The influence of learners' openness to IT experience on the attitude and perceived learning effectiveness with virtual reality technologies

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***Abstract*— The increasingly complex operations in multinational business imposes the need of more advanced training tools to facilitate learners to understand the operations through an interactive and immersive way. This paper analyses the use of virtual reality (VR) technology, a more interactive, immersive and intuitive learning environment when compared to conventional teaching pedagogical development, in teaching complex cargo terminal operations. Learners, upon training with the novel scenes in VR environment, are evaluated with their perception and perceived learning effectiveness through the VR training. Through the learning in the three aspects, the intrinsic factor of individual, including openness to IT experience, influence the perceived usefulness of VR training and attitude towards learning, are reviewed. The study also reflects that learners with open attitude to experience new IT usage perceived more usefulness during the training with the support of VR environment. These learners, with comparatively more positive views, are more engaged in learning during the training.**

Keywords—Virtual Reality; pedagogical development; openness to experience; perceived usefulness of VR; attitude towards learning; Technology Acceptance Model

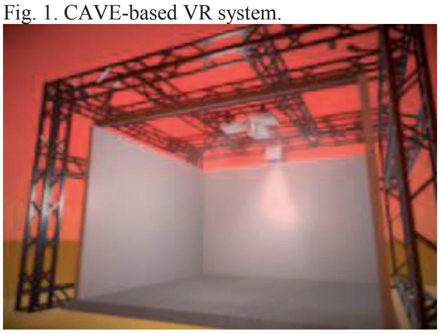
I. INTRODUCTION

Virtual reality (VR) product is selected as one of the top 25 inventions in 2016 [1]. With more technology players, including Facebook, Microsoft, Sony, HTC and Google, are keen in inventing and trademarking the VR technology, let alone Sony has already filed 366 patents for VR technologies [2], the hardware, software and applications development in this field has become the one of the important researches in the recent years. With the increasing demand of installed based VR headsets selling reached 7 million in 2016, it is forecasted that the consumer demand will reach 37 million by 2020. The revenues from VR hardware and software in 2016 is estimated with a USD3.7 billion in the industry, it is expected to reach more than USD40 billion by 2020 [3]. The number of users worldwide is increasing rapidly, results the projected economic impact of VR and Augmented Reality (AR) technologies by 2020 reaches USD15.6 billion. Thus, there is a rise on the VR technology development and the applications of VR are continuously being explored in the industry.

Inventions and experiments related to VR has been started as early as in the 1950s. Reference [4] developed a mechanical device called Sensorama, with three dimensional images, peripheral vision, and multiple senses, including sight, sound, smell and touch. Sutherland [5] developed a VR and augmented reality (AR) head-mounted display (HMD) in 1968, followed by Aspen Movie Map, a hypermedia and VR system, from MIT in 1978, showing a virtual simulation of Aspen, Colorado. Reference [6] later developed various VR devices, including Data Glove, Eye Phone and Audio Sphere. Reference [7] developed the first cubic immersive room, Cave Automatic Virtual Environment (CAVE), which is a cube with display-screen faces surrounding the viewer who moves within the CAVE. The VR systems detect the position of user and project immersive and interactive scenes with corresponding field of view and stereo projection. VR is then started to be commercialised with various devices launched in the market, including Sega VR headset [8], VFX1 headset [9], Oculus Rift [10], Google Cardboard [11] and HTC Vive [12]. Advanced features and functions are further developed, e.g. higher resolution, wireless headset, better sensor tracking, and more interactive user-interface.

The invention of CAVE in the early 1990s has triggered extensive research in developing user-friendly and low-cost CAVE-like products for teaching, research and industrial applications. The CAVE is comprised of a cube integrated with screens, 3D projectors, motion capture system, stereoscopic LCD shutter glasses, and computer hardware and software for the VR systems. Considering the field of view, user experience and system specifications, CAVE is built in different forms, including cube shape [13][14][15], Fishtank VR systems [16], Star-CAVE [17], L-shape CAVE [18], and Dome-shape CAVE [19]. A CAVE-based system is developed with a cube-like structure with four 3D projectors and screens, audio and acoustic system, server, display system, 2 high performance workstations, frame and tracking systems, 3D modelling and VR software, and 12 sensors. The CAVE setup is shown in Figure 1.

Fig. 1. CAVE-based VR system.



VR has been applied in many applications in the recent years, including logistics and transport [20], manufacturing [21], product design [21], construction [22], healthcare [23], art appreciation [24] and education [25][26]. The VR CAVE technology has been applied in teaching and learning in various disciplines, including science [27][28], engineering [29], healthcare [30], cultural heritage [31], and logistics [32]. With the use of VR in teaching and learning, users are able to understand the complex teaching content in an interactive, immersive and multi-dimensional way anytime anywhere. Through immersing into the designed VR scenes, users can understand complex material handling systems in air cargo terminal, practice crane operations in container terminal, and appreciate ancient art and culture. This facilitates users learn the context in a more vivid, visualised and interactive way.

Applying VR CAVE in education has been started in various disciplines for years. With the VR technology moving ahead in a rapid way, are the public users accept the new advanced way of learning? What are their attitude towards these innovative learning platforms? How effective is the learning through VR compared to the traditional classroom learning? Majority of the research of VR focus on the technology knowhow and industrial applications. There are not much studies investigating the attitude, perception and effectiveness of using VR CAVE in the context of learning. Reference [33] investigated the VR users on their emotional responses towards virtual stimuli. Reference [34] studied learners' attitudes towards the VR learning environments and conducted a total of 190 university students who have been taught on how to use the VR system during learning. The questionnaire has been carried out with a constructivist theoretical approach with hypothesis testing on effects of using VR and its effectiveness on improving learners' problem-solving capability. The results indicated that immersion had a higher contribution than interaction and imagination for users when using VR while capability of VR interaction assisted the development of users' problem-solving skills.

The acceptance of VR technology and how the personality variables and presence in VR affect their learning performance are becoming important when VR starts to be widely adopted in education and trainings. Researchers investigated these human interactions and behaviour using various models, including Technology Acceptance Model (TAM) and Big Five personality traits. Bertrand and Bouchard (2008) investigated how TAM can be applied to the use of VR in clinical settings through sampling 141 adults who are interesting in using VR technology [35]. Kober and Neuper (2013) examined the relationship between personality variables and presence in VR with thirty female participants. Results indicated that absorption, mental imagination, perspective taking and immersive tendencies showed significant correlations with presence [36]. This paper analysed the attitude and perceived learning behaviour of users who are learning through the VR technologies, and how the learner's openness to IT experience as an internal factor affecting these attitude and perception. A study on the responses from 175 respondents have been carried out to investigate how the interactive and immersive VR simulation technologies assisted learning as well as evaluate whether there is significant relationship between openness to IT experience, perceived usefulness of VR training, and attitude towards learning.

II. HYPOTHESIS DEVELOPMENT

Reference [37] defined a VR experience as "any in which the user is effectively immersed in a responsive virtual world." (p.16). Because VR technology is responsive and interactive, it has been widely used in education, assisting teaching and training. Researches on VR in education usually focused on technical issues [38][39][40]. Users' attitude towards VR learning determines the degree to which they can be benefited from the VR-assisted teaching and training. In addition, the factors affect users' attitude are also worth research efforts.

The TAM suggested external factors influence users' attitudes towards a technology. Moreover, this relationship is mediated by perceived usefulness of a technology, defined as the degree to which a user feels the technology can enhance performance [41]. Reference [42] further developed the TAM model to TAM3 model, which indicated that perceived ease of use and perceived usefulness can also be determined by individual differences. People have high openness to experience, one of the Big-Five personality traits, tend to adopt an open attitude and be more willing to try new and different things [43]. Therefore, openness to experience is found to have a positive impact on perceived usefulness, technology acceptance and use (e.g. [44][45]). In the present study, we developed the openness to IT experience to depict individuals' openness and willingness to be exposed to VR technology. High openness to VR experience users are more willing to experience VR technology, which is new to them, hence they are more likely to believe that VR technology can enhance their learning and performance. Accordingly, we predict that:

H1: Users' openness to IT experience positively relates to their perceived usefulness of VR training.

Users' attitude towards learning describes people's attitude towards the use and applications of VR technology in learning other areas or disciplines. Users' positive attitude means they perceive VR technology can assist and facilitate learning in many disciplines. For example, a user of VR learning in operations management believes that VR technology can be extended to use for training and teaching in banking and finance or other disciplines. Consistent with TAM and TAM3, which states the perceived usefulness directly influences users' attitude, we can expect that the deeper the beliefs of usefulness, the more positive attitude they have towards VR training. Therefore, we hypothesize that:

H2: Users' perceived usefulness of VR training is positively associated with their attitude towards learning.

Drawing on TAM and TAM3, we also expect that:

H3: Users' perceived usefulness of VR training mediates the positive relationship between openness to IT experience and their users' attitude towards learning.

III. METHODOLOGY

A. Simulation learning in VR

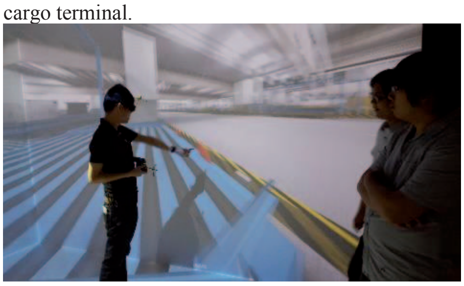
The increased complexity operations processes in corporations has posted a growing demand on data analysis and interactive visualization in many industries. The current mode of classroom teaching and learning using textbooks and case studies, or even field studies and on-site visits, are not able to illustrate the complexity of operations to the students. The multi-dimensions operations and statistics are often unable to be demonstrated in two-dimension textbooks or videos. Large data sets with multi-dimensions require sophisticated virtual environment for visualization. A lot of practitioners might not able to have a chance to visualize the end-to-end process of a company, the entire supply chain in logistics industry, or complex medical operations in healthcare industry. A mounting awareness in the security and safety of industrial operation sites has limited the accessibility of restricted areas for students to visit and understand their operations. Common restricted areas include cargo terminals, cranes, and vessels in logistics industry, trading platforms and servers in financial sectors, surgery operations in medical service, etc. Thus, teaching and learning using VR technologies simulating the actual environment in an interactive and immersive manner are becoming important for higher education.

A VR system with a CAVE-like structure is set up with three interactive and immersive scenes for teaching and learning. The VR simulation scenes include Logistics and transportation – a training on air cargo terminal operations and maritime port operations via VR learning platform. Learners in different age groups have been undergone the training scene.

B. Learning content

In logistics and transportation scene, the training covers the air cargo container, i.e. a unit load device (ULD), flowing through the air cargo terminal, from inbound to terminal, weighting and customs clearance, storage in material handling systems, transport in dolly, to loading into aircraft. Figure 2 shows the use of VR in illustrating the functions of the facilities in the air cargo terminal. An illustration of crane operations in a container terminal is also included.

Fig. 2. Using VR to explain and illustrate the functions of facilities in air cargo terminal.



C. Sampling

Participants in this study were students, full-time staff and visitors who participated the VR training mentioned above. Upon completion of the VR training, they were asked to complete a questionnaire.

In total, 175 person participated. The sample included 44 students (25.1%) and 128 full time worker (73.1%). With regard to their age, 5.1% were under 18, 69.7% in the range of 18-25; 8.6% were in the range of 26-35; 5.1% were in the range of 36-45; 8.0% were in the range of 46-60; and 2.3% were older than 60 years of age.

D. Survey

The survey has 11 questions (See Table I) that are to be evaluated using 7-point Likert scale (ranging from 1 which means strongly disagree" to 7 which means "strongly agree"). The survey is based on a constructivist theoretical approach to query learners' attitude towards the use of VR in learning.

TABLE I. MEANS AND STANDARD DEVIATIONS OF THE ITEMS AMONG STUDY VARIABLES

Items	*M*	*S.D.*
Openness to IT Experience		
I like being exposed to new advanced technologies, such as virtual reality and Internet of Things (IoT), etc.	6.00	.92
I like learning with the use of new technologies, platform and channels.	5.99	.98
I aware of the recent development of virtual reality and its application in education and training.	5.65	1.11
Perceived Usefulness of VR Training		
I find the use of virtual reality in learning is stimulating and interesting.	6.07	.97
I find using virtual reality will increase my interest in business operations in companies.	5.86	.98
I find using virtual reality can assist me to understand and learn complex business operations in logistics, finance, information technology and other disciplines.	5.86	1.16
Attitude towards learning		
Upon experiencing the Cave Automatic Virtual Environment (CAVE), I find the CAVE and VR are interesting and stimulating.	5.94	1.03
I find the visual effect in CAVE can arise my interest in learning.	5.80	1.05
I find the audio effect in CAVE can arise my interest in learning.	5.69	1.10
I find the immersive environment of CAVE can arise my interest in learning.	5.81	1.12
I find the interaction between human and virtual environment in CAVE can stimulate my learning.	5.87	1.07

E. Measures

1) Openness to IT Experience: Participants were asked to assess their openness to IT experience by use of a 7-point Likert scale. The measure contains three items, such as "I like being exposed to new advanced technologies, such a virtual reality and Internet of Things (IoT), etc.". Cronbach's alpha for the measure was .88.

2) Perceived Usefulness of VR Training: Perceived usefulness of VR Training was also assessed by each participant with a 5-item measure in 7-point Likert scale.

Sample item is "I find the visual effect in CAVE can arise my interest in learning". Cronbach's alpha was .90.

3) Attitude towards learning: Each participant was also asked to indicate their attitude towards learning with a 3-item measure. 7-point Likert scale was also adapted. Cronbach's alpha for this measure was .94.

IV. RESULT

A. Descriptive Statistics of Study Variables

Table II displays the mean, standard deviations, internal consistency reliabilities and bivariate correlations for the measures used in the current study.

TABLE II. MEANS, STANDARD DEVIATIONS, AND INTERCORRELATIONS AMONG STUDY VARIABLES

	M	*SD*	1	2	3	4	5
1. Student/ Employee[a]	.74	.44	--				
2. Age[b]	2.53	1.20	-.39**	--			
3. Openness to IT experience	5.88	.91	.05	.11	(.88)		
4. Perceived usefulness of VR training	5.82	.92	-.02	.11	.72**	(.90)	
5. Attitude towards learning	5.93	.89	-.08	.12	.81**	.82**	(.94)

Note. ***n*** **= 175 (listwise)**

[a] Dichotomous variable (0 = Student, 1 = Full-time Employee).

[b] Ordinal variable (1 = less than 18 years old; 2 = 18–25 years old; 3 = 26–35 years old; 4 = 36–45 years old; 5 = 46–60 years old; 6 = 60 years old or above).
*** *p* <.05, ** *p* <.01, two tailed.**

B. Hypotheses Testing

1) *Openness to IT Experience as Predictor of Perceived Usefulness of VR Training:* As shown in Figure 1, the Structural Equation Modelling (SEM) result showed that openness to IT Experience had a positive effect on perceived usefulness of VR training (β = .73, p < .001). This result supported the first condition for mediation. Therefore, hypothesis 1 was supported.

2) *Perceived usefulness of VR Training as Predictor of Attitude towards Learning:* The SEM result showed that perceived usefulness of VR training had a positive effect on attitude towards learning (β = .48, p < .001; see Figure 3), supporting the second condition for mediation. Therefore, hypothesis 2 was supported.

3) *The Mediating Effect of Perceived Usefulness of VR Training*: The SEM result in Figure 1 showed that openness to IT Experience related positively to attitude towards learning (β = .45, p < .001). Therefore, perceived usefulness of VR training partially mediated the openness to IT experience-attitude towards learning relationship. Thus, hypothesis 3 was supported.

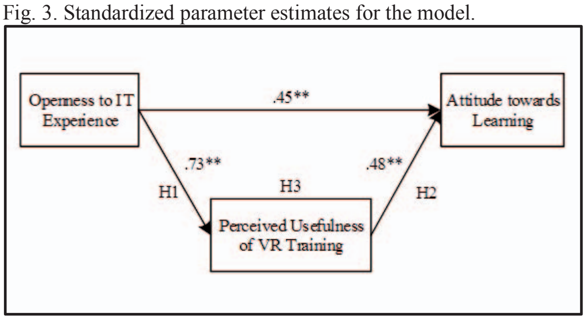
V. DISCUSSION AND IMPLICATION

This study contributes to the enrichment of our understandings towards the learning effectiveness of VR training, especially in education setting. Based upon TAM3, the findings of this study have advanced our understandings of the adaptation process of VR training by, firstly, exploring the impacts of individual intrinsic factor (i.e., openness to IT experience) on the perceived usefulness of VR training, thus the attitude towards learning. By exploring these relationships, our study contributes in bridging the gap between the management psychology and VR literature. The result showed that participants who are open to new experience in IT usage gave higher rating in the perceived usefulness in VR training and more positive towards learning. It reflected that people who are more willing to accept new experience are more adaptable to new form of learning like VR training and more likely to generate positive attitude to learn. This finding is consistent with the previous studies of big five personality in management literature, in which openness to experience is a crucial personal trait in determining the learning effectiveness of individuals [46, 47].

Secondly, this research also examined the important role of perceived usefulness of VR training in the learning process of VR training. According to TAM3, the perception of usefulness of technology mediated the relationship of individual differences and behavioral intention in learning, while previous studies such as references [48, 49] indicated that perceived usefulness is the strongest predictor of behavioral intention to adapt new learning practice. In this study, perceived usefulness of VR training help explaining why people with high openness to IT experience learn better than those who are low in openness to IT experience. It is because they own more positive view to VR training, so they are more engaged in the learning process of VR training, leading to more positive perception in learning, particularly in specific subject matters.

In the future, more research should be done to explore more individual difference factors, such as other traits in Big Five (such as conscientiousness, emotional stability, extraversion, and agreeable- ness) [50,51], and situational factors, such as complexity of the learning task [52,53] that may moderate the learning effectiveness of VR training.

Fig. 3. Standardized parameter estimates for the model.



VI. CONCLUSION

With the increasingly use of VR technology and its applications in education, educators needs to understand the effectiveness of training via VR, user acceptance and attitude towards new pedagogical methodology and challenges in adopting VR systems in teaching and learning. This paper reveals the intrinsic factor of individual, including openness to IT experience, influence the perceived usefulness of VR training and attitude towards learning. With reference to the

TAM3, the results on the measures on learners' attitude towards the use of VR in learning revealed that participants who are open to new experience in IT usage showed higher ratings in the perceived usefulness in VR training and more positive towards learning. The findings in examining the role of perceived usefulness of VR training processes are also consistent with the the big five personality management theories, in which openness to experience is a crucial personal trait in determining the learning effectiveness of individuals. Further research would be explored on the individual factors in the big five traits and analysis on user behaviour and experience upon the use of VR in learning complex problem solving situations in the cargo terminal and aircraft load planning operations.

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