Why do some people enjoy their Second Life so much? The impact of an idealized identity on experiential learning within a social virtual world.

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ABSTRACT

This study examined how multi-user virtual worlds can enhance learning, by extending a prior VR-based model and then refining it to include two new constructs: *virtual identity*, and *social constructivism*. The fit of the two models was analyzed using structural equation modeling, and the results supported both the extension and the hypothesized refined model. Findings: VR features were found to indirectly impact on the learning outcomes, mediated by the perception of usability and the learning experience. The learning experience was measured by seven individual psychological factors: *presence, virtual identity, motivation, cognitive benefits, agentic learning, social constructivism,* and *reflective thinking*. These factors mediated the learning outcomes, measured by the perception of learning effectiveness and satisfaction, and may have a range of implications for the instructional design of learning activities using the virtual world. This research blends a technology acceptance model with the technology-mediated learning perspective to advance the development of a hybrid theoretical framework as a basis for future research into enhanced learning within a social virtual world.

Keywords: desktop virtual world; virtual learning environment; hybrid TAM/TML model; experiential learning; learning outcomes

1. Introduction

This study examined how multi-user virtual worlds can enhance learning, by extending a prior VR-based model and then refining it to include two new constructs: virtual identity, and the perception of an environment that supports the social construction of knowledge. This mixed-methods research found evidence to support the hypothesized model with seven psychological factors describing the learning process, and explored a range of implications for the instructional design of learning activities using the virtual world.

Over the past three decades two streams of theory have sought to explain the behavior of people using technology: the Technology Acceptance Model (TAM) tried to predict adoption, and the Technology-Mediated Learning (TML) proponents tried to predict learning outcomes. Both streams depended on the examination of user attitude towards technology, but the TAM view looked at attitude as a predictor of behavior, while the TML model looked at the internal learning experience as a predictor of attitude.

The Technology Acceptance Model was developed to assess the acceptance and intention to use information technology tools such as email in office workplace environments (Davis, 1989). Based on the cost-benefit paradigm from behavioral decision theory and Bandura's self-efficacy theory (1977), Davis developed survey items to assess the scale of *perceived usefulness*, a construct measuring people's belief that that using an IT tool will enhance their job performance, and the scale of *perceived ease of use*, which measures the belief that using an IT tool will be free of effort. Based on Duncan's (1975) pioneering work introducing Structural Equation Modeling (SEM), Davis (1993) developed structural equations to determine the factor loadings between the constructs of the TAM model. The TAM has become one of the most widely used and accepted theoretical frameworks for explaining the process of adopting emerging technologies in professional and educational contexts.

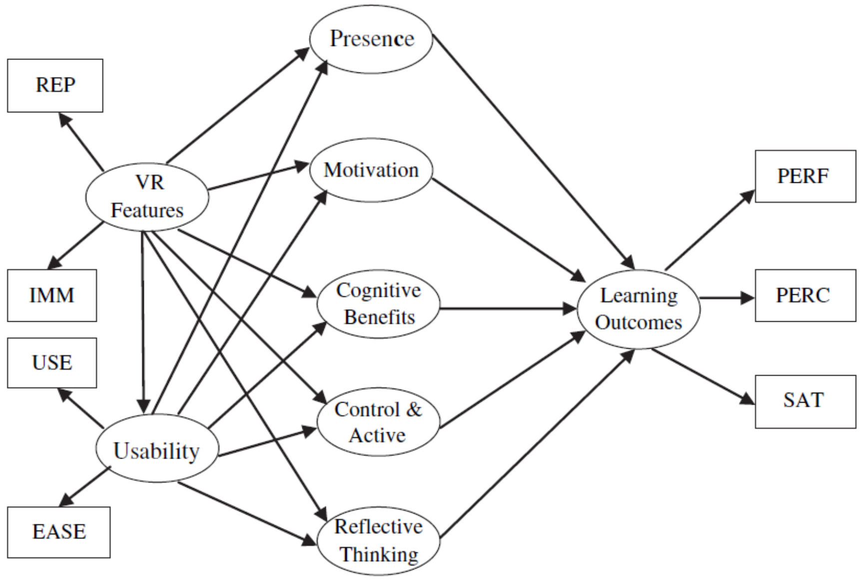
Salzman's model (1999) is commonly viewed as the starting point for the evolution of the input-process-output technology-mediated learning perspective. Sharda's model (2004) contributed an emphasis on 'immersive presence' as a key element, and Wan, Fang, and Neufeld (2007) added the instructional design perspective. Dalgarno & Lee's (2010) inclusion of a 'construction of identity' factor was key to the understanding of motivation and engagement in virtual worlds, where learners are embodied by highly customizable avatars. These studies iteratively developed the TML model to include an ever-increasing range of input factors and learning outcomes, but the psychological factors and activities in the learning process were rarely elaborated. In addition, these studies had no effective way to comprehensively test their proposed axiomatic theoretical frameworks against observed survey data.

2. Conceptual background

In 2008 Fetscherin & Latteman built upon the TAM model to investigate the behavioral intention to use the technology of Second Life, a multi-user virtual world environment quite new at that time. They included several psychological variables such as *attitude towards technology, subjective norms, performance expectancy,* and *anxiety*, as well as socio-demographic variables which moderate the perceived usefulness. In addition, they included a *community* variable to include measurement items examining the affordances of the social virtual world to support communication, collaboration, and cooperation. In order to test their research hypotheses, Fetscherin & Latteman (2008) performed a confirmatory factor analysis using structural equation modeling. Their results found that the *community* variable had the highest impact on perceived usefulness, so therefore the perceived functionalities of the virtual world to enable users to communicate, collaborate, and cooperate were the most important factors predicting user acceptance and adoption of virtual world technology (Fetscherin & Latteman, 2008).

2.1 The Lee (2010) model as a hybrid of both TAM and TML perspectives

In 2010 Lee, Wong, and Fung conducted a study to examine how desktop-based VR technology supports and enhances learning. The Lee *et al* (2010) study adopted a hybrid approach, blending elements of both TAM and TML models to create their conceptual model (see Figure 1). Like the Salzman (1999) input-process-output TML model, the Lee (2010) model stipulated that the features of the VR environment, such as representational fidelity and immediacy of control, moderate Usability. On the other hand, the Lee (2010) research model was clearly based upon the original TAM model (Davis, 1989), with the latent variable Usability (attitude towards using the technology) being measured by the observed variables of perceived usefulness (USE) and perceived ease of use (EASE). One possible weakness of the Lee (2010) model is that the researchers chose to represent EASE as having a direct influence on Usability, yet most TAM-based studies have found this correlation to be weak, or even not significant (Davis, 1993; Fetscherin & Latteman, 2008; Shen & Eder, 2009; Huang *et al*, 2016). In the original 1989 study proposing the TAM model, Davis reported that “results are consistent with an ease of use -> usefulness -> usage chain of causality” (Davis, 1989, p. 334).



Notes: REP = Presentational fidelity; IMM = Immediacy of control; USE = Perceived usefulness; EASE = Perceived ease of use; PERF = Performance achievement, PERC = Perceived learning Effectiveness; SAT = Satisfaction

Figure 1. The research model of the Lee *et al* (2010) study.

The Lee (2010) model elaborated on the learning process by specifying five variables which described the psychological aspects of the learning experience. These five psychological constructs mediated the learning outcomes, reflecting the technology-mediated learning (TML) approach of prior studies in the field. Like prior TAM-based studies, however, the Lee *et al* (2010) study used structural equation modeling analysis to test the fit of their research model to the observed survey data.

2.2 Descriptions of constructs in the Lee (2010) model

The evolution of the graphic capabilities of virtual world simulation illustrates a key feature of virtual reality (VR): *representational fidelity* (REP), which describes the degree of realism along three dimensions: rendered images and scenes, smooth motion of those images and scenes, and behavior of objects consistent with the physics of reality (Dalgarno, Hedberg & Harper, 2002). Compare the realism of the Habitat virtual world (1985) in Figure 2, to the Second Life virtual world (2014) in Figure 3.

Figure 2. *A typical scene from the Habitat virtual world (© LucasArts Entertainment Company, 1985)*

Figure 3. *A research meeting in the Second Life virtual world (Knutzen, 2014)*

As the graphical capabilities of the software and hardware grew, so did the ability of VR to more accurately represent the detail, movement, and behaviors we associate with the immersive panorama our senses and brains create to represent the physical world. Lee (2010) defined their construct of *immediacy of control* (IMM) as based on two abilities: to smoothly change their viewpoint as a simulation of movement through the world, and to observe, acquire, and control objects (Dalgarno *et al*, 2002).

The Lee (2010) model relied on the Davis (1989) TAM constructs of *perceived usefulness* (USE) and *perceived ease of use* (EASE) in order to measure the latent variable *Usability*. Perceived usefulness is based on the perception that technology is useful to support learning, and perceived ease of use is based on the perception that learning to use the technology is easy.

Salzman's model (1999) included 'immersive tendency' as a learner characteristic which impacts on learning outcomes. Slater (2003) delineated *immersion* as an objective feature of the virtual environment technology, and *presence* as a subjective user response which is context dependent. Effective immersion in a virtual experience requires the willing suspension of disbelief, which is dependent on the inclusion of sensory, actional, and symbolic factors in the instructional design (Dede, 2009). The Lee *et al* (2010) study defined their construct of immersive *presence* as based on the feeling of 'being there' in the virtual environment, a concept identified by Hedberg & Alexander in 1994 as a key element of a 'superior learning experience'.

The construct of motivation was measured by 15 survey items in the Lee *et al* (2010) study, and looked for intrinsic motivation factors such as enjoyment, competence, and fun. The construct of *cognitive benefits* was based on the Antonietti *et al* (2000) study and looked for the use of VR technology enhancing memorization, application, and comprehension. The Lee (2010) model defined the control and active learning construct as an element of the learning process characterized by user control over the pace, and a more responsive, active approach. Instructional design based on self-paced and self-guided learning activities would therefore maximize user agency.

Notably absent from both the Salzman (1999) and Dalgarno & Lee (2010) models is any specific mention of *reflective thinking* as part of the learning process. Reflective thinking, or the process of examining experience in order to construct meaning, is widely recognized by learning theorists and educational psychologists as a key construct for the understanding of thinking and learning processes (Bransford *et al*, 2000; Leung & Kember, 2003; Sitzman, 2011; Merchant *et al*, 2014). Although Phan (2007) found a significant correlation between support for reflective thinking and performance outcomes, a number of researchers have recently called for additional study of this key construct and instructional design of activities which promotes deeper understanding and enhanced learning outcomes (Dalgarno *et al*, 2002; Lee *et al*, 2010; Merchant *et al*, 2014).

The Lee (2010) model measured learning outcomes in two domains: cognitive and affective. The cognitive domain was measured by *performance achievement* (PERF), which consisted of a 32-item post-test assessing the students' retention of subject matter relating to the dissection of frogs. The affective domain was measured by *perceived learning effectiveness* (PERC) and *satisfaction with the learning process* (SAT). The eight items indicating the construct of perceived learning effectiveness were drawn from several prior studies, and tended to focus on student perception of gaining knowledge and understanding, and finding the learning activities meaningful and interesting. The seven items indicating the satisfaction construct asked about several different aspects of the learning process, including the environment, the experience, the teaching methods, and the overall learning effectiveness.

2.3 Results of the Lee et al (2010) study

The Lee *et al* (2010) study used IBM AMOS (version 16) to do structural equation modeling analysis using maximum likelihood estimation, and found that their research model had an acceptable goodness of fit, with the model explaining 97% of the variance in learning outcomes (see Figure 4). However, two constructs where the Lee (2010) model exhibited only a moderate ability to predict variance were Presence (R^2=42%), and Reflective Thinking (R^2=63%). These moderate values for the coefficients of determination indicate that these two constructs in the Lee (2010) model may have been influenced by unidentified variables.

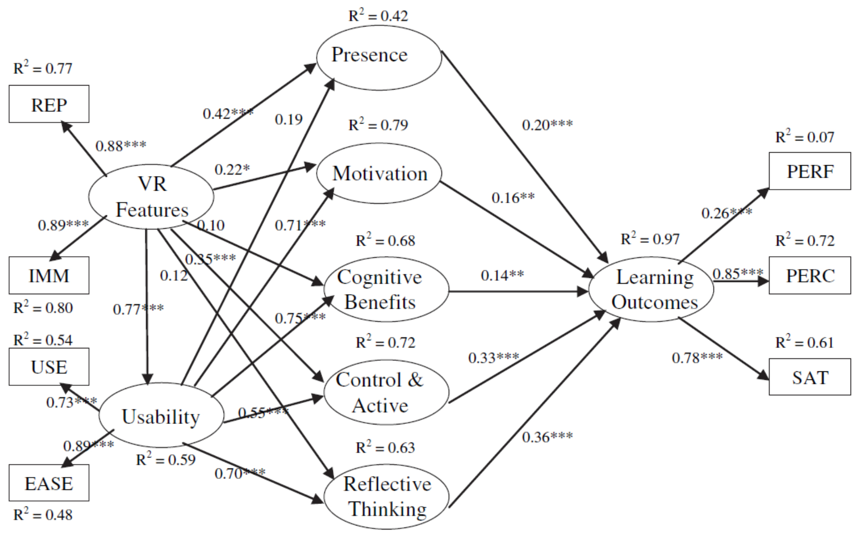


Figure 4. Results of SEM analysis of the Lee *et al* (2010) structural model:
Chi-square χ^2=78.473, df=43, normed chi-square = 1.825, CFI=.979, RMSEA=.063

VR Features was a strong predictor of Presence, Motivation, Control & Active learning, and Usability. Usability was a strong predictor of Motivation, Cognitive Benefits, Control & Active learning, and Reflective Thinking. All five of the psychological mediating variables were strong predictors of learning outcomes. Of the sixteen hypotheses in the Lee 2010 study, only three were not supported by a significant positive correlation: VR Features were not found to be significantly correlated to Reflective Thinking or Cognitive Benefits, and Usability was not found to be significantly related to Presence.

2.4 Extending the Lee (2010) model to a virtual world

The VR learning environment used in the Lee (2010) study was V-Frog, a single-user 3D virtual environment which enables the simulated dissection of a frog. VR-Frog does not support the creation of a virtual identity as an avatar, nor does it support any communication or collaboration with other users for the social construction of knowledge. The current study sought to confirm the validity of extending the Lee (2010) research model, with its five psychological factors describing the learning experience, to the multi-user virtual world of Second Life.

2.5 Refining the Lee (2010) model

The current study (2018) also proposed to refine the Lee (2010) model so that it better describes learning in the multi-user virtual world. To describe the additional affordances of the social virtual world of Second Life compared to the solo virtual reality of V-Frog, this research proposed a theoretical framework which included two additional psychological constructs (highlighted in red) which mediate the learning experience: Virtual Identity, and Social Constructivism (see Figure 5).

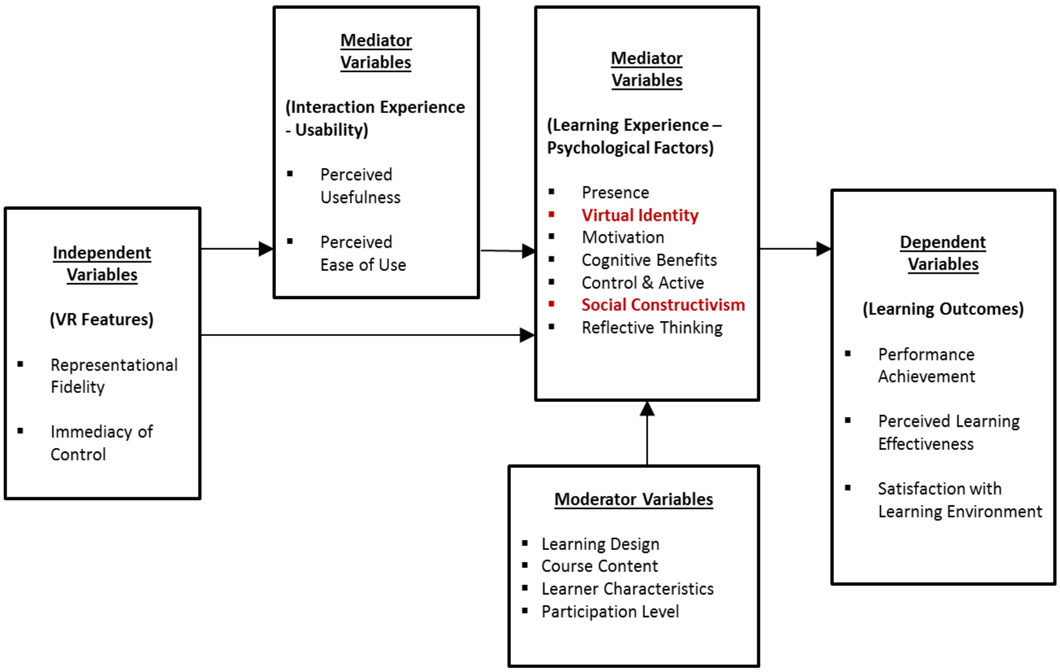


Figure 5. Proposed conceptual framework of the outcomes and their causal relationships in a multi-user desktop virtual world with avatars, communication and collaboration.

2.5.1 Interactions between Virtual Identity, Presence, and Motivation

In 2010 Hew & Cheung called for future research to explore how the use of avatars to represent online identity might influence the perception of interactive communication, and even the perception of the users themselves. The Lee (2010) conceptual model views presence and motivation as psychological factors affecting the learning experience which then mediate the learning outcomes, but this model is based on a 3D virtual environment which does not use avatars to embody the in-world user, and therefore does not recognize the concept of a virtual identity. The conceptual model promulgated by Dalgarno & Lee in 2010 did recognize 'construction of identity' as a precursor to the learning tasks that a 3D virtual environment affords, but they placed this factor in parallel with other factors involving a sense of presence. Therefore, their model did not indicate any interaction or correlation between identity and presence. Dalgarno & Lee (2010) did list ‘engagement’ as one of the benefits of learning in a 3D virtual environment, which typically correlates with intrinsic motivation in students.

Although the role of immersive presence has been widely recognized as a key factor in the virtual environment learning process, extant conceptual models do not describe any relationship between identity formation, presence, and motivation. The current study tests the relationship between these constructs by investigating the impact that the development of a virtual identity and concomitant social feedback from others can have on the subjective feelings of immersive presence and intrinsic motivation. Virtual identity is also examined as a construct which mediates the learning process to impact on learning outcomes.

2.5.2 Interactions between Social Constructivism, Control & Active Learning, and Reflective Thinking

When feedback is combined with effective instruction, it can be very powerful in enhancing learning (Hattie & Timperley, 2007). Students in Hong Kong have been found to have a significant correlation between approach to learning and reflective thinking: those with a surface approach to learning tended to rely on the habitual action of rote learning with little conscious thought, while those with a deep approach to learning tended to engage in more reflective thought with a conscious appraisal of assumptions and beliefs (Leung & Kimber, 2003). The approach to learning, mediated by the psychological process of reflective thinking, has been found to be predictive of learning outcomes on the mathematic performance of South Pacific students (Phan, 2007). Reflective thinking in a virtual learning environment was also a significant antecedent of learning outcomes involving the performance of learning biology for Malaysian students (Lee *et al*, 2010). The use of virtual learning environments has been shown to facilitate better reflection and the ‘trading of stories’ between online learners (Kirkup, 2001). The perception of a social constructivist learning environment may also influence the perception of control over learning by participants, or the perception of active learning. Jonassen *et al* (1995) found that the same principles which guide the instructional design of a constructivist environment also create learner-centered and collaborative environments that support critical reflection and experiential processes. The constructivist sense of ‘active learning’ is to ask the learner to participate in and interact with the surrounding environment in order to create a personal understanding of the world (Jonassen *et al*, 1995).

The more accurately a theoretical framework can describe the unique learning process that the virtual environment affords, the better teaching practitioners in the field can apply the theory to create effective instructional design. The current study tests the relationship between these constructs by investigating the impact that participant perception of an environment which supports the social construction of knowledge has on control & active learning, and reflective thinking. The perception of a social constructivist environment is also examined as a construct which mediates the learning process to impact on learning outcomes.

3. Refined research model

Based on this refined conceptual framework, a research model with two new intermediate variables (highlighted in red) was developed to evaluate how a virtual world enhanced learning (see Figure 6).

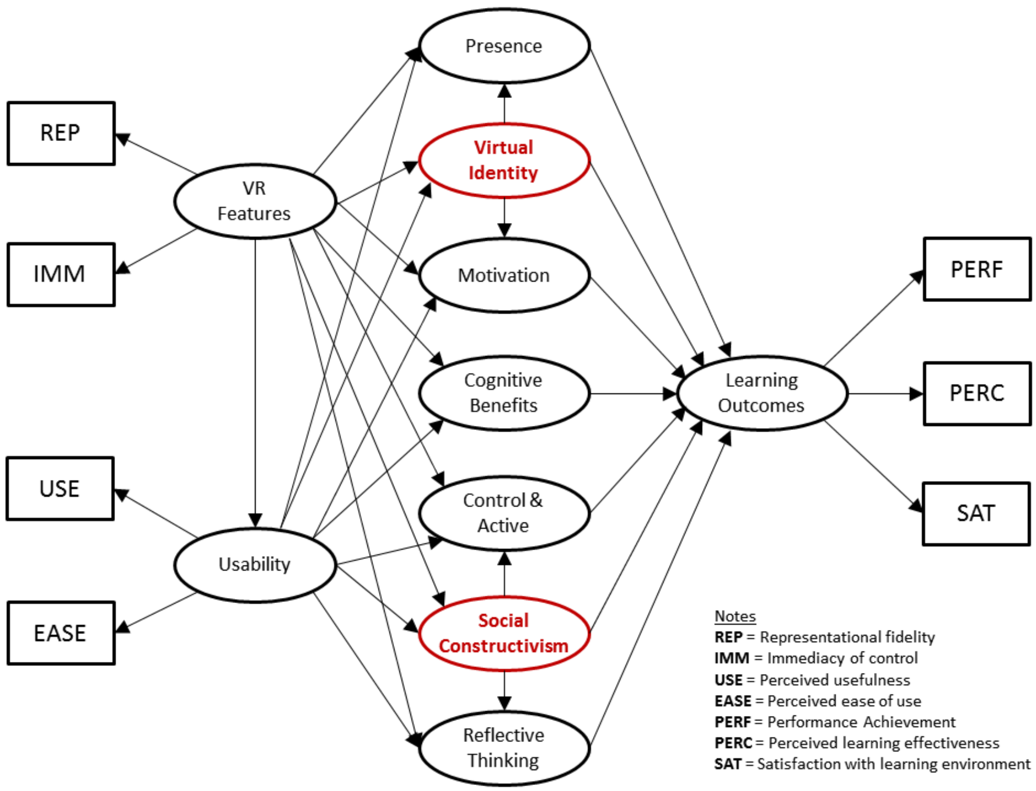


Figure 6. The proposed 7-factor research model refines the Lee *et al* (2010) model to better describe the learning experience within a virtual world.

The latent variable VR Features is measured by immediacy of control (IMM) and representational fidelity (REP). The latent variable Usability is measured by ease of use (EASE) and perceived usefulness (USE). The psychological constructs are represented by variables which build on the Lee (2010) model: reflective thinking, control & active learning, cognitive benefits, motivation, and presence. Based on the conceptual framework, the proposed research model predicts that the additional intermediate variables which refine the Lee (2010) model will also enhance the influence of other psychological constructs: Virtual Identity will positively influence Presence and Motivation, and Social Constructivism will positively influence Control & Active learning and Reflective Thinking. The Learning Outcomes are measured by satisfaction with the learning environment (SAT), perceived learning effectiveness (PERC), and performance achievement (PERF). Structural equation modeling evaluated the fit of the hypothesized model, which analyzes the underlying relations between the constructs, and can infer the directionality of significant relationships (Schreiber *et al*, 2006).

4.0 Research hypotheses

4.1 Hypotheses for the relationships between constructs in the Lee (2010) 5-factor model

To replicate and extend the Lee (2010) model to the virtual world, the following hypotheses were tested:

H1: VR features are significantly related to usability.

H2: VR features are significantly related to presence.

H3: VR features are significantly related to motivation.

H4: VR features are significantly related to cognitive benefits.

H5: VR features are significantly related to control and active learning.

H6: VR features are significantly related to reflective thinking.

H7: Usability is significantly related to presence.

H8: Usability is significantly related to motivation.

H9: Usability is significantly related to cognitive benefits.

H10: Usability is significantly related to control & active learning.

H11: Usability is significantly related to reflective thinking.

H12: Presence is positively related to learning outcomes.

H13: Motivation is positively related to learning outcomes.

H14: Cognitive benefits are positively related to learning outcomes.

H15: Control & active learning is positively related to learning outcomes.

H16: Reflective thinking is positively related to learning outcomes

Based on the hypothesized refined research model with the two additional psychological constructs, the research questions were:

1) What are the psychological constructs that mediate learning experiences in the virtual world?

    a) How does identification with a ***Virtual Identity*** as embodied self-representation for social interaction increase the sense of immersive presence and motivation, and enhance learning outcomes?

    b) How does perception of a learning environment which supports ***Social Constructivism*** increase reflective thinking and a sense of control & active learning, and enhance learning outcomes?

    c) How do these constructs correlate to enhance the learning outcomes based on experiences in the virtual world?

2) When the various predictors of outcomes are combined in a multivariate analysis, what set of variables best predicts the learning outcomes?

To answer these research questions, the following hypotheses were developed:

H17: VR Features are significantly related to Virtual Identity.

H18: VR Features are significantly related to Social Constructivism.

H19: Usability is significantly related to Virtual Identity.

H20: Usability is significantly related to Social Constructivism.

H21: Virtual Identity is significantly related to Presence.

H22: Virtual Identity is significantly related to Motivation.

H23: Social Constructivism is significantly related to Control and Active learning.

H24: Social Constructivism is significantly related to Reflective Thinking.

H25: Virtual Identity is significantly and positively related to Learning Outcomes.

H26: Social Constructivism is significantly and positively related to Learning Outcomes.

Figure 7 represents the hypothesized relationships in the model, with the new constructs and hypotheses in red:

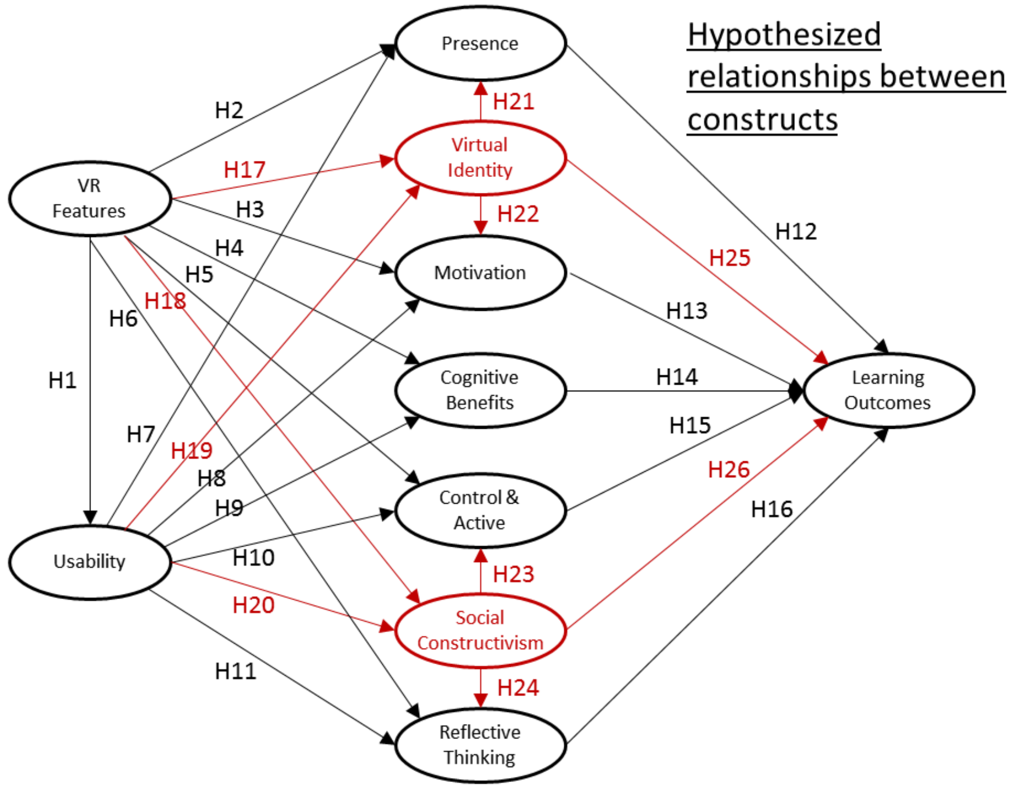


Figure 7. Hypothesized relationships between constructs of the proposed 7-factor research model,
with the new constructs and hypotheses in red.

5. Methodology

5.1 Subjects and procedures

Participants in this study were initially recruited from a small university undergraduate course using convenience sampling, and then the entire global user population of the Second Life virtual world was invited by setting up the Quest activity as an official Featured Event Destination (Hill & Knutzen, 2017). Participants undertook a series of 10 challenges designed to train students in the basic navigation and user interface skills of the Second Life virtual world. In each challenge, participants were given a clue written in English which guided them to navigate through a simulated medieval village, walk and fly in specific compass directions, find secret doors, open treasure chests, collect new virtual items, and try on new clothing outfits.

The average length of the Quest learning experience was about one hour, and informed consent was obtained before administration of the online survey.

Over a 15 month period, an estimated population of 2000 users attempted the Quest activity, a treasure hunt on Lingnan University Island in the virtual world of Second Life (Hill & Knutzen, 2017). The researcher monitored the arrivals of new visitors, and directly observed hundreds of participants as they attempted to solve the 10 problems of the Quest. Potential participants were incentivized to take the survey by offering them access to an 11^{th} level of the Quest. Some "member check" feedback was collected from the participants through post-survey interviews using typed IM chat to improve the internal validity of the study.

5.2 Measurement

During the 15 month period, 405 survey records were collected using an online Google Form. New survey records were screened every few days for content non-responsivity, defined as careless responding without regard to item content (Meade & Craig, 2012). These invalid records were often the result of pervasive careless responding across the entire survey, and could usually be detected by the failure to reverse the pattern of answers on reverse-coded items. Another type of invalid record was due to respondent fatigue, where the first two survey pages of responses appeared to be thoughtfully considered, but on the third page the respondent carelessly gave a single answer on all the items (e.g. Neutral), and typically very curt responses on the last page of open-ended items as well (e.g. "no"). Upon detection, all invalid records were immediately labeled "JUNK" in a Comments field, often with a brief note as to the reason for the designation. Records left by users who opened the survey form but then after reading the consent form chose "No – I will not answer this survey" were labeled "REFUSE".

After the data collection cut-off date, the Google Form data was reviewed, 86 records labeled "JUNK" and 9 labeled "REFUSE" were deleted, so that 310 records were deemed valid and remained in the sample (n=310). All fields in the survey form had been set to "required", so there was no missing data in any fields. Finally, the data was imported into IBM SPSS for further screening and statistical analysis.

The survey collected demographic data across 13 items to better understand the learning context of the participants. See Table 1 for a summary of five demographic items.

Table 1
Summary of participant demographics.

Age		Education		Experience in Virtual World		PC Proficiency		Virtual World Proficiency	
18-22	15.5%	Secondary	17.0%	< 1 hour	7.1%	Novice	3.2%	Novice	14.8%
23-29	14.2%	Undergrad	41.0%	1 day	8.1%	Moderate	50.6%	Moderate	50.0%
30-39	17.1%	Postgrad	19.7%	1 month	9.0%	Expert	46.1%	Expert	35.2%
40-59	41.9%	Vocational	7.1%	> 1 month	9.4%				
60+	11.3%	Professional	11.3%	> 1 year	23.9%				
		Other	3.2%	> 5 years	37.4%				
				> 10 years	5.2%				

The minimum age of participants in the sample was 18, and the mean age response was in the bracket 30-39. Prior research had reported that the population of users in the Second Life virtual world has a large proportion of highly educated middle-aged people, and this belief was supported by the demographics of the participants in this study, with 41.9% aged 40-59, and over 60% of the participants were university undergraduates or postgraduates. Only 15.2% of the participants were doing the Quest on their first day in the virtual world, while 42.6% of the participants were veteran users with 5 or more years of experience.

The worldwide study sample was dominated by North American participants at 70.6%, followed by Europeans with 14.2%, Australians/New Zealanders at 5.2%, and Asian participants at 6.7%. The majority of the sample were casual users at 83%, followed by students at 9%, and teachers were 8%. Most participants (51%) required between 16 and 59 minutes to complete the activity, while 29% completed it between 1 and 3 hours. The study participants identified themselves as mostly female at 66.5%, males at 31.0%, and “Other” at 2.6%. Several of the “Other” gender selections were specified as “Fluid”, which indicated that these participants change their gender to suit their contextual situation.

Only in the past decade have studies been collecting data from the global population of virtual world users (Gabisch, 2011). The collection of data from actual users of the Second Life virtual world, as opposed to experiments in the laboratory or university students on assignment, supports greater insight into the use of virtual identities and the social construction of knowledge in a multi-user learning environment. This sample of participants, drawn from the full range of the global population of Second Life, should result in findings that are more generalizable (Huang *et al*, 2016).

One of the key learner characteristics examined by this study was the level of avatar customization the participants chose to do, and for what purpose. The largest group (44%) highly customized their avatar to represent themselves with an idealized identity, followed by 29% who chose some customization of their avatar with clothing, shape, or accessories. 10% highly customized their avatar to represent an extension of their real-life identity, 6% slightly customized their avatar, 7% chose a pre-made avatar from the range of choices supplied (People, Vampires, Classic), and 4% chose a pre-made male or female avatar. See Figure 8 for the level of avatar customization.

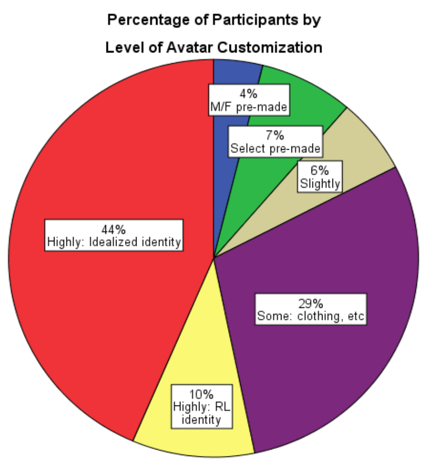


Figure 8. Percentage of participants by level of avatar customization.

5.2.1 Quantitative survey

A post-test self-report quantitative survey was developed with items to measure the rest of the observed and latent variables in the hypothesized research model, based on the instrument used in the Lee (2010) study. Of the 59 items used in the Lee (2010) study, 27 items were selected for the survey instrument of the current research. Descriptive labels in the Lee (2010) survey items such as “3D images”, and “computer program”, were updated to “virtual world”, while “computer-based learning environment” was updated to “virtual world environment” to reflect the virtual learning environment context of this research. Three additional items were selected from the same study sources used by the Lee (2010) study, and three new items which relate to the use of an avatar in a multi-user environment were self-developed by the researcher.

To measure the new Virtual Identity construct, one survey item was sourced from the Relational Self-Concept Survey, one new survey item was based on the avatar identification levels defined by Bartle (2004) and refined by Neustaedter & Fedorovskaya (2009), and two new items were self-developed by the researcher which directly addressed possible moderating effects on Presence and Motivation. To measure the new Social Constructivism construct, two survey items were selected from the same study sources used for the Lee *et al* (2010) survey instrument, and two new items were self-developed by the researcher which directly addressed possible moderating effects on Control & Active Learning, and Reflective Thinking. The total number of items in the new survey instrument relating to the research constructs was 41. All items were measured with a 5-point Likert scale with 1=strongly disagree and 5=strongly agree. See Appendix A for the complete survey instrument and the item sources.

5.2.2 Measure of observed variable – Performance Achievement

Five items were developed to assess the performance of the participants in retaining content knowledge, a learning outcome from the cognitive domain. The post-test assessment measured the level of digital literacy achieved by the students after they completed the Quest activity in the Second Life virtual world. Content validity of these items was initially determined by the expert judgment of the researcher (as developer of the Quest activity), and then subsequently evaluated by feedback from member checks as part of the post-survey debriefing process. Several participants pointed out that one of the performance achievement items was invalid, as the correct answer depended on the type of virtual viewing software in use. This item was removed from analysis.

The reliability of the survey scale items was determined by calculating the internal consistency based on Cronbach's Alpha coefficient (1951). In addition, the data was analyzed using exploratory factor analysis to determine the uni-dimensionality of each measurement indicator. After both the internal consistency and uni-dimensionality had been calculated, the raw measurement values were averaged as a composite measure of reliability. Once the reliability of the survey scales was determined, a few items were removed to improve the scale reliability.

5.2.3 Qualitative survey

Qualitative data was collected from the participants using an online survey with 8 open-ended items based on the research questions. These same items formed the basis for informal post-test debriefing and member checks with some participants. The first item checked for prior experience using virtual worlds or virtual reality, and asked the participant to describe any prior experiences. The next three items directly addressed the learning outcomes based on their learning experience in the virtual world: performance achievement in retaining course content, perception of learning efficacy, and satisfaction with the learning environment. Each of these items was followed by an invitation for further elaboration by the respondent.

The next two items addressed the research questions regarding the two additional constructs in the proposed new conceptual framework for learning in a virtual world: virtual identity, and social constructivism. These items were structured to examine if the participant experiences which relate to these new constructs affected their feelings regarding the nearby constructs, and thus impact on the learning outcomes. These items helped to triangulate the quantitative data and identify possible causal inferences between the constructs. The seventh item examined two possible areas for future research related to examining the learning experience in virtual worlds: learning style and spatial ability. The final item asked for any suggestions for improving the virtual world experience as a tool for learning.

The current study examined the learner's experience in the virtual world using several data collection methods: quantitative and qualitative survey data, as well as some informal debriefing interviews. This approach was designed to increase internal validity by confirming that emerging themes are supported by multiple sources of data (Merriam, 2009). Although it is difficult to replicate qualitative research based on a point-in-time study due to variations in the learning intervention activity, sampling methods, participant demographics, and the dynamic nature of human behavior, reliability can be maximized if the results are consistent with triangulated data, audit trails, effective derivation of categories, and effective decision-making (Merriam, 2009).

6. Data analysis and results

An SPSS syntax file was developed to compute the four reverse scored "check" items. Then, the internal reliability of the scale items was checked by calculating Cronbach's Alpha coefficient. In computing the single-indicator scale composite values, several items were dropped to improve the internal reliability. The criterion validity of the survey instrument was evaluated using IBM AMOS version 24 and maximum likelihood estimation to determine the ability of the proposed research model to explain the variance in the constructs, which is a measure of the predictive power of the model.

6.1 Measurement model

Table 2 lists the measures of convergent validity of the constructs in the model: composite reliability and average variance extracted (AVE). Almost all of the constructs have a composite reliability above 0.6, and most are above the typical threshold value of 0.7 (Nunnally, 1978). The notable exception is the Motivation scale construct with a calculated composite reliability of .495, which is based on three survey items in the current study, a selected subset of the Motivation scale in the Lee (2010) study which had 15 items. The internal reliability for the Presence construct was low at .531, and it was determined that the second item was measuring another dimension, that of co-presence. In order to maintain uni-dimensionality of the scale, the co-presence item was excluded from the calculation of the scale composite score, leaving only the original Lee (2010) survey Presence item. The average variance extracted was calculated by adding the squares of the standardized estimates of factor loading for each item, and dividing by the number of items. Most of the constructs had an AVE above 0.4, and some were above the conventional threshold of 0.5 (Hair *et al*, 2010). Of the two additional constructs in the hypothesized 7-factor model (shown in yellow), the Virtual Identity construct had a composite reliability (.726) above the threshold, but its AVE was below the threshold (.360). The Social Constructivism construct had a high composite reliability (.795) and a high AVE (.571), both above the typical thresholds. The Motivation construct had a low composite reliability (.495) and a low AVE (.337), both below the required thresholds. Because this construct did not have a high level of convergent reliability, its inclusion weakens the overall validity of the model. The Performance Achievement construct had the lowest convergent validity (shown in **red**), with a composite reliability of .470 and a very low AVE of .216. This lack of convergent validity indicates that the Performance Achievement construct is probably not suitable for inclusion in a parametric analysis to confirm or reject the research hypotheses. The discriminant (or divergent) validity was assessed using the correlational method, which defines an acceptable discriminant validity when an indicator variable correlates more highly with the intended construct than with other constructs (Garver & Mentzer, 1999).

Table 2

Measures of Convergent Validity: composite reliability and average variance extracted (AVE). New construct scales in yellow, Performance Achievement construct in **red**.

Construct	Composite	Average Variance
Representative Fidelity	0.721	0.441
Immediacy of Control	0.679	0.429
VR Features	0.814	0.697
Perceived Usefulness	0.814	0.629
Perceived Ease of Use	0.649	0.547
Presence	0.531	0.490
Virtual Identity	0.726	0.360
Motivation	0.495	0.337
Cognitive Benefits	0.798	0.571
Control & Active Learning	0.731	0.579
Social Constructivism	0.795	0.571
Reflective Thinking	0.747	0.632
Performance Achievement	**0.470**	**0.216**
Perceived Learning	0.614	0.466
Satisfaction with Learning	0.652	0.403
Learning Outcomes	0.227	0.351

6.2 Normality

Because many significance tests assume multivariate normality, Bradley (1982) states that statistical inference becomes less robust when distributions depart from normality (as cited in Tabachnik & Fidell, 2008). The univariate normality of the continuous variables was assessed using both statistical and graphical methods. The count, range, mean, skew, and kurtosis of the scale composite variables was measured using SPSS DESCRIPTIVES, see Table 3 for the output. The typically accepted threshold for skewness and kurtosis is +/-2 (Gravetter & Wallnau, 2016). The only scale composite variable with skew and kurtosis measures that were not within this limit was Performance Achievement, with a positive kurtosis of 2.992 (highlighted in **red**), as well as a strong negative skew of -1.797. A lack of univariate normality will tend to cause the underestimation of variance for this construct. This lack of normality indicates that the Performance Achievement construct is probably not suitable for inclusion in a parametric analysis to confirm or reject the research hypotheses.

Table 3

Descriptive statistics measuring normality in the scale composite variables. New construct scales in yellow, Performance Achievement measures in **red**.

	Stat	Mi Sta	Ma Stat	Mea Stat	Std. Stat	Skewness Stat	Std.	Kurtosis Stat	Std.
Representational_Fi	310	2.0	5.00	3.94	.675	-.227	.138	-.326	.276
Immediacy_of_Cont	310	1.5	5.00	4.20	.613	-.614	.138	.873	.276
Useful_Avg	310	1.0	5.00	3.84	.710	-.182	.138	.085	.276
Perceived_Ease_of_	310	1.5	5.00	3.82	.833	-.509	.138	-.182	.276
Presence	310	1	5	4.05	.809	-.494	.138	-.167	.276
Virtual.Identity_Avg	310	1.0	5.00	3.81	.665	-.525	.138	1.03	.276
Motivation_Avg	310	2.0	5.00	3.95	.623	-.369	.138	-.126	.276
Cog.benefits_Avg	310	1.0	5.00	3.77	.654	-.255	.138	.870	.276
ActiveLearning_Avg	310	2.3	5.00	4.01	.607	-.051	.138	-.540	.276
Soc.Constructionis	310	1.0	5.00	3.84	.752	-.917	.138	1.66	.276
Reflective.Thinking	310	1.6	5.00	3.62	.676	-.170	.138	.227	.276
Perceived_learning	310	2.0	5.00	3.88	.652	-.260	.138	-.203	.276
Satisfaction_Avg	310	2.3	5.00	4.03	.592	-.089	.138	-.567	.276
Performance_Achie	310	1.0	5.00	4.50	.815	-	.138	**2.99**	.276
Valid N (listwise)	310								

The Performance Achievement items on the survey were designed to test the retained knowledge of novice users after doing the Quest as their first learning experience in the virtual world, but most of the study participants had considerable prior experience in the virtual world. The demographic item Virtual Experience before Quest found that 92.9% of the participants had some prior experience in the virtual world, and the majority (66.5%) had 1 year to more than 10 years of prior experience. Similarly, the Virtual World Proficiency demographic item found that 85.2% of the participants self-rated their proficiency in the virtual world as higher than Novice. This high level of prior experience and skills resulted in a mean score of 4.51 on the quiz, and a negative skew of -1.797.

The means of the distribution on both of the two new constructs Virtual Identity and Social Constructivism were nearly 4, resulting in a moderate level of negative skew, as the maximum Likert response of 5 tended to cap the right side of the distribution. The distribution of the Virtual Identity variable had a skew statistic of -.525, and the distribution of the Social Constructivism variable had a skew statistic of -.917. Waternaux (1976) advised that if the sample size is over 100, the underestimates of variance associated with positive kurtosis tend to disappear (as cited in Tabachnik & Fidell, 2008).

To assess the multivariate normality in the ungrouped data, the relationship between pairs of continuous variables was checked for linearity and homoscedasticity using bivariate scatterplots. In addition, the observations farthest from the centroid of the data (Mahalanobis distance) were checked using AMOS. Observation #35 was the farthest from the centroid of the data by Mahalanobis distance, and this outlier was located in the bivariate scatterplot of the scale composite variables Useful and perceived Ease of Use. Although this observation was undoubtedly located far from the centroid, visual examination found it symmetrical with other observations on the opposite side of the x=y line, so homoscedasticity was preserved. As a test, this observation was removed from the data set, and this change was found to negatively affect the model measures of goodness-of-fit. Therefore, it was decided that this observation would remain in the data set for final path analysis of the model goodness-of-fit measures.

6.3 Minimum sample size for analytical power using RMSEA fit index

Literature in the SEM analysis research area commonly state that a reasonable threshold for the minimum sample size is 200 (Kenny, 2015; Barrett, 2007, p. 820). With a sample size less than 200 the chi-square test lacks power and thus may not discriminate well between good and poor fitting models (Kenny & McCoach, 2003). On huge datasets (for example, n > 10,000), the issue of "model goodness of fit" based on statistical tests becomes irrelevant (Burnham & Anderson, 2003). Other guidelines in the literature relate required sample size to the complexity of the model. Bentler & Chou (1987) suggested a ratio of 5 to 1, or five participants for each free parameter. Since the hypothesized 7-factor model has 40 free parameters to be estimated, this ratio would require a sample size of 200. Garson (2015) notes that sample sizes in SEM studies in the literature typically run 200-400 for models with 10-15 indicators. The current study, with a sample size of n=310 and 12 indicators in the model, fits within these ranges. Using an approach proposed by MacCallum *et al* (1996), Preacher & Coffman (2006) developed an online resource for calculating the minimum sample size to achieve a desired level of analytical power using the RMSEA fit index. Starting with the input values of α=.05 (Type 1 error), df=35, desired power=.8, null RMSEA=.05, and alt RMSEA=.08, the Preacher & Coffman (2006) online resource calculated a minimum sample size of n=278.125.

6.4 Selection of fit indices

Hu & Bentler (1998, p. 447) recommend that researchers choose a two-index strategy for presenting their results: one from the class of relative fit measures (also called incremental fit), and one from the class of absolute fit measures. Tabachnik & Fidell (2008, p. 725) state that the Comparative Fit Index (CFI) and Root Mean Square Error of Approximation (RMSEA) are the most frequently reported fit indices, and Blunch (2008, p. 117) further suggests the reporting of Chi-square (χ^2) with degrees of freedom (df) and P-value, CFI, and RMSEA with confidence interval and PCLOSE. MacCallum *et al* (1996, p. 130) also strongly urge the use of confidence intervals with fit measures such as RMSEA. For the current study, model goodness-of-fit measures are presented using Chi-square (χ^2) with degrees of freedom (df) and probability P-value, CFI (relative fit) and RMSEA (absolute fit), with lower confidence level (LO 90), upper confidence level (HI 90), and PCLOSE.

6.4 Structural model

This research sought evidence to confirm the extension of the 5-factor technology-mediated learning model proposed by Lee *et al* (2010) to the context of the Second Life multi-user virtual world, and evidence to confirm the addition of two new constructs (Virtual Identity and Social Constructivism) to create the hypothesized 7-factor model. The quantitative data from survey was analyzed by following the methodology of the Lee *et al* (2010) study as closely as possible, in order to maximize the validity of extending the research model of that study.

6.4.1 Single-indicator observed variables

Each of the five psychological constructs were single-indicator observed variables, so for the structural analysis and comparison with the Lee (2010) model it was decided to represent them in the structural model using their scale composite values. The scale composite value for each construct was calculated using SPSS and stored in the data file, and the structural model examined using IBM AMOS (version 24) and maximum likelihood estimation to determine how well it predicts the observed data values.

6.4.2 Removal of irrelevant indicators

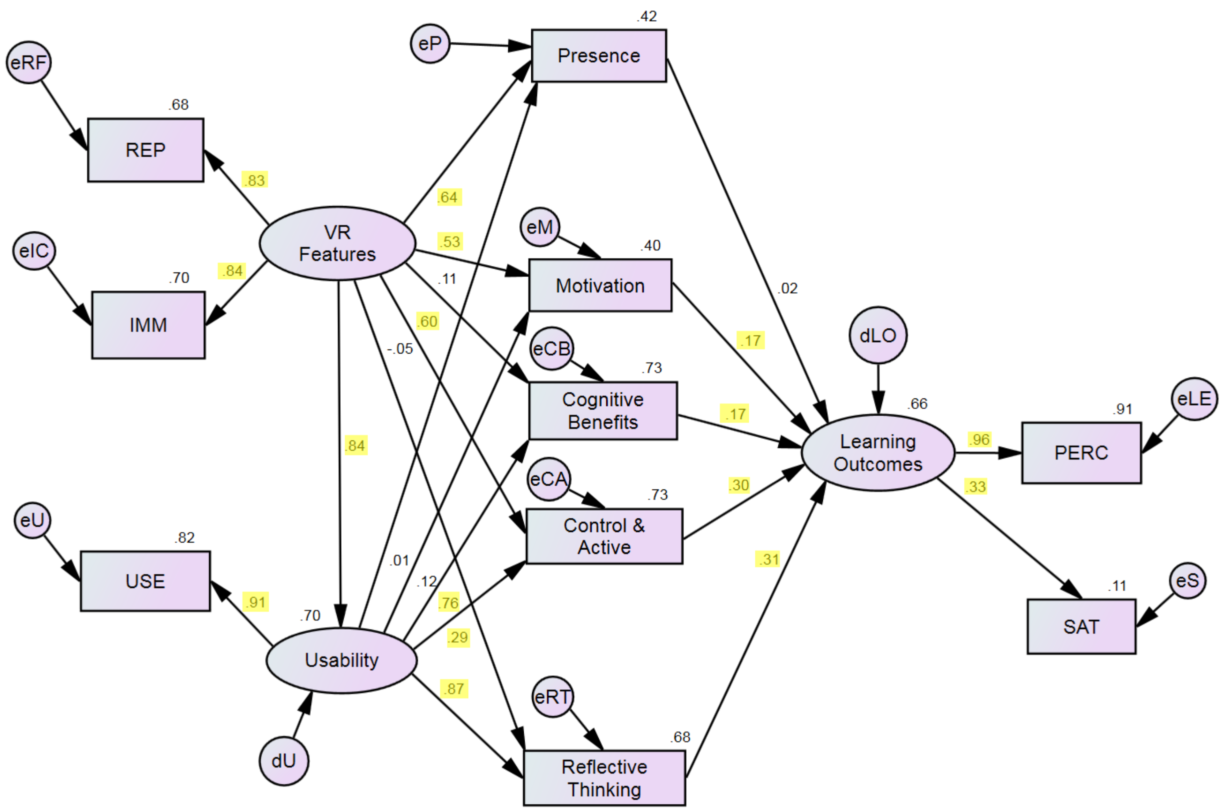
While the Lee (2010) model explained 7% of the variance in the Performance Achievement (PERF) construct, the current replication of the five-factor model explained 0% of PERF. The lack of analytical power to explain variance in this construct would be affected by the lack of convergent validity and univariate normality of the Performance Achievement variable. The lack of convergent validity indicated that the Performance Achievement construct was probably not suitable for inclusion in the covariance analysis to confirm or reject the research hypotheses.

Another construct with low variance was the perceived ease of use (EASE) construct, with only 2% explained by the model. For a novice user new to the virtual world, the perceived ease of use is a major issue, but for a veteran user with moderate to expert skills and more than a year of experience, any issue with ease of use may be a distant memory! In addition to the demographics of the sample, another factor may also be the design of the model itself: a direct path between perceived ease of use and usability may not be supported. In addition to the low variance of the Performance Achievement (PERF) construct and the Ease of Use (EASE) construct, both of the factor loadings indicated by these paths were not significant ($p<.05$).

6.4.3 Results of SEM analysis of the 5-factor structural model

See Figure 9 for the results of path analysis of the five-factor model optimized with the removal of the irrelevant indicators Performance Achievement (PERF) and Ease of Use (EASE). The SEM analysis of the 5-factor structural model resulted in goodness-of-fit measures of chi-square $\chi^2=41.030$, degrees of freedom df=24, probability p=.017, for a normed chi-square=1.71. The CFI=.991 goodness-of-fit measure exceeds the recommended threshold of CFI >.95 (Hu & Bentler, 1999), and the RMSEA=.048 exceeds the recommended threshold of RMSEA <.06 (Hu & Bentler, 1999), thus indicating that this model has acceptably good fit. In addition, the RMSEA measure had a lower confidence level of LO 90=.020 and an upper confidence level of HI 90=.072, well the recommended threshold level of .08 (Hu & Bentler, 1995). The PCLOSE value indicates that the probability is .523 that the RMSEA for the path analysis of the entire population would be .05, a close fit.

Based on every comparable measure of model fit, the path analysis results of the current 5-factor structural model exceed those found by the Lee (2010) study. This path diagram analysis provided strong evidence to confirm that the 5-factor model is a reasonable fit with the survey data collected from a sample of the general population of users of the Second Life multi-user virtual world doing the Quest treasure-hunt activity.



REP=Representational fidelity, IMM=Immediacy of control, USE=perceived usefulness, PERC=Perceived learning effectiveness, and SAT=Satisfaction.

Estimated factor loadings highlighted in yellow are significant (p<.05)

Figure 9. 5-factor structural model with indicators PERF and EASE removed.
Chi-square χ^2=41.030 df=24 p=.017 normed chi-square=1.71
CFI=.991 RMSEA=.048 LO 90=.020 HI 90=.072 PCLOSE=.523

The three paths from VR Features -> Cognitive Benefits, VR Features -> Reflective Thinking, and Usability -> Presence, were not significant, replicating the results of the Lee (2010) model. Overall, of the 16 hypothesized relationships (H1-H16) between constructs of the structural model, 14 replicated the results of the Lee (2010) study, and only two were not replicated: the paths Usability -> Motivation (H8) and Presence -> Learning Outcomes (H12) were not found to be significant. See Table 4 for these results in tabular form, with replicated results in **green**, and NOT replicated results in **red**.

Table 4
Comparison of support for hypotheses based on SEM analysis of structural model: Lee (2010) study vs 5-factor model.

	Lee (2010) SEM analysis results		5-factor model SEM analysis results	
Structural Model Hypothesis #	**Factor Loading**	**Significance ($p < .05$)**	**Factor Loading**	**Significance ($p < .05$)**
H1: VR Features -> Usability	0.77	Supported	0.84	Supported
H2: VR Features -> Presence	0.42	Supported	0.64	Supported
H3: VR Features -> Motivation	0.22	Supported	0.53	Supported
H4: VR Features -> Cognitive Benefits	0.10	NOT	0.11	NOT
H5: VR Features -> Control & Active	0.35	Supported	0.60	Supported
H6: VR Features -> Reflective Thinking	0.12	NOT	-0.05	NOT
H7: Usability -> Presence	0.19	NOT	0.01	NOT
H8: Usability -> Motivation	0.71	Supported	0.12	NOT
H9: Usability -> Cognitive Benefits	0.75	Supported	0.76	Supported
H10: Usability -> Control & Active	0.55	Supported	0.29	Supported
H11: Usability -> Reflective Thinking	0.70	Supported	0.87	Supported
H12: Presence -> Learning Outcomes	0.20	Supported	0.02	NOT
H13: Motivation -> Learning Outcomes	0.16	Supported	0.17	Supported
H14: Cognitive Benefits -> Presence	0.14	Supported	0.17	Supported
H15: Control & Active -> Learning	0.33	Supported	0.30	Supported
H16: Refl. Thinking -> Learning	0.36	Supported	0.31	Supported

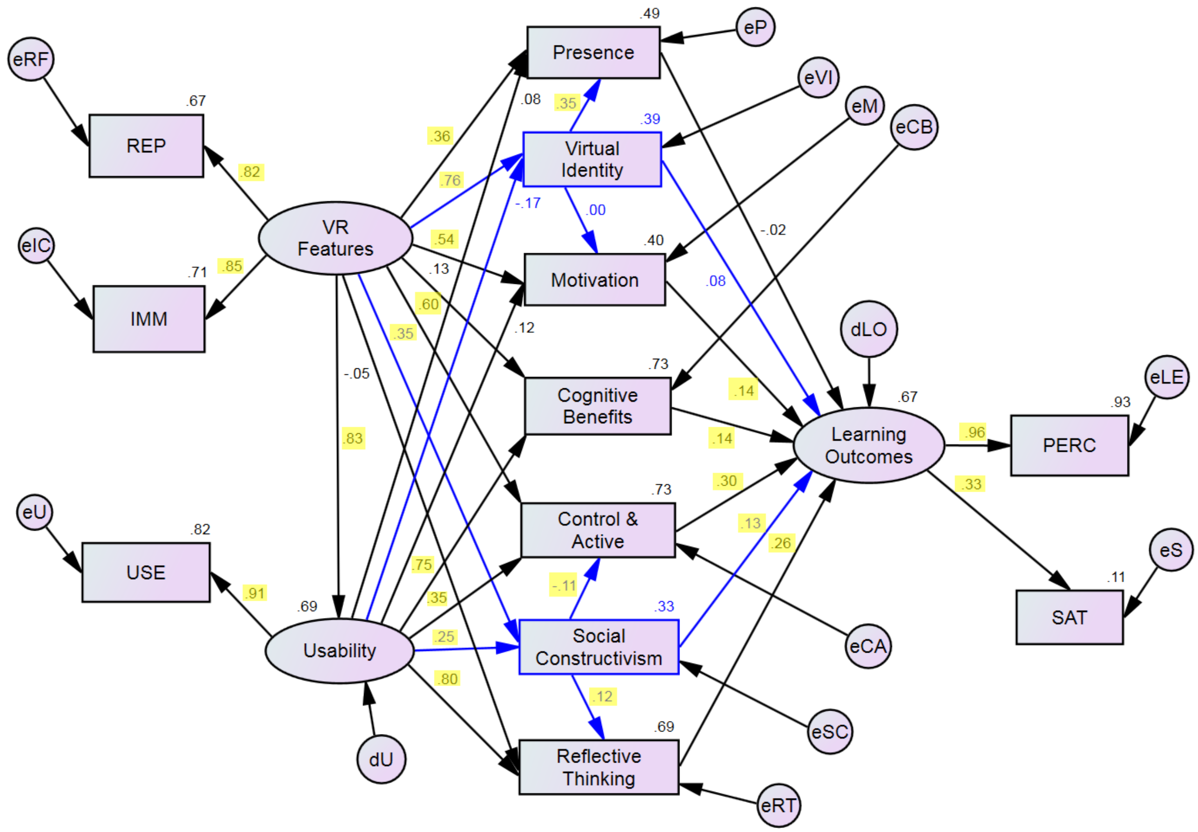
6.4.4 Setting up the hypothesized 7-factor measurement model

A measurement model was developed to include the two hypothesized psychological constructs Virtual Identity and Social Constructivism as mediating variables between the inputs and the learning outcomes, as well as four paths indicating possible moderating influences on the other constructs. Each of the constructs was measured with four survey items. All of the factor loadings for the survey items for both the Virtual Identity and Social Constructivism constructs exceeded 0.3, indicating the sufficient unidimensionality of these proposed constructs (Hair *et al*, 2010). Based on the co-variances detected in the modification indices, the SPSS syntax file commands were modified to exclude items V1, V4, and SC3 from the calculation of scale composite values for the Virtual Identity and Social Constructivism constructs in the SPSS data file. To maintain the validity of comparisons with the 5-factor model, the scale composite values for all seven single-indicator psychological variables were calculated using SPSS and stored in the data file.

6.4.5 Results of SEM analysis of the hypothesized 7-factor structural model

SEM analysis of this 7-factor structural model was performed using IBM AMOS to confirm the predictive power of this model relative to the observed data collected for this study. As with the analysis of the 5-factor model, the indicator constructs Performance Achievement and Ease of Use explained very little of the variance of the data, at .00 and .02 respectively. In addition, the modification indices indicated that these two indicator constructs contributed to a range of co-variances which were negatively affecting the fit of the model. After removing the PERF and EASE indicators, see Figure 10 for the resulting hypothesized research model, where the two new constructs, Virtual Identity and Social Constructivism, have been added (in **blue**) as additional internal psychology variables, for a total of seven factors. SEM analysis results indicated goodness-of-fit measurements of chi-square χ^2= 49.798, df= 35, p=.050, for a normed chi-square=1.42. The CFI=.993 goodness-of-fit measure exceeded the recommended threshold of CFI >.95 (Hu & Bentler, 1999), and the RMSEA=.037 was well below the recommended threshold of RMSEA <.06 (Hu & Bentler, 1999), thus indicating that this model has an acceptably close fit. In addition, the RMSEA measure had a lower confidence level of LO 90=.000, and an upper confidence level of HI 90=.059, well below the recommended threshold level of .08 (Hu & Bentler, 1995), and a PCLOSE=.819. The PCLOSE value indicated that the probability is .819 that the RMSEA for the path analysis of the entire population would be .05, a close fit.

The factor loadings which are significant (p<.05) are highlighted in yellow. These goodness-of-fit measures indicate that the hypothesized 7-factor structural model of technology-mediated learning, with the inclusion of Virtual Identity and Social Constructivism as new psychological constructs, provided a reasonable fit with the survey data collected from a sample of the general population of users of the Second Life multi-user virtual world doing the Quest treasure-hunt activity.



REP=Representational fidelity, IMM=Immediacy of control, USE=perceived usefulness, PERC=Perceived learning effectiveness, and SAT=Satisfaction.

Estimated factor loadings highlighted in yellow are significant (p<.05)

***Figure 10**. 7-factor model Chi-square χ^2 =49.798 df=35 p=.050 normed chi-square=1.42 CFI=.993 RMSEA=.037 LO 90=.000 HI 90=.059 PCLOSE=.819*

Although the factor loading on the path from Social Constructivism to Control & Active Learning was negative (-.11), nonetheless the standardized estimated regression weight was significant (p<.05) and deleting this path degraded the model measures of goodness-of-fit, so it was included in this model which best predicts the observed data. The negative factor loading between Social Constructivism and Control & Active Learning is an interesting finding which may provide direction for further research. This path analysis of the hypothesized 7-factor model explained 67% of the variance in learning outcomes, 67% of the representational fidelity, 71% of the immediacy of control, 82% of the usefulness, 69% of the usability, 93% of the perceived learning effectiveness, and 11% of the satisfaction with the learning environment. For the psychological variables, this model explained 49% of the Presence, 39% of the Virtual

Identity, 40% of the Motivation, 73% of the Cognitive Benefits, 73% of the Control and Active learning, 33% of the Social Constructivism, and 69% of the Reflective Thinking. See Table 5 for the comparison of the Lee *et al* (2010) research model hypotheses results compared to the hypothesized 7-factor model, with replicated results in **green**, and not replicated in **red**, as well as the support for the research hypotheses which relate to the new constructs Virtual Identity and Social Constructivism. Overall, of the 10 hypothesized relationships of the two new constructs within the 7-factor model (highlighted in yellow), 7 were supported by significant path coefficients, and 3 were not supported (**red on yellow**).

Table 5

Comparison of support for hypotheses based on SEM analysis of structural model: Lee *et al* (2010) study vs 7-factor model, and new hypotheses H17-26 (highlighted in yellow).

	Lee (2010) SEM analysis results		7-factor model SEM analysis results	
Structural Model Hypothesis #	**Factor Loading**	**Significance (p < .05)**	**Factor Loading**	**Significance (p < .05)**
H1: VR Features -> Usability	0.77	Supported	0.83	Supported
H2: VR Features -> Presence	0.42	Supported	0.36	Supported
H3: VR Features -> Motivation	0.22	Supported	0.54	Supported
H4: VR Features -> Cognitive	0.10	NOT Supported	0.13	NOT Supported
H5: VR Features -> Control &	0.35	Supported	0.60	Supported
H6: VR Features -> Reflective	0.12	NOT Supported	-0.05	NOT Supported
H7: Usability -> Presence	0.19	NOT Supported	0.08	NOT Supported
H8: Usability -> Motivation	0.71	Supported	0.12	NOT Supported
H9: Usability -> Cognitive Benefits	0.75	Supported	0.75	Supported
H10: Usability -> Control & Active	0.55	Supported	0.35	Supported
H11: Usability -> Reflective	0.70	Supported	0.80	Supported
H12: Presence -> Learning	0.20	Supported	-0.02	NOT Supported
H13: Motivation -> Learning	0.16	Supported	0.14	Supported
H14: Cognitive Benefits ->	0.14	Supported	0.14	Supported
H15: Control & Active -> Learning	0.33	Supported	0.30	Supported
H16: Refl. Thinking -> Learning	0.36	Supported	0.26	Supported
H17: VR Features -> Virtual			0.76	Supported
H18: VR Features -> Social			0.35	Supported
H19: Usability -> Virtual Identity			-0.17	NOT Supported
H20: Usability -> Social Construct.			0.25	Supported
H21: Virtual Identity -> Presence			0.35	Supported
H22: Virtual Identity -> Motivation			0.00	NOT Supported
H23: Social Construct. -> Contr. &			-0.11	Supported
H24: Social Construct -> Refl.			0.12	Supported
H25: Virtual Identity -> Learning			0.08	NOT Supported
H26: Social Construct -> Learning			0.13	Supported

See Figure 11 for a graphical summary of the SEM analysis results, based on the CFI and RMSEA fit indices. The CFI of the 5-factor model is higher than the CFI of the Lee *et al* (2010) model (.991 > .979), and the CFI of the 7-factor model is higher than the CFI of the 5-factor model (.993 > .991). The RMSEA of the 5-factor model was lower than the RMSEA of the Lee *et al* (2010) model (.048 < .063), and the RMSEA of the 7-factor model was lower than the RMSEA of the 5-factor model (.037 < .048). This graph summarizes the quantitative analysis results which provide evidence that the 5-factor model confirms and extends the Lee *et al* (2010) study to describe learning in a virtual world environment, and the 7-factor model further refines the model to more accurately predict the observed survey data. The red loop around the 7-factor model indicates the RMSEA confidence interval from LO 90=.000 to HI 90=.059.

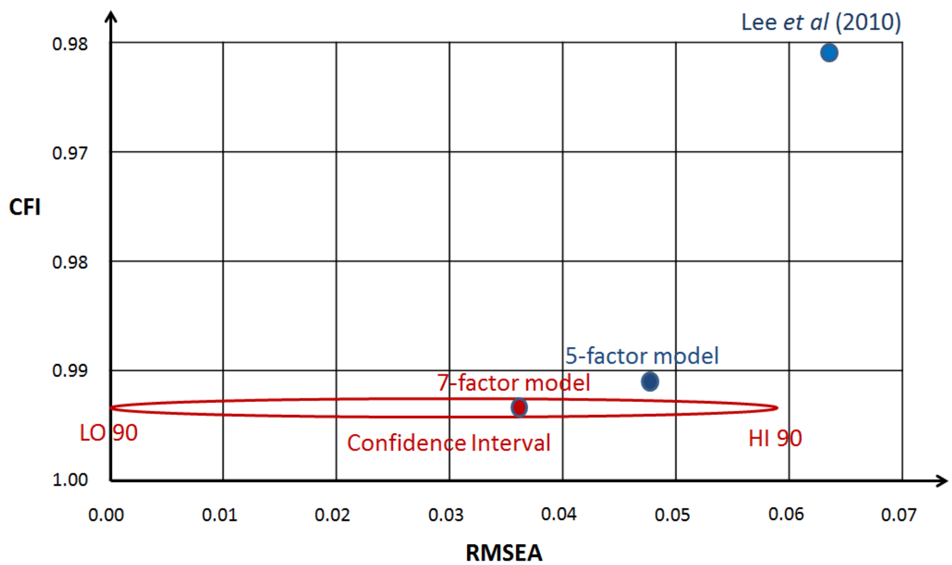


Figure 11. A graphical summary of the SEM analysis results, based on the CFI and RMSEA fit indices.
The red loop around the 7-factor model indicates the RMSEA confidence interval, from LO 90=.000 to HI 90=.059.

7. Discussion

This study proposed to extend the Lee *et al* (2010) research model to the multi-user virtual world of Second Life, where avatars embody self-representation, and social co-presence combined with communication affordances support the interaction and collaboration between users required for the social construction of knowledge. This study also hypothesized a refined model which included two additional psychological constructs (Virtual Identity and Social Constructivism), and examined the global population of Second Life virtual world users for evidence to determine if the inclusion of these constructs would improve the ability of the model to fit survey data collected from participants having a structured learning experience in the virtual world. Because the study participants covered the full range of possible levels of avatar customization, identification with their virtual self-representation, and perceived collaboration and support from others, this study could be viewed as a natural experiment.

7.1 The impact of Virtual Identity on Presence and Motivation

SEM analysis of the hypothesized model found that the construction of a virtual identity as an avatar had a significant and positive standardized estimated covariance (.35) with the perception of presence within the virtual world. No significant factor loading was found between virtual identity and motivation. Qualitative analysis of open-ended responses found an emergent behavior: participants consistently reported a high level of emotional attachment to their highly customized avatars as an idealized self. This identification with an idealized self-representation, combined with the heightened sensation of presence within the virtual world, was often reported to result in a more confident identity with increased motivation to engage socially with others, and cognitively with learning tasks. These findings support the assertion of recent research that embodiment in gamified instructional design tends to increase engagement, deeper understanding, and higher levels of satisfaction with the learning experience (Abrahamson, 2014; Banks & Bowman, 2016).

7.2 Implications for instructional design

These findings imply that the instructional design of virtual learning environments would be enhanced through the provision of time and infrastructure to create an idealized self-representation, which is a balance between a recognizable self and an enhanced self. Students need to be given guidance and allotted time to set up their profiles to present a confident, happy, and social face for future interactions with peers. Further development of an online identity can take place using an introductory online discussion forum, which can be provided for users to post a picture of themselves engaging in a favorite hobby, pastime, or social occasion. Profiles and introductory forums initiate the process of creating a social environment which links names to faces, and faces to projected personalities (Knutzen & Kennedy, 2012).

These instructional design strategies are designed to assist users of the virtual learning environment to make attitudinal changes in self-efficacy, trust, and the willingness to take risks. Once users commit to this meta-cognitive strategy to create a more confident social self-presentation, they are more likely to achieve a learning self-identity (Kolb & Kolb, 2009). The implementation of meta-cognitive strategies to increase social interaction can help users dissolve social boundaries, enhance the development of a learning community, and the network-based peer production of artifacts (Barab *et al*, 2005; Craig, 2007; McGee, 2007; Dede *et al*, 2005).

7.3 The impact of Social Constructivism on Agentic Learning

SEM analysis of the hypothesized model found that an increased perception of a learning environment which supports the social construction of knowledge had a significant and negative standardized estimated covariance (-.11) with the perception of an agentic learning environment, where the user is active and in control of their actions. One possible explanation for this finding is that in a social and shared learning environment, virtual world users engaged in a collaborative task may perceive a decrease in their feeling of being in control, or less active in their learning. If individual roles are not clearly delineated in the group activity, it is reasonable that this may reduce the feeling of individual agency in the learning process, or "ownership" of the knowledge produced.

These findings confirm and extend some prior research (Compeau & Higgins, 1995; Rutten *et al*, 2015; Pellas, 2014), and may contribute to the direction of future research and instructional design using shared virtual environments. The Compeau & Higgins study (1995) found that support had a negative influence on self-efficacy and outcome expectations, and the researchers surmised that the presence of high levels of social support might actually hinder the formation of high self-efficacy judgments. The Rutten *et al* (2015) study found that the level of active student participation was lower when teachers implemented the inquiry cycle as part of instruction. Rutten *et al* (2015) explained this inverse relationship by noting that the teachers found it difficult to teach according to the inquiry cycle and still provide the opportunity for the students to answer questions. This finding may also apply to the virtual world, in that the instructional design needs to carefully design the learning activity so that the social construction of knowledge does not preclude the active participation of all students. The Pellas (2014) study found that while cognitive and emotional engagement increased with self-efficacy, meta-cognitive self-regulation, and affective self-esteem, the active learning and participation defined as behavioral engagement decreased. The researchers in the Pellas (2014) study speculated that this outcome may be due to poor instructional design of the virtual world activities which did not require much participation from the most confident students. This study also suggested that the instructional design of learning activities in the virtual world could include interoperability with the web-based LMS Moodle (Pellas, 2014).

7.4 Implications for instructional design

These findings could guide the instructional design of self-guided, gamified collaborative learning to counteract this potential degradation of student agency and intentional learning within shared virtual environments. A learning activity in a virtual world should require the development of group strategies and roles which actively engage all of the participants (Bower *et al*, 2017). To effectively design such an activity, the social interaction must be an inherent requirement for success. Emotional engagement can be achieved through the inclusion of gamified elements which make up that elusive quality of fun (Alsawaier, 2018). The development of a strategic plan and role assignment should engage the participants cognitively, and then the exciting implementation of tactics should require every group member to play an active role to capture the flag, defeat the Dark Lord, or dramatically cure the patient of disease (Kim *et al*, 2018; Van Eck, 2006).

7.5 The impact of Social Constructivism on Reflective Thinking

SEM analysis of the hypothesized model found that an increased perception of a learning environment which supports the social construction of knowledge had a significant and positive standardized estimated covariance (.12) with reflective thinking. The analysis of the qualitative responses also supported the positive relationship between these constructs, with the additional insights that increased reflection may be motivated more by difficulties than easy success, and that most people are not aware of the internal review that reflection entails. This finding confirms existing research and the implementation of "productive failure" and "epistemic games" in the instructional design of discovery learning (Abrahamson and Kapur, 2017).

7.6 Implications for instructional design

The design of learning environments in the virtual world which are more likely to be perceived as supportive of the social construction of knowledge has not been adequately addressed in the research literature (Ghadirian *et al*, 2014). The sharing of tacit knowledge from early adopters is rarely available (Lakhmani *et al*, 2016), and most teachers attempting to create a virtual learning space have very little design training or experience. Technical staff are often assigned to the setup and maintenance of a virtual learning space, although they have no pedagogical background or classroom teaching experience. Effective virtual world design requires the intersection of technology, pedagogy, and content knowledge expertise, but the TPACK approach is difficult to achieve in most educational settings. Resources such as Cudworth's (2014) book about Virtual World Design which explain the rudiments of terraforming, sound and lighting design, and the use of cameras and avatars, are starting to become recognized as essential primers for the use of 3D immersive technology in education.

7.7 The impact of Virtual Identity on Learning Outcomes

Although SEM analysis of the hypothesized model did not find a significant factor loading for the Virtual Identity construct with the learning outcomes, the qualitative responses often indicated that study participants felt that their idealized virtual identities had a strong impact on their affective attitude: more confident, more willing to interact socially, and increased self-efficacy in dealing with challenges. These qualitative responses confirm recent research (Yee, 2014; Watts, 2016). Future research could explore the development of quantitative and qualitative survey items which more effectively differentiate between the various roles that an idealized virtual identity plays in social interactions and group collaboration on problem solving.

7.8 The impact of Social Constructivism on Learning Outcomes

SEM analysis of the hypothesized model found that the perception of a learning environment that supports the social construction of knowledge had a significant and positive factor loading (.13) with learning outcomes. This construct was significantly dependent on both VR features (.35) and system usability (.25). This implies that the ability to create a social constructivist environment depends on both the communication features offered by the system, and how they are incorporated by the instructional design to support and facilitate interaction between users. Qualitative responses revealed that many users revel in the affordances of the virtual world that support collaboration within groups, and that this alternative social world is key to their engagement with learning tasks they might not attempt in the physical world (e.g. coding, clothing design, the construction of houses, etc). This finding confirms the recent study by Cho & Lim (2017) investigating the effectiveness of collaborative learning within 3D virtual worlds.

8. Limitations

One limitation of this study is that of non-probability sampling. The original class of university students was selected using convenience sampling. Subsequently, the other approximately 2000 participants from the global Second Life user population self-selected to attempt the Quest activity, which can cause a biased sample that responds differently compared to the people who did not choose to participate.

Another possible limitation of this study is the indeterminate focus of the survey. Judging from the qualitative responses to the open-ended survey items, some responses were about the participants' attitude towards the Quest experience they had just completed (A_B, or user attitude towards a specified behavior using that object), while some responses were about their general attitude towards their entire history of experiences using the virtual world technology (A_O, user attitude towards the object). If some participants were responding to the survey items based on A_O instead of A_B, this will reduce the validity and generalizability of the study findings (Fishbein & Ajzen, 1975; Davis, 1993).

Although the use of SEM as a second-generation statistical technique allows researchers to answer a set of inter-related research questions in a single comprehensive analysis (Gefen *et al*, 2000), it has weaknesses that must be recognized and addressed. For a given set of data and variables, the penalty of model complexity states that the goodness-of-fit of a more complex, highly parameterized model tends to be greater than for simpler models because of the loss of degrees of freedom of the complex model (Stieger & Lind, 1980). In counterpoint, the RMSEA fit index favors parsimony in that it will choose the model with the lesser number of parameters, and thus avoids the penalty of model complexity. The SEM analysis of this study used the RMSEA fit index to evaluate model goodness-of-fit, paired with the older CFI relative fit index.

8. Conclusions and future research

This research found strong evidence to confirm the validity of extending the Lee *et al* (2010) model to the multi-user virtual world. This study also found even stronger evidence to support the hypothesized seven-factor model, finding that the inclusion of Virtual Identity and Social Constructivism constructs improved the ability of the model to fit the observed survey data. The use of SEM analysis allowed this study to test the two competing models (5-factor vs 7-factor) with the same data, and the results are easily replicated (Kline, 2015). These findings are significant because they build on the hybrid TAM/TML approach pioneered by Lee, Wong, and Fung (2010) to create a theoretical framework which more accurately describes the learning process in the virtual world.

The inclusion of Virtual Identity and Social Constructivism constructs in a theoretical framework which accurately describes the learning process is essential to designing effective learning experiences within the virtual world. The perception of immersive presence in a virtual world is a *sine qua non* for user engagement, and the new conceptual model indicates that the construction of an idealized virtual identity is a strong precursor to presence. The virtual world is an ideal "safe zone" for social interaction and small-group collaborative work. This conceptual framework also indicates the importance of designing learning experiences which are based on the social construction of knowledge, with the benefits of increased reflective thinking and a potential effect on the perception of control and active learning.

Overall, the five-factor model confirmed and extended the prior research model of Lee (2010) to the multi-user virtual world of Second Life, where avatars embody self-representation, and a communication infrastructure supports interaction and collaboration between users for the social construction of knowledge. The inclusion of two new constructs (Virtual Identity and

Social Constructivism) was found to improve the ability of the model to fit survey data collected from participants having a structured learning experience in the virtual world. The inclusion of these two new constructs in a 7-factor theoretical model may have a wide range of implications for the instructional design of learning activities using the virtual world.

Future research can build upon these findings in three directions: further refine the theoretical model and improve upon the method, develop a cyclic or iterative model to predict the intention to continue using the virtual world, and develop a general or unified theoretical framework.

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Appendix A

Quantitative survey items and sources.

Note: **(R) = reverse coded**, and strike-through (e.g. ~~3.~~) indicates items that were dropped from the calculation of the scale composite score for that construct.

Measurements	Items	Sources
Representational Fidelity	1. The realism of the images in the virtual world motivates me to learn. 2. The smooth movement in the virtual world makes learning more motivating and interesting. 3. The realism of the images in the virtual world helps to enhance my understanding.	Dalgarno *et al* (2002)
Immediacy of Control	1. The ability to look at objects from different sides in the virtual world allows me to learn better. 2. The ability to move around and explore in the virtual world makes learning more motivating and interesting. 3. The ability to change my avatar within the virtual world makes learning more motivating and interesting.	Dalgarno *et al* (2002), Knutzen (Q3)
Perceived Usefulness	1. Using this virtual world enhances the effectiveness of my learning. 2. This virtual world is useful in supporting my learning. ~~3.~~ I'd rather learn in a more traditional way. (**R**)	Davis (1989), Martens, Bastiaens, & Kirschner (2007),
Perceived Ease of Use	1. Learning to operate this virtual world is easy for me. 2. Learning how to use this virtual world in is too complicated and difficult for me. (**R**) ~~3.~~ This virtual world is easier to use for people who have a visual learning style.	Davis (1989) Antonietti, Ras, Imperio, & Sacco (2000)
Presence / Co-presence	1. I feel a sense of presence (being there in the virtual world) while learning with this virtual world. ~~2.~~ I feel a sense of co-presence (being there with	Lee *et al* (2010), Knutzen (Q2)

	others in the virtual world) while learning with this virtual world.	
Virtual Identity	~~1.~~ I feel that my avatar in this virtual world shows people what I am really like. 2. I feel that my avatar represents an extension of my real-life identity. 3. Using my avatar to explore the virtual world helps me to feel like I'm really there. ~~4.~~ Using my avatar to explore the virtual world helps motivate me to learn.	Schott & Bellin (2000) (Q1); Neustaedter & Fedorovskaya (2009) (Q2), Knutzen (Q3-4)
Motivation	1. I put a lot of effort into this virtual world. 2. It was important for me to do well using this virtual world. 3. This virtual world did not hold my attention. (**R**)	McAuley, Duncan, & Tammen, (1989)
Cognitive Benefits	1. This virtual world makes the comprehension of concepts easier. 2. This virtual world helps me to better apply what I learned. 3. This virtual world helps me to better analyze the problems.	Antonietti, Ras, Imperio, & Sacco (2000)
Control and Active Learning	1. This virtual world allows me to be more responsive and active in the learning process. 2. This virtual world allows me to have more control over my own learning. ~~3.~~ This virtual world promotes self-paced learning.	Lee et al (2010)
Social Constructivism	1. The learning environment in the virtual world stimulates contacts with my fellow students. 2. Social interaction and discussion with my fellow students contributed in a positive way to my own learning. ~~3.~~ The learning environment in the virtual world	Martens, Bastiaens, & Kirschner (2007), Maor & Fraser (2005), Knutzen (Q3-4)

	helped me to feel in control and active in my learning. 4. Social interaction in the virtual world and discussion with others helped me to reflect on my learning.	
Reflective Thinking	1. This virtual world helped me to reflect on how I learn. 2. This virtual world helped me to link new knowledge with my previous knowledge and experiences. 3. This virtual world helped me to think deeply about how to become a better learner.	Maor & Fraser (2005)
Perceived Learning Effectiveness	1. I gained a good understanding of the basic concepts using this virtual world. 2. I was interested and stimulated to learn more in this virtual world. 3. What I learned in the virtual world, I can apply in a real context.	Benbunan-Fich & Hiltz (2003), Martens, Bastiaens, & Kirsrchner (2007)
Satisfaction with the learning environment	1. I was satisfied with this virtual world learning experience. 2. A wide variety of learning experiences was provided in this virtual world environment. 3. I don't think this virtual world environment would benefit my learning achievement. (**R**)	Chou & Liu (2005)

Qualitative survey items (all self-developed by the researcher)

1. Can you describe your prior experience in a virtual world or virtual reality (if any)? *(PriorVirtualExp)*
2. Do you think that the virtual world experience helps you remember what you learned? If yes, why? If not, how would you change the virtual world experience to help you remember what you learned? *(CogBenefits)*
3. Do you feel that learning in the virtual world is effective? If yes, why? If not, how would you change the virtual world experience to make the learning more effective? *(LearnEffective)*
4. Do you feel satisfied with your experience learning in the virtual world? If yes, why? If not, how would you change the virtual world experience to make your learning experience more satisfying? *(Satisfaction)*
5. When you set up your avatar, did this change your feeling of presence (being there in the virtual world), or affect your motivation to learn? If yes, why? If not, how would you change the avatar to increase your feeling of presence, or increase your motivation to learn? *(PresenceMotivation)*
6. When you communicated with others in the virtual world, did this make you feel more involved with your experience, or make you reflect on your experience? If yes, why? If not, how would you change the communication with others to increase your involvement or reflection? *(SocialReflection)*
7. Do you think that your preferred learning style (visual vs verbal) or spatial ability (ability to see or manipulate shapes) might affect your virtual world learning experience? *(LearningStyle)*
8. Do you have any suggestions for improving the virtual world experience as a tool for learning? *(Suggestions)*

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