Investigating Mental Workload of VR Training versus Serious Game Training on Shoot Operation Training

Ta-Min Hung, Tien-Lung Sun

***Abstract*—**Thanks to VR technology advanced, there are many researches had used VR technology to develop a training system. Using VR characteristics can simulate many kinds of situations to reach our training's goal. However, a good training system not only considers real simulation but also considers learner's learning motivation. So, there are many researches started to conduct game's features into VR training system. We typically called this is a serious game. It is using game's features to engage learner's learning motivation. However, VR or Serious game has another important advantage. That is simulating feature. Using this feature can create any kinds of pressured environments. Because in the real environment may happen any emergent situations. So, increasing the trainees' pressure is more important when they are training. Most pervious researches are investigated serious game's applications and learning performance. Seldom researches investigated how to increase the learner's mental workload when they are training. So, in our study, we will introduce a real case study and create two types training environments. Comparing the learner's mental workload between VR training and serious game.

***Keywords*—**Intrinsic Motivation, Mental Workload, VR Training, Serious Game

I. INTRODUCTION

EFFECTIVELY education training is extremely important for newly hired employees. It can help them to acquire relevant knowledge and skills quickly. Furthermore, effectively education training can reduce the occurrence of errors during the operation, and ensure the employees safety.

With 3D VR technology advanced, there are many scholars used VR technology to develop virtual training system [1], [2], [3]. Improved the traditional training defects with textbook instruction, tutorial of videos or learned by instructor.

However, an effective virtual training system not only consider content of training course, but also consider the learner's motivation. So, Malone, T.W. et al. [4] focused on learner's intrinsic motivation, investigated how to motivate the learner to learn without extrinsic reward.

Therefore, in the recent years, there are many scholars adding game's features into training [5], [6]. There are expecting through the game's features can increase learner's learning motivation and engagement. We general called this is serious game. Michael, D. & Chen, S. referred to serious game have became more important in education and training. Serious game is used computer games to captivate and engage the learners for a particular objective. Enabling to learners develop new knowledge and skills [8]. It could be enable learners attempt to some tasks or experience many kinds of situations which are impossible or difficult to execute in real environment.

Although adapting serious game can provide an interesting training environment than VR training and enable learners in the fun environment do the training. But which types of training method can obtain better performance, there have been seldom researches addressed.

Operator's mental workload is an important factor for human performance [9]. In the previous researches almost investigated how to decrease operator's mental workload. But in the VR training or serious game training are not the same. If we can use VR or serious game characteristics increasing learner's mental workload indirectly and enabling learners to experience pressure environment in the training stage. It would be help learners to adapt in many situations. Gilbert T. C. Leung, et al. [9] developed a virtual training system of computer numerical control. In this research reported that higher of task level could affect learner's higher mental workload and lower performance.

Therefore, if we can increase learners' mental workload when they training. It can help operators in management of crisis. Because for this reason, our study will focus on VR training and serious game training and investigate which type of training environment can lead higher mental workload.

II. LITERATURE REVIEW

With 3D VR technology advanced, there are many scholars having developed many kinds of virtual training system. Susi, T. [10] referred using virtual training allow learners to experience situations that are impossible in the real world for reasons of safety, cost, time, etc. Therefore, there are many virtual training systems have developed.

VR general be defined by Coates, G. [11] referred to "VR is electronic simulations of environments experienced via head mounted eye goggles and wired clothing enabling the end user to interact in realistic three-dimensional situations". In addition defined of "Virtual reality (VR) is typically defined in terms of technological hardware [12]. This system usually includes a computer capable of real-time animation, controlled by a set of wired gloves and a position tracker, and using a head-mounted stereoscopic display for visual output". Therefore, used VR technology to train the learners, could be called VR-Based training in our study.

A. VR-Based Training

Brough, J.E. et al. [1] proposed a virtual training system for mechanical assembly operations. This training system is focus on recognize parts, remember assembly sequences, and correctly orient the parts during assembly operations.

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Arroyo-Figueroa, G. et al. [2] developed an intelligent virtual environment for training of industrial operators. This intelligent system can let instructors design training contents by themselves. According to learners learning conditions design suitable training scenarios. [3] In order to reduce the injuries of conveyor belts training, developed a VR task-based training tool for conveyor belt training. This system divided to two parts to train the trainees. One is instructional-based module and other is task-based module. Furthermore, this training system can track the trainee's operational performance and let the instructor to evaluate the trainee's learning condition.

B. VR training to Serious Game

However, a good virtual training system is not only considering pedagogical design, but also considering learner's intrinsic motivation of learning. In order to increase learner's intrinsic motivation of learning, there have many scholars starting to conduct game's features in training [13]. We generally called this to serious game.

Zyda, M. [13] referred to serious games have more than just story, art, and software. It is not only having entertainment elements but also having pedagogical content. It makes games into serious.

Michael, D. & Chen, S. [7] referred to serious game has played an important role in the global of education and training. Serious game can enable learner be trained in safety, flexible and fun. Moreover, serious game, the same with VR training, can simulate many situations because of difficult to execute in some reasons. Corti, K. [8] mentioned serious game is learning-based by using computer games to captivate and engage the learners for a particular objective to develop new knowledge and skills. Furthermore, Malone, T.W. & Lepper, M.R. [4] who focused on learner's intrinsic motivation, investigated how to motivate the learner to learn without extrinsic reward. Therefore, conducting game's features into VR training has became more important.

C. Serious Game for Training

Backlund, P. et al. [14] constructed a training simulator for breathing apparatus entry. In this training system, they added the level design of tasks. This pedagogy of learning is step by step to understand domain knowledge and skills. Each learner must complete the current task and then go to next level. When they finish the designate level, learner will get additional bonus.

Cowley, B. et al. [15] developed a massively multiplayer serious game: Green My Place. This serious game is designed for general public and to train of energy efficient knowledge and behavior to users. In this serious game, they use competitive method to train the people, let people learned in game environment with contest.

D. VR and Serious Game Effectiveness

There are more researches developed VR training system or serious game to train the learner. But which type of training method may get more effectiveness for learner, there have seldom researches investigated. Wong, W.L. et al. [16] mentioned that there are many research investigating how to develop learner's intrinsic motivation, but preliminary comparative studies on the learning effects of games versus traditional media have seldom researches investigated. So, Wong, W.L. et al. [16] compared the media richness on science learning of games versus traditional media. And in this research result, richness media of learning can assimilate knowledge gains effectively.

However, the learning effectiveness not only includes richness media, but also includes other important factors. Therefore, in our research, we want to compare the mental workload when learner trained in the different training environments. If we can increase learner's mental workload when they training. Thus, may have some advantages, like as learner's compressive strength or management of crisis et al.

III. RESEARCH DESIGN

Mental workload's degree is an important factor for effecting employee's performance. If employee's mental workload is increased then they may get lower performance [9]. Therefore, if we can increase the learner's mental workload when they in trained. We can let learners adapt in this pressure environment in early stage. According to this reason, we will use shoot of operation training scenario do our research experiment and we will design two types of training environment, one is not adding any game features and the other is having added game features. Investigating which type training environment can lead higher mental workload of learner.

A. Virtual Training Environment Constructing

The 3D scene of the shoot operation training, which contains the geometry and materials of the virtual objects, are constructed using Cinema 4D [17], a 3D modeling and animation tool. The user interactions of the virtual objects and virtual system's responses by the user's interactions are programmed using a game authoring tool called Unity 3D [18]. Any interaction scripts in Unity3D could be programmed using java script or C#. And then, the first constructed virtual environment as show in Fig.1

Fig.1 No game's features training environment

This figure is one of our training environments. This training environment didn't add any game features. It just provided a virtual environment enabling learner to understand the operation of knowledge and skills. And then we will discuss another training environment for net section.

B. Game-Based Training Environment

Zyda, M. [13] referred to game is a physical or mental contest, played according to specific rules, with the goal of amusing or rewarding the participants. So, how do we create a training environment that has game's features of mental contest?

In our research, we want to add enemies in our training game. Learner has their life's degree, if they can't finish of fighting enemies in constraint time. They will be died. Furthermore, in order to enable learner to experience operating method, when each learner started the game, learner must complete the first task before fighting to enemies. So, we designed the simple targets in the scene, and learner must hit the designed targets in the first. If learner completed the simple task, then they can go to next task to fight with enemies. Expecting of fight with enemies can create learner's mental workload. Besides, we also add the timer constrain into the game. Hoping through these game's features of mental contest can increase learners' mental workload. Our game-based training environment as show in Fig.2

Fig.2 Game-based training environment

C. Evaluation of Two Types Training Environment

In this section, we will talk about our evaluation method. Because of our study is investigating which training environment can increase more mental workload. So NASA-TLX questionnaire is to be used.

We will use NASA-TLX questionnaire to compare two types training environment. NASA-TLX questionnaire is proposed by [19]. It is using to investigate the study subjects' mental workload. NASA-TLX questionnaire can divide to six aspects by [19]:

1) *Mental demand*
   How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
2) *Physical demand*
   How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
3) *Temporal demand*
   How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
4) *Performance*
   How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
5) *Frustration level*
   How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?
6) *Effort*
   How hard did you have to work (mentally and physically) to accomplish your level of performance?

IV. EXPERIMENT DESIGN

In our experiment, we design two types of training environments. These training environments have the same of course. The course is designed to train the learner to develop the knowledge and skill of shooting operation.

In our research, we focus on comparing VR training and serious game training. Investigating which type training method can cause higher mental workload of learner. Therefore, our experiment hypothesis, independent variable, dependent variable as described as follow below:

1) *Experiment hypothesis:*
   In our research, we assume that game-based training type may have higher mental workload with learner.
2) *Independent variable:*
   Our research independent variable is adding game' features not.
3) *Dependent variable:*
   In our research dependent variable is learner's mental workload.

V. DISCUSSION AND FURTURE WORK

Utilizing the VR or Serious game to train the learner had many years. Although there have not strongly significant of learning performance in the many researches. However, utilizing the VR training or serious game to train the learners can simulate that difficult to execute in real training environment. Furthermore, game-based training can increase learner's intrinsic motivation, let learner trained in the interesting and fun environment. These two kinds of training methods are improving the traditional training's defects.

Although, in these kinds of training methods, which training method may get more effective training performance that no strongly significant to proof that. Owing to mental workload is still the important factor of operator's operating performance. On the other words, if operator's mental workload too high, they may get lower operating performance. For this reason, if we can enable learner to experience the environment of higher mental workload in the training stage, it may help learner to solve the problems when the face to pressure situations.

Therefore, we designed two types of training environments and wanted to investigate which types of training environment can lead higher mental workload of learner. In the present study, we just present the investigating concept. In the future, we will use NASA-TLX aspects to design our mental workload questionnaire

and do the experiment.

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