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Learning Concentration on Virtual Reality Learning: Scale Development and a Pilot Study

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Abstract: The purpose of this study was to develop and validate a multidimensional instrument for elementary and junior high school students' learning concentration on learning using Virtual Reality Technology. Two studies were conducted. The VR Learning Scale (VRLS) was developed based on in-depth literature review and theories followed by a review of eight experts. Data from 259 students ranging from 4th grade to 7th grade with VR learning experience was collected and analyzed using the exploratory factor analysis, the VRLS was validated in four dimensions: immersion, behavior concentration, cognitive concentration, and emotional concentration. A pilot study of 37 elementary school students was conducted and the results indicated the significant correlation between the four factors of VR learning and, learning motivation, technology acceptance and satisfaction. Implication for future studies is provided.

Keywords: learning concentration, VR learning, Virtual Reality

1. Introduction

Virtual Reality (VR), also known as Immersive Virtual Environments (IVE), creates the impression of being in a virtual world and produces sensory stimuli that surround the subject perceptually. The adoption of VR for learning has redefined learning environments. The advancement of VR technology, coupled with a drop in prices and increased affordability, has attracted educators' attention (Bower et al., 2020; Huang et al., 2019), enabling educational institutions to seamlessly integrate it into their teaching practices. The integration of VR devices into learning scenarios has provided students with diverse and engaging experiences. Three primary types of virtual reality (VR) used in educational settings can be delineated: (1) VR for observational learning, (2) VR for skill training, and (3) VR for creative endeavors. When effectively implemented, VR can provide a profound sense of presence and immersion, opening up new educational possibilities (Häfner et al., 2018).

The most recent studies have focused on the adoption of VR to facilitate learning or have discussed the development of VR content alongside learning strategies (Hamilton, et al., 2021; Won et al., 2023). However, there is a gap in the research when it comes to evaluating learner interaction and participation during VR-based learning experiences. Therefore, the primary objective of this study was to develop a VR Learning Scale (VRLS) that assesses the spectrum of learner involvement and engagement, drawing inspiration from Witmer and Singer's (1998) explication of presence, immersion and engagement. The resulting scale was validated through factor analysis. This paper provides an overview of the development process of the VRLS and its subsequent evaluation using Exploratory Factor Analysis (EFA). A pilot study was conducted to further investigate students' VR learning experience.

2. Literature Review

Utilizing VR to support learning provides learners with immersive environments and educational experiences. These experiences have the potential to enhance learner engagement, ultimately leading to increased involvement and self-directed exploration over

the course of the learning process (Won et al., 2023). The effectiveness of virtual environments would be related to the sense of presence, and according to Witmer and Singer (1998), presence is defined as the subjective experience of being in one place or environment, and refers to experiencing the computer-generated environment rather than the actual physical locale. To measure presence, one should address factors that influence involvement and immersion. Involvement depends on the degree to which individuals attach themselves to stimuli, activities, or events. When individuals pay more attention to the stimuli within the virtual environment (VE), their engagement with the VE experience increases (Witmer & Singer, 1998). Immersion refers to interacting with an environment that provides a continuous stream of stimuli and experiences (Witmer & Singer, 1998). A VE that generates a greater sense of immersion will result in higher levels of presence. Both involvement and immersion are necessary for experiencing presence. Involvement

The developed VRLS in this study encompassed two primary factors: immersion and learning concentration. The items assessing immersion were drawn from a Presence Questionnaire (PQ) developed by Witmer et al. (2005), which gauges the extent to which individuals experience presence in a virtual environment. The PQ factors include Involvement, Adaptation/Immersion, Sensory Fidelity, and Interface Quality. Specifically, items from the Adaptation/Immersion factor were incorporated into our VRLS. For learning concentration, the items were designed to capture the flow experience, involvement, and learning engagement. Flow, as defined by Csikszentmihalyi (1975, p. 36), is a 'holistic sensation that people feel when they act with total involvement.' Involvement, according to Witmer and Singer (1998), represents a state resulting from focusing one's mental energy and attention on a coherent set of stimuli or meaningfully related activities or events. Fredericks, Blumenfeld, and Paris (2004) posit that engagement comprises behavioral, emotional, and cognitive dimensions, with engagement playing a pivotal role in successful learning (Henrie, Halverson, & Graham, 2015). A higher level of engagement holds the potential to yield favorable learning outcomes (Lee, 2014). Therefore, items from the behavioral, cognitive, and emotional scales were incorporated into the measure of learning concentration within the VRLS.

3. Results and Conclusion

3.1 Results: Instrument Validity and Reliabilities

The developed VRLS, encompassing two primary factors: immersion and learning concentration. To ensure the content validity, the VRLS was reviewed by eight experts, including three college professors specializing in educational technology, and five experts who are current elementary and junior high school teachers. 259 students ranging from 4th grade to 7th grade with learning experience with VR participated in this study. As to the construct validity, the item-analysis result indicated the CR value of each item was above 3.0 and reached the significant level. An EFA determined the factor structure with KMO values exceeding .90 for each factor. Principal component analysis with Varimax orthogonal rotation extracted the factors. Items with factor loadings below .40 were removed, and the scale structure was made up of four factors, immersion, behavioral concentration, cognitive concentration, and emotional concentration. The Cronbach's alpha (α) internal consistency reliability coefficient for each sub-scale was .94, .95, .97 and .96, respectively.

Additionally, this study tried to establish the validity of using the emotional graphics to present participants' emotion status. We invited 214 elementary students to match the six emotional graphics with corresponding text-based description. As shown in Table1, the emotional graphics mostly aligned with the intended emotional states, except the "Expected" item which accounted for 67.8%.

Table 1. Descriptive Results of Emotional Graphics for Presenting Participant Emotion Status

	Happy	Expected	Curious	indifferent	depressed	scared
Agreed	191	145	193	199	194	206
%	89.3	67.8	90.2	93	90.7	96.3

3.2 Pilot Study

37 students with the learning experience with VR participated in the study. Students' reported scores of the variables, including immersion, behavior concentration, cognitive concentration, emotional concentration, learning motivation, technology acceptance, and learning satisfaction, were listed in Table 2. As shown in Table 3, significant correlations between learning motivation and the four factors of VRLS were found. Similar results were obtained in the relationship between the four factors and technology acceptance. However, the relationship between immersion and learning satisfaction is not significant.

Table 2. Descriptive Results of Students' reported score *(N=37)*

	immersion	behavior concentration	cognitive concentration	emotional concentration	motivation	technology acceptance	Satis-faction
M	5.06	5.12	5.13	5.19	5.39	5.33	5.42
SD	0.64	0.96	0.82	0.81	0.98	1.06	0.85

Table 3. *The Correlation among Examined Variables (N=37)*

	motivation	technology acceptance	learning satisfaction
immersion	0.49**	0.43**	0.32
behavior concentration	0.40*	0.48**	0.36*
cognitive concentration	0.48**	0.50*	0.40*
emtional concentration	0.52**	0.63**	0.51**

3.3 Conclusion

In this study, the VRLS was developed based on a comprehensive review of the literature and comprised two primary factors: immersion and learning concentration. The scale items were adapted from Witmer et al.'s PQ (2005) and Fredericks, Blumenfeld, and Paris (2004). The VRLS demonstrated content and construct validity, and a pilot study of using the VRLS in comprehending students' learning experiences was carried out. Upcoming findings of this research series will be shared in the coming times.

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