *Presence: Teleoperators and Virtual Environments, 13*(4), 484-493.

Slater, M., Linakis, V., Usoh, M., & Cooper, R. (1996, July). *Immersion, presence, and performance in virtual environments: An experiment using tri-dimensional chess.* Paper presented at 1996 Virtual Reality and Software and Technology Conference, Hong Kong.

Slater, M., & Wilbur, S. (1997). A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. *Presence: Teleoperators and Virtual Environments, 6*(6), 603-616.

Slater, M., Usoh, M., & Steed, A. (1994). Depth of presence in virtual environments. *Presence: Teleoperators and Virtual Environments*, *3*, 130-144.

Snelling, J. (2016). Virtual reality in K-12 education: How helpful is it? *Converge.* Retrieved from http://www.centerdigitaled.com/k-12/Virtual-Reality-in-K-12-Education-Is-It-Really-Helpful.html

Space, S. (2001). Gender gap shows cyberspace bias. *TRN: Latest technology research news.* Retrieved from http://www.trnmag.com/Stories/070401/gender_gap_shows_cyberspace_bias_070401.html

Spagnolli, A., Lombard, M., & Gamberini, L. (2010). Editorial. *Virtual Reality, 14*(1), 1-2.

Spielberger, C. D., & Sydeman, S. J. (1994). Sate-trait anxiety inventory and state-trait anger expression inventory. In M. E. Maruish (Ed.), *The use of psychological testing for treatment planning and outcome assessment* (pp. 292-321). New York, NY: Lawrence Erlbaum Associates.

Terlecki, M., & Newcomb, N. (2005). How important is the digital divide? The relationship of computer and videogame usage to gender differences in mental rotation ability. *Sex Roles, 53,* 433-441.

University of Washington. (2001). *Lost in virtual space: Gender differences are magnified.* Retrieved from http://www.washington.edu/newsroom/news/2001archive/06-01archive/k061301.html

Van Baren, J., & Ijsselsteijn, W. (2004*). Measuring presence: A guide to current measurement aproaches.* (OmniPress Project Report IST-2001-39237, pp. 1-80).

Van Deursen, A. J. A. M., Helsper, E. J., & Eynon, R. (2016). Development and validation of the Internet Skills Scale (ISS). *Information, Communication & Society, 19*(6), 804-823. doi:10.1080/1369118X.2015.1078834

Voyer, D., Voyer, S., & Bryden, M.P. (1995). Magnitude of sex differences in spatial ability: A meta-analysis and consideration of critical variables. *Psychological Bulletin, 117,* 250-270.

Waller, D. (2000). Individual differences in spatial learning from computer-simulated environments. *Journal of Experimental Psychology: Applied, 6*(4), 307-321.

Waller, D., Hunt, E., & Knapp, D. (1998). The transfer of spatial knowledge in virtual environment training. *Presence: Teleoperators and Virtual Environments, 7,* 129-143. doi:10.1162/105474698565631

Waller, D. K., Knapp, D., & Hunt, E. (1999). *Spatial representations of virtual mazes: The role of virtual fidelity and individual differences.* Retrieved from http://depts.washington.edu/huntlab/vr/pubs/mazes5.pdf

Washington, A. L. (2013). *Effects of desktop virtual environment training on state anxiety and vocational identity among persons with disabilities during job placement/job readiness activities* (Unpublished doctoral dissertation). Oklahoma State University, Stillwater, OK.

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