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A Hybrid Model of Experiential Learning within the Social Virtual World of Second Life

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Abstract

This study examined how multi-user virtual worlds can enhance learning, by extending and refining a prior VR-based model to include two new constructs: *virtual identity*, and *social constructivism*. The fit of the model was analyzed using structural equation modeling (SEM), 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.

1. Introduction

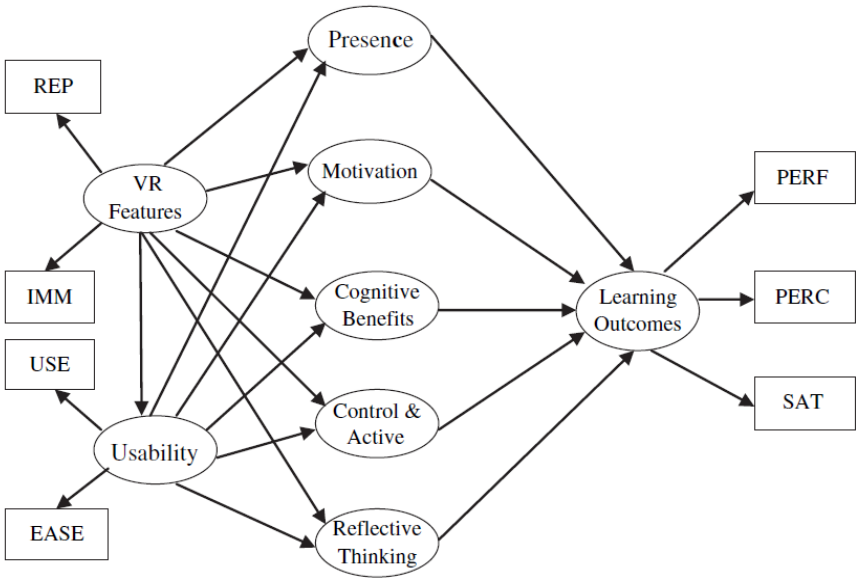
This study examined how multi-user virtual worlds can enhance learning by extending and refining a prior VR-based model to include two new constructs: *virtual identity*, and *social constructivism* (the perception of an environment that supports the social construction of knowledge). This mixed-methods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

In 2010 Lee, Wong, and Fung developed a hybrid model to describe learning in virtual reality (VR) by combining elements of both the TAM and TML theories, and used structural equation modeling (SEM) to measure the fit of their model to the observed data. The current study sought to replicate the methodology of the pioneering Lee et al. (2010) study, including the survey instrument and the SEM analysis procedure, in order to increase the validity of extending that hybrid model to a new learning context. This study extended the Lee et al. (2010) model to the virtual world environment, and refined it with two new constructs, to better describe learning experiences in the social virtual world of Second Life.

2. Conceptual Background

The Lee, Wong, and Fung (2010) study examined how desktop-based VR technology supports and enhances learning. Their study blended elements of both TAM and TML models to create a hybrid conceptual model (see Figure 1). Like the Salzman, Dede, Loftin, & Chen, (1999) input-process-output TML model, the Lee et al. (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 et al. (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 et al. (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, Backman, Backman, & Chang, 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 et al. (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.

The VR learning environment used in the Lee et al. (2010) study was V-Frog, a single-user 3D virtual environment which enables the simulated dissection of a frog. V-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 et al. (2010) research model, with its five psychological factors describing the learning experience, to the multi-user virtual world of Second Life.

The current study (2018) also proposed to refine the Lee et al. (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 which mediate the learning experience: Virtual Identity, and Social Constructivism.

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 2).

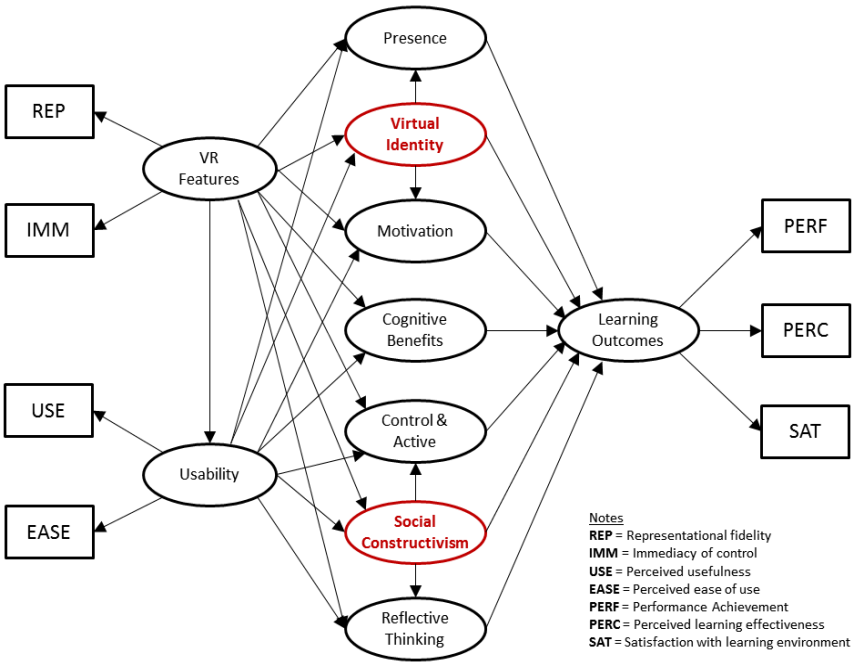


Figure 2: The proposed 7-factor research model refines the Lee et al. (2010) model to better describe the learning experience within a virtual world.

4. Research Hypotheses

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?

2. 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?

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

4. How do these constructs correlate with enhancing the learning outcomes based on experiences in the virtual world?

To answer these research questions, the following hypothesized structural model was developed, with the two new constructs and hypothesized relationships in red (Figure 3):

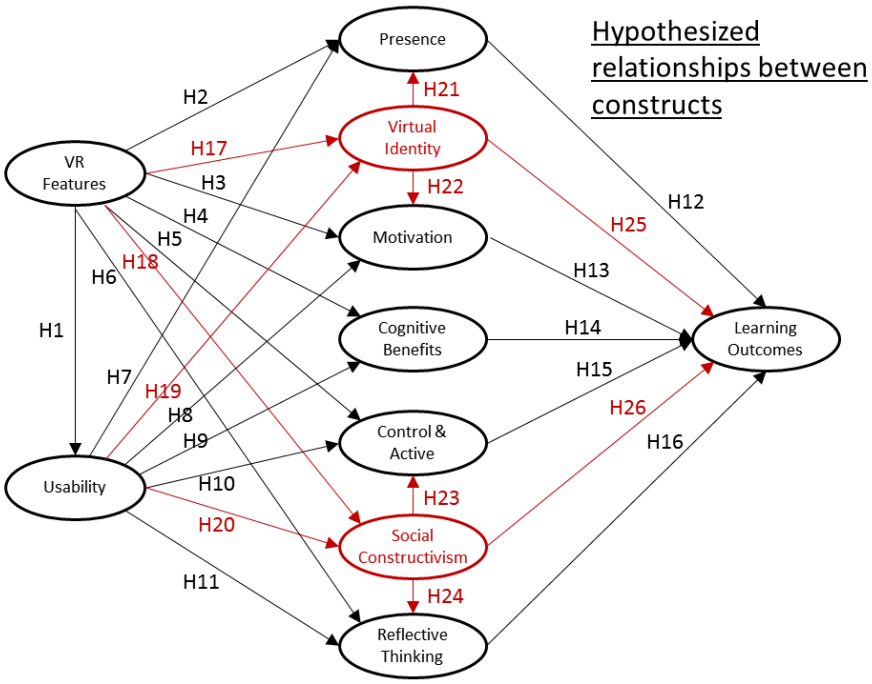


Figure 3: Hypothesized relationships between constructs of the proposed 7-factor structural model, with the two new constructs and hypothesized relationships in red.

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 as an English poem 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 period of 15 months, an estimated population of 2000 users attempted the Quest experiential learning activity. This activity challenged participants to hunt for hidden treasures 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 11th 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. The minimum age of participants in the sample was 18, and the mean age response was in the range 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 global online 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.

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.

5.3. Survey Instrument

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 et al. (2010) study. 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.

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.

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

The Performance Achievement construct had the lowest convergent validity, 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).

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 were measured using SPSS DESCRIPTIVES. 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, 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.

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. No observations were excluded.

6.3. Minimum Sample Size for Analytical Power Using RMSEA Fit Index

Literature in the SEM analysis research area commonly states that a reasonable threshold for the minimum sample size is 200 (Kenny, 2015; Barrett, 2007, p. 820). With a sample size of n=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 the 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 the 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.

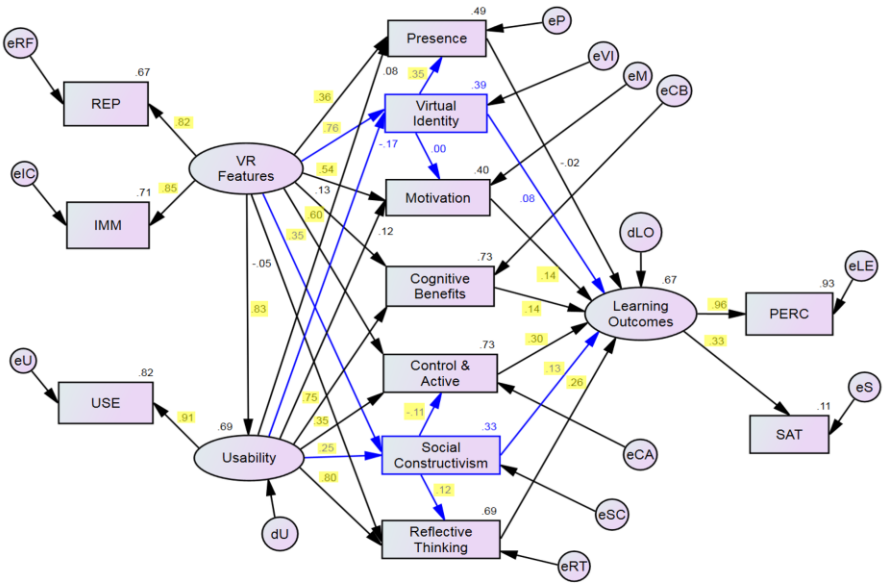
6.5. Structural Model

A structural 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 uni-dimensionality 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. The scale composite values for all seven single-indicator psychological variables were calculated using SPSS and stored in the data file.

6.6. 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. 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 4 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.



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 4: 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

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.

See Table 1 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 1: 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 Benefits	0.10	NOT Supported	0.13	NOT Supported
H5: VR Features -> Control & Active	0.35	Supported	0.60	Supported
H6: VR Features -> Reflective Thinking	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 Thinking	0.70	Supported	0.80	Supported
H12: Presence -> Learning Outcomes	0.20	Supported	-0.02	NOT Supported
H13: Motivation -> Learning Outcomes	0.16	Supported	0.14	Supported
H14: Cognitive Benefits -> Presence	0.14	Supported	0.14	Supported
H15: Control & Active -> Learning Out.	0.33	Supported	0.30	Supported
H16: Refl. Thinking -> Learning Out.	0.36	Supported	0.26	Supported
H17: VR Features -> Virtual Identity			0.76	Supported
H18: VR Features -> Social Construct.			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. & Active			-0.11	Supported
H24: Social Construct -> Refl. Thinking			0.12	Supported
H25: Virtual Identity -> Learning Out.			0.08	NOT Supported
H26: Social Construct -> Learning Out.			0.13	Supported

The CFI of the 7-factor model is higher than the CFI of the Lee et al. (2010) model (.993 > .979), and the RMSEA of the 7-factor model was lower than the RMSEA of the Lee et al. (2010) model (.037 < .063). These quantitative analysis results provide evidence that the 7-factor model extends and refines the Lee et al. (2010) study to describe learning in a virtual world environment.

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 hypothesized a refined model which included two additional psychological constructs (Virtual Identity and Social Constructivism). It tested this refined model by examining the global population of Second Life virtual world users for evidence to determine if the inclusion of these additional constructs would improve the ability of the model to fit survey data collected from participants having a structured learning experience in this social 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 Effective Virtual World 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 in making 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 et al., 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 might 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 Effective Virtual World 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. 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 Effective Virtual World 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 is 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, or the construction of houses.). 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 small 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, and of that group 405 participants were willing to complete the survey. This voluntary response to do the activity and complete the survey can cause a biased sample that responds differently compared to the people who did not choose to participate, or did not choose to complete the survey.

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 would reduce the validity and generalizability of the study findings (Fishbein & Ajzen, 1975; Davis, 1993).

9. Conclusions and Future Research

This research found strong evidence to confirm the validity of extending and refining the Lee et al. (2010) model to the multi-user virtual world. This research found that the inclusion of Virtual Identity and Social Constructivism constructs improved the ability of the model to fit the observed survey data. 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 hypothesized seven-factor model confirmed and extended the prior research model of Lee et al. (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 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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