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HOW DO PERCEPTIONS OF VIRTUAL WORLDS LEAD TO ENHANCED LEARNING? AN EMPIRICAL INVESTIGATION

Completed Research Paper

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Abstract

Virtual worlds are receiving increasing attention as a promising technology to engage students in learning. However, the use of these technologies for educational purposes is currently hampered by a lack of understanding of how better learning can be achieved in such environments. Thus motivated, this study uses the lenses of flow and social translucence of technology theories to model the individual and technology-related perceptions that influence learning outcomes. Our results show that better learning is associated with learners' flow experience variables (concentration and enjoyment) as well as a sense of presence (social and telepresence) in the virtual world. Further, the flow experience variables are influenced by the social and telepresence felt by participants, directly or indirectly via social norms. Unique to the virtual world environment, the three-dimensional realism experienced by learners is important in shaping their presence perceptions. The findings provide implications for both research and practice in this area.

Keywords: Virtual worlds, learning outcome, flow, social presence, telepresence, social norms, three-dimensional realism

Introduction

Education has become an important area of application for emerging virtual world technologies such as Second Life[1]. Virtual worlds provide three-dimensional (3D) simulated spaces in which educators can engage students for learning activities, including lectures, discussions, case studies, projects, and labs. These technologies differ from traditional courseware systems such as Blackboard or WebCT in that they afford a 3D graphical environment, allow the use of avatars by participants to represent themselves, make distributed participants feel as if they are together in a class, and facilitate social interaction among the participants in a common virtual space (Berge 2008; Dickey 2005; Eschenbrenner et al. 2008). As noted by Rebecca Nesson, who employed Second Life in her teaching of law at Harvard University, "Second Life gives us the capability to really have a classroom experience with the students…", and "changes the way the classroom conversation proceeds because you have a sense of all of these people being there participating in one way or another...." (Lamb 2006). In addition to Harvard University, over 200 other educational institutions worldwide including Leicester University and Universität Hamburg as well as companies such as IBM and Sun (Berge 2008) are actively exploring the use of virtual worlds for their learning programs. Among them, many have invested in creating their own virtual campuses within Second Life complete with buildings and facilities for conducting classes.

Despite the growing interest in the use of virtual worlds for educational purposes (Schultze et al. 2008), little is known of how enhanced learning outcomes can be obtained in these environments (Berge 2008). Existing research on virtual worlds has focused on their applications for leisure, entertainment, and economic purposes (e.g., Davis et al. 2009; Hemp 2006; Ives and Piccoli 2007; Mennecke et al. 2008), with less attention on their use in the learning context (Chen et al. 2008). Among the limited studies on the use of virtual worlds for learning, research has investigated issues related to the use of these environments for distance learning through a case study (Dickey 2005). Eschenbrenner et al. (2008) provided a conceptual description of the benefits and challenges of these environments for education. Chen et al. (2008) developed a model that focuses on the adoption intention of these technologies by university students. Thus, there is a paucity of theoretically-driven empirical research that focuses on how enhanced learning outcomes can be obtained in such environments.

The lack of understanding of how better learning outcomes can be achieved in such environments may hinder educators from making serious use of virtual world technologies in their learning programs (Berge 2008; Graetz 2006). Due to such uncertainty, faculty members may even feel reluctant to invest their time and effort to utilize the virtual world learning environments initiated by their organizations, causing such environments to be just a curiosity factor. University administrators also want to understand how these technologies can be effectively leveraged considering the costs of setting up such environments[2].

To address this gap, this study builds on flow theory (Csikszentmihalyi 1975, 1990) and social translucence of technology theory (Erickson and Kellogg 2000) to develop a research model of individual and technology-related perceptions leading to better learning in a virtual world environment. Specifically, our aim is to address the following research question, "how do perceptions of the virtual world environment lead to students' enhanced learning in the environment?" The model was tested through a survey of undergraduate students at a large public university conducting course activities in Second Life. The findings have implications for research and practice in the area of e-learning, particularly in how educators can exploit innovative technologies such as virtual worlds.

Theoretical Foundation

We develop our research model based on two theoretical lenses i.e., flow theory and social translucence of technology theory. Specifically, flow theory explicates the psychological state (flow) of individuals that is conducive to their learning. Social translucence of technology theory is employed to shed light on the perceptible characteristics of virtual world environments and how such perceptions may lead to the desirable psychological state that promotes better learning.

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[1] http://secondlifegrid.net/slfe/education-use-virtual-world

[2] Having a virtual campus in Second Life requires purchasing a piece of land that costs USD 700 for educational institutions and paying a monthly maintenance fee of approximately USD150 (http://secondlife.com/land/privatepricing.php). The cost of developing the 3D buildings and facilities varies according to the complexity of these virtual creations. For example, Case Western Reserve University spent approximately USD 30,000 to build its virtual campus (Wongtangswad 2008).

Flow Theory

Flow theory (Csikszentmihalyi 1975, 1990) was developed to describe a psychological state (flow) that occurs when a person is so absorbed in an activity that s/he excels in performance without consciously being aware of his/her every movement (Finneran and Zhang 2005). Such an experience is often recognized by people when engaging in activities such as chess playing, rock climbing, dancing, music composing, and even web surfing. Borrowed from psychology, flow theory has been applied to various IS research areas including online consumer behavior (Novak et al. 2000, 2003; Koufaris 2002), human-computer interaction (Finneran and Zhang 2003), communication (Trevino and Webster 1992), and e-learning (Choi et al. 2007). Ghani (1995) found that flow positively affected learning and creativity in a computer course. Choi et al (2007) found that flow led to higher technical self-efficacy in a web-based e-learning program for ERP training. The above studies indicate the applicability of flow theory to explain learning.

Prior research has identified three dimensions of flow i.e., concentration, enjoyment, and control (Trevino and Webster 1992; Webster et al. 1993). In other words, when individuals are in a flow state while performing an activity, they tend to become engrossed in the activity such that irrelevant thoughts are screened out (i.e., *concentration*). The individuals are also likely to experience a gratifying state of mind (i.e., *enjoyment*); and perceive themselves to be unrestricted in their actions (i.e., *control*). Further, these flow constructs may in turn be influenced by *skills*, *challenge*, and *involvement* (Ghani 1995; Koufaris 2002). It is posited that for individuals to experience flow, they need to have the relevant skills, feel positively challenged in performing the focal activity, and perceive that the object of activity is relevant and important to them i.e., involvement (Csikszentmihalyi 1975; Koufaris 2002).

Additionally, research investigating flow in computer-mediated environments has also noted the importance of users' perceptions of the environment in influencing their flow experience (Hoffman and Novak 1996). When performing an activity in a computer-mediated environment, individuals may feel a sense of *presence* that can be understood as "a perceptual illusion of nonmediation" that occurs "when a person fails to perceive or acknowledge the existence of a medium in his/her communication environment and responds as he/she would if the medium were not there." (Lombard and Ditton 1997) The presence felt by individuals in such environments and its effect on their flow experience is consistent with literature from environmental psychology, which states that the stimuli in the environment would influence an individual's psychological state (Mehrabian and Russel 1974). In the computer-mediated communication literature, the presence felt by individuals who engage in an activity through a medium is explained by the social translucence of technology theory, which we will discuss next.

Social Translucence of Technology Theory

The social translucence of technology theory (Erickson and Kellogg 2000) proposes that communication technologies can bridge users in different locations by enabling them to "carry on coherent discussions; to observe and imitate others' actions" (p.62). Thus by using a socially translucent technology such as virtual worlds, users are able to make information and activity visible, are aware of the interaction status of other participants, and are thus accountable to each other due to the resulting mutual expectation (Erickson and Kellogg 2000). Such social implications of technologies are consistent with prior media research which posits that the effects of a medium are principally caused by the degree of presence afforded by the medium (Ou et al. 2008; Short et al. 1976). Studies in this direction have identified two prominent types of presence i.e., social presence and telepresence (Ijsselsteijn et al. 2000; Ou et al. 2008; Qiu and Benbasat 2005). *Social presence* refers to the feeling of being close with others (Biocca et al. 2003; Short et al. 1976), and a communication medium with high social presence is one that is perceived by users as personal, sociable, friendly, warm, or intimate (Short et al. 1976). *Telepresence* refers to the illusion or sensation of being physically present in the environment simulated by the medium (Steuer 1992). Of the two types of presence, social presence has to do with individual's interaction with others through the medium; whereas telepresence is concerned with the sense of presence resulted from individual's interaction with the medium. Thus, social presence and telepresence cover both the social and technical aspects of presence experienced by users of a medium.

Additionally, the social translucence of technology theory emphasizes the ability of communication technologies to enable users "to engage in peer pressure; to create, notice, and conform to social conventions" (Erickson and Kellogg 2000, p.62). This highlights the importance of *social norms*, or the pressure from surrounding people (Mathieson 1991), in affecting one's behavior in an interactive environment (Erickson and Kellogg 2000). Since the theory suggests that social cues can be portrayed by a medium through mimicking the physical environment

(Erickson and Kellogg 2000), we also consider the realism of the 3D environment of virtual worlds, henceforth called *3D realism*, as a variable that can influence users' perceptions of presence in the medium.

To summarize, we will employ the constructs of *social presence*, *telepresence*, *social norms*, and *3D realism* that are derived from the social translucence of technology theory. We expect these constructs to constitute the pertinent perceptions towards virtual worlds as an interactive environment whereby individuals are engaged in classroom discussion with one another. As our central interest is about how such perceptions may lead to enhanced learning, we will focus on the flow constructs that are likely to be influenced by social presence, telepresence, social norms, and/or 3D realism. Specifically, the following flow constructs are included in the research model i.e., *concentration* and *enjoyment* (see Figure 1). The other flow construct i.e., control, is not considered as this construct is related to individuals' own perceived ability to operate the virtual world application (Koufaris 2002), and is less affected by the identified perceptions about the virtual world environment. Nevertheless, in testing our research model, we will control for the effects of this construct (control) as well as the antecedents of the flow constructs mentioned in the flow theory i.e., involvement, skills of using the virtual world application, and challenge perceived in the learning activity.

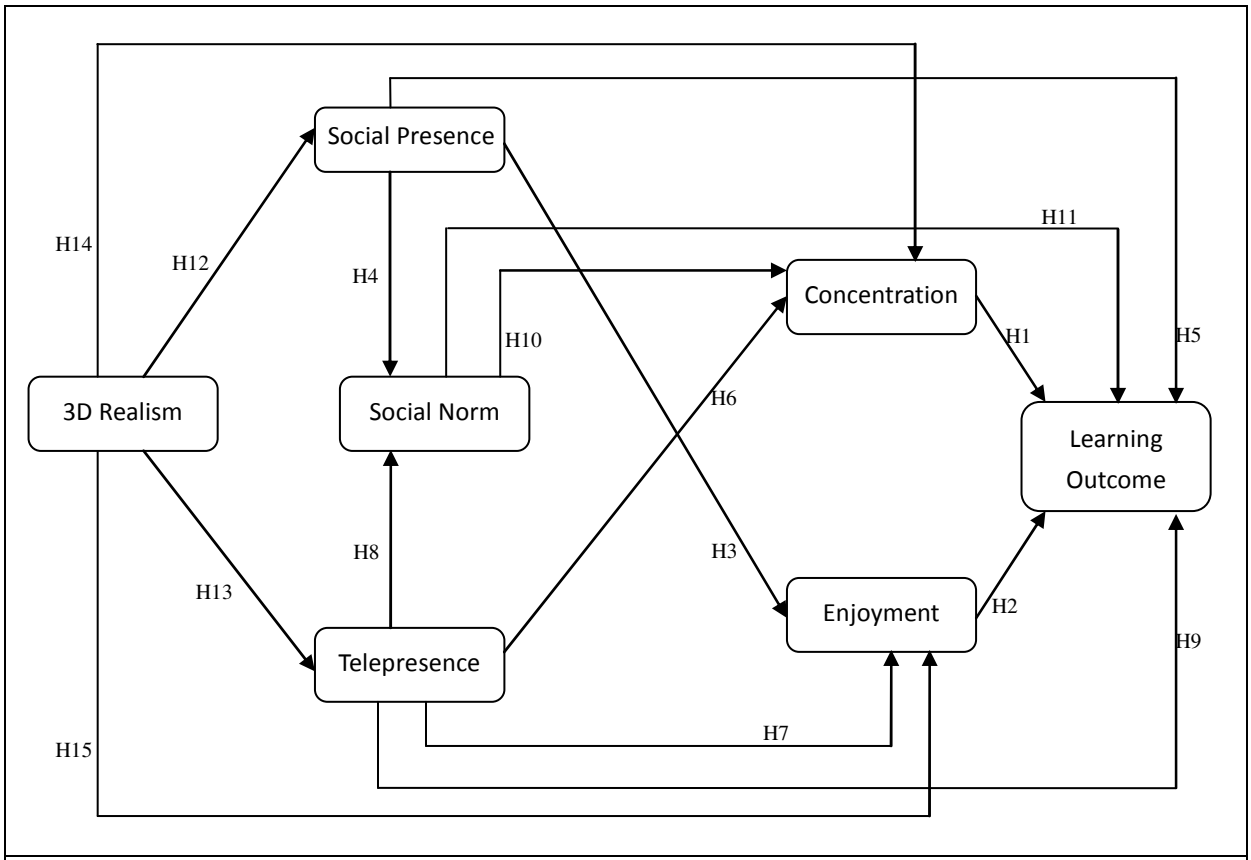

Figure 1. Research Model

Hypotheses Development

The dependent variable in our model is learning outcome, which is defined as the learning perceived by students in terms of a better understanding and knowledge of the important course concepts (Alavi 1994). In addition to perceived learning, we also assess the learning outcome through the objective examination score of the students in the course. Below we will begin with a discussion of the effects of flow-related constructs on the learning outcome.

Flow experience constructs

For individuals to experience flow, they must concentrate on their activity (Koufaris 2002). This implies that individual's attention is focused on the activity s/he is performing, such that irrelevant thoughts are filtered out (Csikszentmihalyi 1975). Previous research has shown that concentration is beneficial to individual's learning outcome (Ghani 1995). With attention focused on the learning activity, individuals tend to absorb and understand the knowledge being transferred better. Accordingly, we hypothesize that:

H1: Concentration has a positive effect on learning outcome

Another common measure of flow is enjoyment, which is similar to the emotional response of pleasure from environmental psychology (Koufaris 2002). When individuals find engaging in a learning activity enjoyable, they tend to strive for learning for its sake, which may result in better learning (Csikszentmihalyi 1975; Ghani 1995). This is because individuals who find the learning enjoyable tend to be more interested and persistent in learning complex concepts and in seeking deeper understanding of the knowledge (Csikszentmihalyi 1975; Deci and Ryan 1980; Ghani 1995). Therefore, we hypothesize:

H2: Enjoyment has a positive effect on learning outcome

Social Presence

Social presence refers to the feeling of being close with others (Biocca et al. 2003; Short et al. 1976) and has been highlighted as a desirable characteristic of a communication medium in the social presence (Short et al. 1976) and media richness theories (Daft and Lengel 1986). A virtual environment with high social presence means that it is rich in social cues (Qiu and Benbasat 2005). Hence, a higher level of social presence will make learners feel that their fellow participants are psychologically closer in the environment and that interpersonal communications are warmer and friendlier. This may in turn lead to a higher level of enjoyment in participating in the learning activity (Zhu et al. 2006):

H3: Social presence has a positive effect on enjoyment

We do not expect a relationship between social presence and concentration. A sense of high social presence, wherein an environment is perceived to be warm and friendly, may not help an individual to focus his/her attention on performing an activity in the environment. However, we do expect the perception of social presence to influence social norms, or individual's perception of the pressure from surrounding people to perform a behavior (Mathieson 1991). The rationale is that the social cues and the feeling of being psychologically closer to others are likely to make an individual feel a greater pressure to conform to the expectations from surrounding people (Erickson and Kellogg 2000). This is consistent with the reduced social cues theory that provides an inverted logic to understand this relationship i.e., a medium with low social cues may lead to reduced impact of social norms (Kiesler et al. 1984).

H4: Social presence has a positive effect on social norms

Social presence is also expected to have an effect on the learning outcome. A computer-mediated environment that is perceived as warm and friendly is likely to provide a conducive atmosphere for learning to take place. With the feeling that their peers are psychologically close in the environment, students may feel more motivated to engage in intellectual discourses with other participants (Eschenbrenner et al. 2008; Short et al. 1976), which may in turn serve to encourage learning. This is consistent with previous research that identified a positive relationship between social presence and better learning outcome (Richardson and Swan 2003). Therefore, we hypothesize:

H5: Social presence has a positive effect on learning outcome

Telepresence

Telepresence refers to the illusion or sensation of being physically present in the environment simulated by the medium (Steuer 1992). It has been tied to the "transportation" aspect of presence (Lombard and Ditton 1997), whereby a communication medium creates illusions to make users feel as though they are being transported to another place (Qiu and Benbasat 2005). The concept of telepresence has been widely adopted in studies involving virtual reality technologies such as 3D online gaming and 3D lifelike replications of physical shopping environments (Jeandrain 2001; Lombard and Ditton 1997). When individuals perceive high telepresence in a virtual

environment, they experience an illusion of being transported to another place, and hence become less disturbed by their immediate physical environment. Therefore, a sense of high telepresence in the virtual world environment is likely to channel individuals' attention on the activity conducted within the environment:

H6: Telepresence has a positive effect on concentration

Additionally, the illusion of being in another place detached from the users' immediate physical environment may provide a sense of fascination to the users. Previous research has identified a sense of fascination or discovery as among the sources of enjoyment (Packer 2006). Thus, a high level of telepresence may lead the users to perceive a more enjoyable experience of learning in the virtual environment (Mulbach et al. 1995). This leads to the following hypothesis:

H7: Telepresence has a positive effect on enjoyment

In an interactive environment with high telepresence, participants also get the impression of sharing space with other participants i.e., other participants are also being transported to the same simulated place (Lombard and Ditton 1997; Muhlbach et al. 1995). Such a mental state of being "there" with other participants heightens the awareness of how others behave (Majchrzak et al. 2005) within the same virtual environment, thus making the influence from surrounding people more salient to an individual. This leads to the following hypothesis:

H8: Telepresence has a positive effect on social norms

Telepresence is also expected to lead to a better learning outcome. The rationale is that when individuals feel a higher sense of being at the place where the learning activity is held, they will be more mentally ready and prepared to perform learning (Dede 1996; Lombard and Ditton 1997). Thus by "transporting" learners to a context that reinforces and motivates learning (Dede 1996), a higher sense of telepresence should positively affect their learning outcome:

H9: Telepresence has a positive effect on learning outcome

Social Norms

Social norms represent a motivational state that is activated by the influence from surrounding people (Mathieson 1991). Previous studies have shown that social norms may induce an individual to engage in a behavior (e.g., Mathieson 1991). When individuals feel more motivated to partake in the learning activity to conform to the pressure from others, they become more engaged in the activity, and focus more attention on performing it. Therefore, we hypothesize:

H10: Social norms have a positive effect on concentration.

However, we do not expect social norms to influence enjoyment. Social norms operate by imposing external pressure on an individual to engage in an activity for the sake of conforming to others' expectations. Therefore, social norms are not likely to impact individual's enjoyment that is more intrinsic in nature (Deci and Ryan 1980).

Social norms, however, should have a significant effect on the learning outcome. When individuals are motivated to engage in the learning activity in order to conform to the expectations of surrounding people, they may become more committed towards discussion with others and collaborative learning. This may serve to stimulate deeper learning and better outcomes:

H11: Social norms have a positive effect on learning outcome

3D Realism

Research suggests that the appearance of 3D avatars and environments that mimic the physical world can cause a realistic experience (Dickey 2005). The realism afforded immerses users in the simulated environment, which may affect their sense of presence (Biocca et al. 2003; Blascovich 2002; Lombard and Ditton 1997). Specifically, the use of 3D avatars that represent individuals while participating in the learning activity and interacting with others may increase the level of social cues in the environment (Blascovich et al., 2002), which then enhances the social presence perception:

H12: 3D realism has a positive effect on social presence

The immersion of individuals in the 3D simulated environment provides them with a realistic experience that is close to the actual context (Dickey 2005). The realistic, constant stimuli that individuals receive may in turn create an illusion or sensation of "being there" (Biocca et al. 2003, p. 8) in the simulated environment. Therefore,

H13: 3D realism has a positive effect on telepresence

3D realism may also influence concentration. When the virtual environment impresses on a learner that s/he is in the actual physical classroom, the learner may focus more attention on performing the learning activity that is naturally associated with the setting (Dede 1996). In contrast, a virtual environment that appears foreign to a learner may distract his/her attention from the learning activity. Therefore:

H14: 3D realism has a positive effect on concentration

The realistic 3D simulated environment may provide users with a sense of marvel at the sophistication and capability of the technology. This may lead an individual to perceive the use of the virtual world as fun and exciting, which is associated with enjoyment (Ghani et al. 1991; Koufaris 2002). Hence:

H15: 3D realism has a positive effect on enjoyment

Research Method

Survey methodology was employed to test the research model. The survey items for the constructs were generated based on a review of the relevant literatures. Where previously tested measures were not available, items were developed based on the conceptualization of the constructs. The validity of the items was assessed in two ways. First, the items were examined by three experts who are familiar with the topic for face validity. Second, sorting procedures were performed with four judges to assess their conceptual validity (Moore and Benbasat 1991). All items were measured using a 7-point Likert scale (1 = strongly disagree; 7 = strongly agree), unless otherwise indicated. Table 1 summarizes the survey items.

Data was collected from 236 undergraduate students who took an introductory computing course in a public university in Asia. The students were divided into 12 groups each consisting of an average of 20 students, and engaged in classroom discussion sessions conducted in Second Life. Second Life is currently the most popular virtual world platform and has been widely adopted by educational institutions around the world (Berge 2008). A virtual campus was built by the university in Second Life that includes replicas of teaching facilities such as classrooms where the sessions were conducted. The virtual classroom resembles a physical classroom and is equipped with tables, chairs, and a whiteboard.

During the virtual classroom discussion sessions conducted, the students went into Second Life instead of the usual physical classroom using a nickname for their avatar. They were allowed to do so from any location they considered convenient e.g., their hostel room, canteen, or library. These sessions were carefully designed to engage students in discussion of questions covering the major topics in the course. During the sessions the instructor served as a facilitator to describe the concepts and allow students to discuss their answers to questions, similar to a traditional classroom setting.

Prior to the classroom discussion sessions, the personnel in charge of promoting the university's Second Life initiative provided a demonstration session of the virtual campus to the students. Slides containing information to orient students to the Second Life virtual campus were provided. Students were also asked to familiarize themselves with the use of Second Life one month before the classroom discussion sessions by visiting the virtual campus. To ensure that the sessions were uninterrupted, the virtual classroom was protected with security access mechanisms that required the students to perform a series of registration procedures inside Second Life. These procedures necessitated the students to master the basic skills of using the Second Life application including navigation, communication, and teleporting (instantaneous transportation from one place to another). To help students who might face problem to complete the procedures, the instructors, teaching assistants, and university support staff would go inside the virtual campus from time to time to interact with the students and provide the assistance needed. The survey was administered shortly after the classroom discussion sessions were conducted.

Participation in the survey was voluntary and extra course credits were awarded upon the completion of the survey. Altogether 233 responses were collected, yielding a response rate of 98.7%. 16 of the responses were subsequently dropped due to missing data, resulting in a sample size of 217 for our data analysis. Table 2 shows the demographic

information of the sample, and Table 3 provides the information about the number of students in each group administrated, number of students who responded, and number of usable responses obtained from each group.

Table 1. Construct Operationalization	
Measures	**References**
Learning Outcome (LEARN) "The Second Life class session …" + examination grade	
1. Increased my understanding about the important course topics	Hiltz (1988)
2. Helped me learn about the critical issues related to the course topics	
3. Helped me identify the important subject matters related to the course topics	
Concentration (CONCT) "During the Second Life class session …"	
1. I was absorbed intensely in the classroom discussion activity	Ghani et al. (1991); Koufaris (2002)
2. My attention was focused on the classroom discussion activity	
3. I concentrated fully on the classroom discussion activity	
4. I was deeply engrossed in the classroom discussion activity	
Enjoyment (ENJOY) "I found my experience of participating in the Second Life class session …"	
1. Interesting; 2. Enjoyable; 3. Fun; 4. Exciting	Ghani et al. (1991); Koufaris (2002)
Perceived Control (CONTR) "During my participation in the Second Life class session, I felt…" (on a scale of 1-7)	
1. Confused (reversed); 2. Calm; 3. In Control; 4. Frustrated (reversed)	Ghani et al. (1991); Koufaris (2002)
Involvement (INVLN) "We would like to know how interested you are in the topics of discussion in the Second Life class session. Please use the series of descriptive words listed below to indicate your level of interest:" (on a scale of 1-7)	
1. Unimportant – Important; 2. Irrelevant – Relevant; 3. Boring – Interesting; 4. Unappealing – Appealing	McQuarrie and Munson (1992)
Skills (SKILL)	
1. I am very skilled at using Second Life	Koufaris (2002); Novak et al. (1998)
2. I know how to perform what I want with Second Life	
3. I know more about using Second Life than most users	
Challenge (CHALG) "Participating in the Second Life class discussion…"	
1. Challenged me to perform to the best of my ability	Koufaris (2002); Novak et al. (1998)
2. Provided a good test of my ability	
3. Stretched my capabilities to the limits	
Social Presence (SOCPR) "In the Second Life environment, my interaction with others was:" (on a scale of 1 -7)	
1. Impersonal --- Personal; 2. Unsociable --- Sociable; 3. Unfriendly --- Friendly; 4. Of cold feeling --- Of warm feeling; 5. Distant --- Close; 6. Dehumanizing --- Humanizing; 7. Unemotional --- Emotional	Short et al. (1976)
Telepresence (TELPR) "With regard to your experience of being in the Second Life environment..."	
1. When I left Second Life, I felt like I came back to the "real world" after a journey	Kim and Biocca (1997)
2. Second Life created a new world for me, and the world suddenly disappeared when I left Second Life	
3. While I was in Second Life, my body was in the physical room, but my mind was inside the world created by Second Life	
4. The world generated by Second Life seemed to me "somewhere I visited" rather than only "something I saw"	
Social Norm (SOCNR) "During the Second Life class session..."	
1. When I saw my classmates were expressing their ideas, I felt I should participate, too	Taylor and Todd (1995)
2. It was important for me to join the discussion when my classmates were sharing their ideas	
3. With the presence of the instructor, I felt that I should participate	
4. It is important for me to join the discussion when the instructor was present	
3D Realism (REASM) "During the Second Life class session, the 3D classroom environment …"	
1. Constantly reminded me that I was in a real classroom like those classrooms where I usually attend classes	Self-developed
2. Frequently impressed on me that I was in a real classroom like ones where I have been attending classes	
3. Gave me a strong feeling that I was in a real classroom similar to the actual classrooms where I attend classes	

Table 2. Demographic Information of Respondents (N = 217)		
Gender	Male	82 (37.8%)
	Female	135 (62.2%)
Age (years old)	< 20	25 (11.5%)
	20-22	152 (70.1%)
	23-25	37 (17.0%)
	> 25	3 (1.4%)
Year of study	1	65 (29.9%)
	2	67 (30.9%)
	3	69 (31.8%)
	4	16 (7.4%)
Experience of using SL prior to the course (months)	Never	155 (71.4%)
	< 1	43 (19.8%)
	1-2	11 (5.1%)
	> 3	8 (3.7%)
Experience of using the Internet (years)	Mean = 8.97 Standard deviation = 2.00	

Table 3. Information about the Groups Administered			
Group	Total No.	No. Responded (%)	No. of Usable Responses (%)
1	19	19 (100%)	18 (94.74%)
2	21	21 (100%)	18 (85.71%)
3	19	19 (100%)	19 (100%)
4	22	21 (95.46%)	19 (86.36%)
5	22	22 (100%)	22 (100%)
6	18	18 (100%)	17 (94.44%)
7	18	16 (88.89%)	16 (88.89%)
8	21	20 (95.24%)	18 (85.71%)
9	17	17 (100%)	15 (88.24%)
10	21	21 (100%)	20 (95.24%)
11	18	18 (100%)	18 (100%)
12	20	19 (95%)	17 (85%)

Data Analysis and Results

The measurement model was first tested followed by the structural model. To validate the measurement model, reliability and validity of the constructs were assessed. As shown in Table 4, all constructs exhibited acceptable levels of reliability i.e., Cronbach's Alpha (CA) > 0.7 and Composite Reliability (CR) > 0.7 (Fornell and Larcker 1981; Nunnally 1994). The constructs also demonstrated acceptable levels of convergent validity and discriminant validity i.e., in the inter-construct correlations shown in Table 4, diagonal elements (square root of AVE) exceeded other entries in the same row or column (Fornell and Larcker 1981). The results of factor analysis (see Table 5) also indicate that the factor loadings of all items on their intended constructs are above the minimum recommended level of 0.5, and each item loads higher on its intended construct than on any other construct. As some constructs have relatively high correlation with each other e.g., 0.60 between enjoyment and control, we also performed a multicollinearity test. The results show that the highest VIF value (2.17) is well below 5 (Hair et al. 1998), so multicollinearity is unlikely to be a concern.

Table 4. Descriptive Statistics, Reliability, and Correlation Matrix

(STDEV refers to standard deviation, CA refers to Cronbach's Alpha, and CR refers to Composite Reliability)

(LEARN=Learning outcome; CONCT=Concentration; ENJOY=Enjoyment; CONTR=Control; INVLN=Involvement; SKILL=Skills; CHALG=Challenge; SOCPR=Social presence; TELPR=Telepresence; SOCNR=Social norms; REASM=3D realism)

Construct	Mean (STDEV)	CA	CR	1	2	3	4	5	6	7	8	9	10	11
LEARN	4.91 (1.06)	0.95	0.97	**0.95**										
CONCT	5.34 (1.22)	0.93	0.95	0.55	**0.91**									
ENJOY	5.37 (1.28)	0.93	0.95	0.53	0.57	**0.92**								
CONTR	4.17 (1.20)	0.82	0.88	0.45	0.47	0.60	**0.81**							
INVLN	4.96 (1.03)	0.87	0.91	0.47	0.47	0.43	0.39	**0.85**						
SKILL	3.83 (1.32)	0.89	0.93	0.33	0.35	0.34	0.48	0.30	**0.91**					
CHALG	5.00 (1.08)	0.94	0.97	0.49	0.44	0.48	0.39	0.52	0.34	**0.95**				
SOCPR	4.44 (1.06)	0.90	0.93	0.40	0.34	0.33	0.45	0.39	0.46	0.35	**0.80**			
TELPR	4.10 (1.27)	0.87	0.91	0.44	0.39	0.45	0.34	0.35	0.30	0.34	0.26	**0.84**		
SOCNR	5.32 (0.86)	0.82	0.88	0.52	0.48	0.43	0.36	0.42	0.24	0.48	0.25	0.32	**0.81**	
REASM	4.90 (1.06)	0.92	0.95	0.28	0.31	0.42	0.25	0.29	0.20	0.36	0.21	0.53	0.32	**0.93**

With the measurement model established, the structural model was tested using PLS Graph v3.00. Table 6 summarizes the results of hypotheses testing. The results indicate that for *learning outcome* (R^2 = 0.49), concentration, enjoyment, social presence, telepresence, and social norms turn out to be its significant predictors (i.e., H1, H2, H5, H9, and H11 are supported). For *concentration* (R^2 = 0.39), telepresence and social norms are its significant predictors (i.e., H6, and H10 are supported) but not 3D realism (i.e., H14 is not supported). Among the hypothesized antecedents of *enjoyment* (R^2 = 0.38), telepresence and 3D realism are significant (i.e., H7, and H15 are supported) but not social presence (i.e., H3 is not supported). For the hypothesized effect of social presence and telepresence on *social norms (*R^2 = 0.13), both are found to be significant (i.e., H4 and H8 are supported respectively). For both *social presence* (R^2 = 0.04) and *telepresence* (R^2 = 0.28), 3D realism turns out to have a significant effect (i.e., H12 and H13 are supported respectively). The results are robust after controlling for the constructs control, involvement, skills, and challenge as previously mentioned. We also tested for the effect of gender, prior knowledge, previous performance, experience of using Second Life, age, year of study, and Internet experience, and none of these variables was found to be significant.

Table 5. Results of Factor Analysis

	Component										
	1	2	3	4	5	6	7	8	9	10	11
LEARN1	0.15	0.26	0.17	0.14	0.20	0.19	0.09	0.09	0.15	0.79	0.13
LEARN2	0.20	0.21	0.18	0.17	0.17	0.23	0.20	0.03	0.13	0.80	0.06
LEARN3	0.20	0.19	0.16	0.17	0.17	0.21	0.20	0.07	0.12	0.80	0.06
CONCT1	0.06	0.72	0.19	0.15	0.12	0.17	0.23	0.17	0.22	0.18	0.04
CONCT2	0.16	0.76	0.21	0.14	0.17	0.26	0.05	-0.01	0.04	0.21	0.10
CONCT3	0.11	0.85	0.18	0.18	0.06	0.15	0.09	0.06	0.11	0.10	0.10
CONCT4	0.18	0.82	0.22	0.16	0.11	0.06	0.06	0.12	0.10	0.14	0.15
ENJOY1	0.09	0.26	0.74	0.11	0.17	0.11	0.15	0.09	0.19	0.25	0.02
ENJOY2	0.10	0.19	0.76	0.12	0.11	0.14	0.17	0.15	0.30	0.16	0.09
ENJOY3	0.13	0.27	0.78	0.11	0.15	0.11	0.10	0.22	0.16	0.03	0.17
ENJOY4	0.12	0.15	0.78	0.13	0.20	0.16	0.16	0.15	0.21	0.13	0.08
CONTR1	0.13	0.10	0.09	0.04	0.08	0.13	-0.08	0.10	0.77	0.14	0.19
CONTR 2	0.27	0.11	0.32	0.12	-0.01	0.04	0.29	-0.05	0.56	0.11	0.17
CONTR 3	0.24	0.21	0.26	0.13	0.16	0.07	0.20	0.09	0.61	-0.08	0.21
CONTR 4	0.12	0.09	0.30	0.10	0.09	0.11	0.01	0.02	0.73	0.16	0.04
INVLN1	0.15	0.13	0.05	0.74	0.08	0.15	0.18	0.12	0.22	0.15	0.12
INVLN 2	0.14	0.23	-0.06	0.72	0.11	0.05	0.32	0.00	-0.01	0.06	0.06
INVLN3	0.09	0.09	0.25	0.80	0.12	0.12	0.10	0.07	0.09	0.09	0.02
INVLN4	0.21	0.17	0.16	0.78	0.11	0.15	0.06	0.12	0.03	0.12	0.07
SKILL1	0.24	0.13	0.09	0.13	0.06	0.07	0.08	0.03	0.17	0.14	0.85
SKILL2	0.29	0.07	0.10	0.08	0.14	0.07	0.14	-0.01	0.21	0.07	0.79
SKILL 3	0.18	0.12	0.08	0.02	0.09	0.01	0.06	0.11	0.07	-0.01	0.85
CHALG1	0.16	0.13	0.17	0.22	0.10	0.21	0.84	0.09	0.02	0.15	0.08
CHALG 2	0.10	0.14	0.18	0.21	0.12	0.25	0.83	0.09	0.09	0.15	0.08
CHALG 3	0.23	0.09	0.17	0.19	0.09	0.11	0.78	0.24	0.06	0.14	0.14
SOCPR1	0.68	0.06	0.13	-0.04	0.07	0.05	0.09	0.05	-0.09	0.11	0.07
SOCPR2	0.79	0.11	0.15	0.21	0.04	0.08	-0.01	0.00	0.05	0.12	0.15
SOCPR3	0.75	0.06	0.18	0.27	-0.02	0.11	-0.01	0.03	0.08	0.16	0.09
SOCPR4	0.79	0.01	0.10	0.20	0.06	0.08	0.07	0.00	0.10	0.14	0.15
SOCPR5	0.82	0.05	0.04	0.09	0.07	-0.04	0.12	0.03	0.24	0.05	0.11
SOCPR6	0.78	0.08	-0.02	0.07	0.04	0.11	0.10	0.04	0.19	0.01	0.07
SOCPR7	0.70	0.16	-0.15	-0.11	0.14	-0.04	0.14	0.18	0.08	-0.08	0.15
TELPR1	0.09	0.10	0.14	0.11	0.78	0.17	0.10	0.13	-0.11	0.07	0.08
TELPR2	0.05	0.06	0.09	0.04	0.81	0.09	0.16	0.20	0.12	0.08	0.03
TELPR3	0.12	0.15	0.08	0.07	0.73	0.07	0.05	0.18	0.27	0.12	0.10
TELPR4	0.08	0.09	0.19	0.17	0.76	0.01	-0.05	0.25	0.05	0.18	0.11
SOCNR1	-0.05	0.28	0.04	0.15	0.12	0.68	0.20	0.00	0.11	0.15	0.07
SOCNR2	0.04	0.28	0.03	0.13	0.09	0.74	0.24	-0.06	0.12	0.13	0.10
SOCNR3	0.21	0.04	0.15	0.06	0.15	0.78	0.06	0.06	-0.03	0.08	-0.03
SOCNR4	0.08	0.02	0.20	0.14	-0.02	0.72	0.06	0.20	0.18	0.18	0.05
REASM1	0.05	0.11	0.16	0.06	0.15	0.08	0.08	0.88	0.02	0.06	0.02
REASM2	0.12	0.10	0.14	0.03	0.33	0.02	0.17	0.81	0.05	0.06	0.03
REASM3	0.06	0.04	0.12	0.16	0.26	0.08	0.08	0.86	0.07	0.01	0.09
Eigenvalue	14.75	3.66	2.81	2.31	1.79	1.72	1.65	1.52	1.30	1.12	1.07
Variance explained (%)	34.29	8.50	6.53	5.37	4.16	3.99	3.84	3.53	3.03	2.61	2.49
Cumulative variance (%)	34.29	42.79	49.32	54.69	58.85	62.84	66.68	70.21	73.25	75.85	78.34

Table 6. Results of Hypotheses Testing

(*p<0.05, **p<0.01, ***p<0.001)

Hypothesis	Coefficient	Outcome	Hypothesis	Coefficient	Outcome
H1: CONCT → LEARN	**0.20****	**Supported**	H9: TELPR → LEARN	**0.15***	**Supported**
H2: ENJOY → LEARN	**0.14***	**Supported**	H10: SOCNR → CONCT	**0.26*****	**Supported**
H3: SOCPR → ENJOY	0.07	Not supported	H11: SOCNR → LEARN	**0.26*****	**Supported**
H4: SOCPR → SOCNR	**0.18****	**Supported**	H12: REASM → SOCPR	**0.21****	**Supported**
H5: SOCPR → LEARN	**0.16***	**Supported**	H13: REASM → TELPR	**0.53*****	**Supported**
H6: TELPR → CONCT	**0.13***	**Supported**	H14: REASM → CONCT	0.05	Not supported
H7: TELPR → ENJOY	**0.19****	**Supported**	H15: REASM → ENJOY	**0.16***	**Supported**
H8: TELPR → SOCNR	**0.27*****	**Supported**			

We performed additional tests on the mediating role of factors between 3D realism and social norms; and between 3D realism and learning outcome. An alternative model that captures the direct links from 3D realism to social norms and to learning outcome was analyzed. The results show that the two direct links are insignificant, which implies that the effect of 3D realism on social norms is fully mediated by social presence and telepresence, whereas its effect on learning outcome is also fully mediated by enjoyment, social presence, and telepresence.

Furthermore, we also tested for common method bias which may be a concern in this study since we measured the dependent variable together with the independent variables in a single survey (Harrison et al. 1996). Based on the Harman's one-factor test, the threat of common method bias is high if a single factor can account for a majority of the covariance (more than 50%) in the independent and dependent variables (Harman 1967; Mattila and Enz 2002). In our case, the largest factor accounts for 34.29%. Also we followed Podsakoff et al. (2003) to further assess the possibility of this threat. The procedure involves the inclusion of a common method latent variable, which is an unmeasured latent variable containing all the measures employed as indicators. The inclusion of this additional latent variable resulted in an increase of about 1% in R^2 for the model, which is well below the level (16-42%) observed by William et al. (1989). Hence, common method variance is unlikely to be a threat to our results.

To further ensure that our focal dependent variable i.e., learning outcome perceived by students, is a reliable measure, we tested its effect on the final examination score. The results show that learning outcome has a significant effect on the examination score (b=0.19, p<0.01) after controlling for gender, prior knowledge, previous performance, age, and year of study (R^2 = 0.18). It is thus reasonable to assume that students who perceived better learning outcome indeed tended to learn more in the Second Life sessions based on their better performance in the examination. The results are summarized in Figure 2.

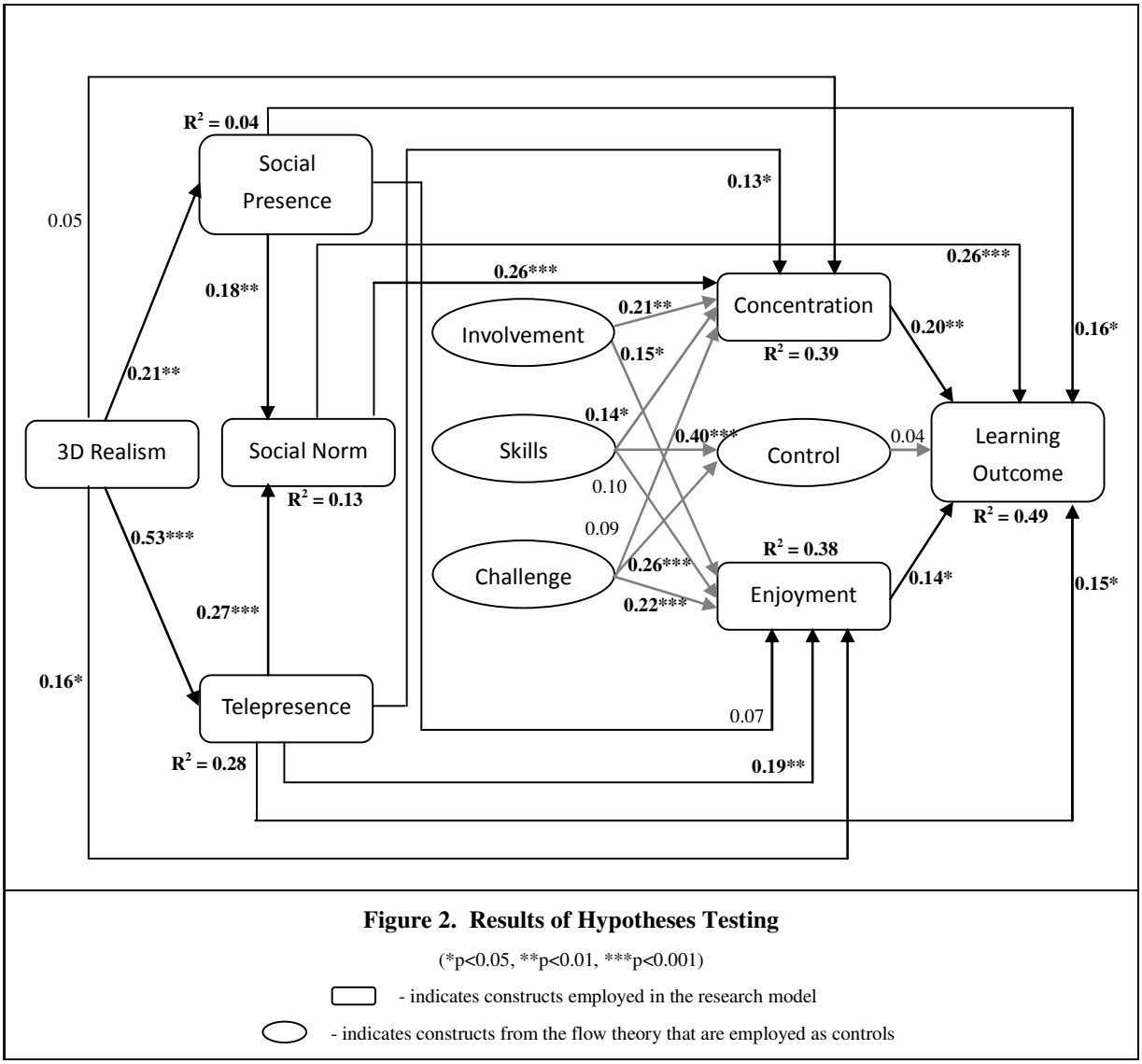

Figure 2. Results of Hypotheses Testing

(*p<0.05, **p<0.01, ***p<0.001)

- indicates constructs employed in the research model

- indicates constructs from the flow theory that are employed as controls

Discussion and Implications

This study aims to explain how perceptions of a virtual world environment lead to students' enhanced learning in the environment. Flow experience variables (concentration and enjoyment) are hypothesized to influence the learning outcome, which are in turn considered to be determined by the sense of presence (social presence and telepresence), 3D realism, and social norms in the environment. The results indicate that 13 out of 15 hypotheses in the model are supported and the model offers explanatory power for the dependent variable (learning outcome) as well as intermediate variables (flow experience constructs, social norms, and telepresence).

For the hypotheses related to individuals' perceptions about the virtual world environment, the results show that the effect of social presence on enjoyment is not significant. It could be that the students, who are mostly youngsters in their early 20s, have had high exposure to technologies with high social presence e.g., messaging tools with videoconferencing facilities, and hence do not feel that such characteristic of the technology is fascinating. The realism of the 3D environment perceived by the students also does not directly affect their concentration. The effect of 3D realism on the concentration of students appears to be fully mediated by the telepresence of the environment. Overall the results provide several important implications for both research and practice as we will discuss below.

Theoretical Implications

This study integrates the flow theory and social translucence of technology theory to investigate how enhanced learning outcomes can be attained in virtual worlds. It attempts to address the lack of theoretically-driven empirical research in this area by systematically examining how perceptible characteristics of a virtual world environment may influence individual's flow experience grounded in a coherent theoretical framework. The social translucence of technology theory is used to identify individuals' perceptions of virtual worlds that determine their flow experience. Specifically, perceived 3D realism, social presence, and telepresence are shown to be important antecedents of flow variables in such interactive 3D environments.

While previous research has applied flow theory to examine technology-mediated learning (e.g., Choi et al 2007), our study extends this approach to investigate learning in a virtual world environment. The results provide support for the use of the theory in this context i.e., individuals who perceive high levels of concentration and enjoyment in such environments tend to learn better. Based on the social translucence of technology theory, our study also highlights the need to consider social norms in an interactive virtual environment. The influence of social norms on learning in such environments has largely been overlooked in previous literature (e.g., Chen et al. 2008; Dickey 2005; Eschenbrenner et al. 2008).

While our research underscores the value of integrating the flow theory and social translucence of technology theory to investigate learning in a virtual world environment, such an approach may also be useful in other contexts such as online consumer behavior and gaming. Also, our study extends previous literature that highlights the importance of 3D realism (Dede 1996; Dickey 2005) by conceptualizing and operationalizing this construct. The measures developed can be employed in future research investigating the use of virtual worlds for diverse purposes such as commerce and leisure.

Last, the study shows the inter-relationships between core flow constructs i.e., concentration and enjoyment, and the perceptions of the virtual world environment (presence and realism) and social norms. The validation of the nomological network of these constructs is a useful contribution towards future research that makes use of them.

Practical Implications

Our study provides educators who are interested to employ virtual worlds in their programs an understanding of how enhanced learning outcomes can be obtained in such environments. Specifically, it identifies the factors and their inter-relationships to be considered when using virtual world technology for educational purposes. These factors include individual's perceptions about the virtual world environment (i.e., 3D realism, social presence, telepresence), their psychological state while performing learning activity in the environment (i.e., concentration, enjoyment), as well the influence from surrounding people (i.e., social norm).

Educators who decide to employ virtual worlds are faced with the choice of making the virtual environment reflective of the physical environment or creating a novel environment that differs from it (Eschenbrenner et al. 2008). Our findings suggest that for participation in classroom discussion, 3D realism is important in determining the social presence and telepresence felt by the participants in the virtual environment. Additionally, 3D realism also improves enjoyment that leads to better learning and indirectly heightens social norms. Collectively, these findings suggest that a realistic classroom experience is valued by the learners. Hence, course designers must be cautious when varying the learning environment created with the virtual world technology.

As social presence and telepresence are both found to be important for learner's flow experience and social norms, an implication for the educators is to improve the level of social cues in the virtual world environment. To do so one may refer to the work of Qiu and Benbasat (2005). For instance, the instructors may make use of their 3D avatars to perform appropriate gestures e.g., clapping to appreciate a good contribution made by a participant. The student participants can also be encouraged to do the same so as to make the sense of presence in the environment more salient.

Limitations and Future Research

The findings from our study need to be interpreted in light of its limitations. First, most of the participants in the virtual world sessions in our study were from a similar cultural background i.e., Asian cultures including Chinese. Previous studies have shown that culture could play a part in influencing learning behavior (Jaju et al. 2002). Future

research may thus investigate whether the findings are applicable to other cultural settings, or in settings that involve participants from diverse cultural backgrounds. Second, future research may employ other measures of learning outcome such as learning time and knowledge retention (Alavi and Leidner 2001; Wisher et al. 2001). Nonetheless, the learning outcome employed in this study was a reliable predictor of students' learning performance in terms of their examination score. Third, while our research improves the understanding of how enhanced learning outcomes can be obtained in virtual world environments, it does not provide information on how this technology compares with other technologies. Future research may conduct systematic comparisons of the virtual world technology with other learning technologies to assess the advantages and disadvantages of each. Last, our study has focused on individuals' perceptions of the virtual worlds and their flow experience to keep the scope of our study manageable. Future research may delve into the learning processes based on the theories such as those proposed by Argyris and Schön (1974) and Kolb (1984) in investigating virtual worlds for educational purposes. For instance, Kolb (1984) proposes four stages of learning cycle i.e., concrete experience, reflection on that experience, application of known theories to interpret the experience, and construction of ways to modify the next occurrence of concrete experience. Based on this knowledge researchers may carefully design the virtual world environment to aid the learning processes e.g., by building simulated mechanical objects to facilitate the learning of physics through the cycle. The objective is to obtain a more comprehensive understanding about the educational potential of the virtual world technology and how such technology can be more effectively employed to enhance learning outcomes.

Conclusion

The use of virtual world environments for educational purposes is currently hampered by a lack of understanding of how better learning can be achieved in such environments. Thus motivated, this study aims to explain how perceptions of the virtual world environment affect students' learning in this new context. The study uses the lenses of flow theory and social translucence of technology theory to model the individual and technology-related perceptions that influence learning outcomes in these environments. Overall the study contributes by explicating how perceptions of the virtual world environment affect learners' flow experience variables and their learning outcome. It also highlights the importance of social influence on learning in such interactive virtual environments and the need for learners to perceive a realistic classroom experience. By providing a better understanding of this emerging technology i.e., virtual worlds, for educational purposes, studies of this nature can help educators' effort in continuously employing innovative technologies to bring about better learning of students.

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