

The Advantages of Virtual Reality in Skill Development Training Based on Project Comparison (2009-2018)

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Abstract: In the era of noble technology, virtual reality (VR) has been adopted in various fields, with the advantages of VR in education being confirmed through numerous studies. In skill development training education, humans or equipment that interact with the trainee are crucial and currently VR is more preferred. In this study, six projects were selected and reviewed in-depth visualizing the use of VR in training and its potential. Comparison between the learning actions of training in the virtual and real environments were conducted. Training through VR is location-dependent, time-dependent, safe, and reversible. VR application is also determined by the preps and feedback-providing functionality which must be emphasized. All the advantages of VR in skill development training make it an opportunity provider. This article can be used by those developing VR projects for skill development training.

Keywords: Skill Development Training; Virtual Reality; Constructivism; Self-learning

1. Introduction

As technology evolves, virtual reality (VR) has been applied in fields like entertainment, sports, education, games, medical, military, etc. The reason that VR is referred to as a high-potential medium in various fields is due to its nature that enables the user to experience life-like events using real-time simulation and interaction through multiple sensory channels that create 'Presence' [1, 2]. Presence is defined as an idea of transportation i.e., the subjects who experience immersive media in various experiments report a sensation of being in a virtual world [2]. Particularly, the efficiency of VR in education and training is confirmed through many pieces of research [3]. According to Hu-Au & Lee [4], VR is beneficial in providing opportunities, increasing student engagement, providing constructivist (i.e., allowing students to construct their own knowledge from meaningful experiences.), authentic experiences to impact student's identity; allowing new perspective-taking, empathy and supporting creativity and the ability to visualize complicated models hence its preference among young students. Virtual environments (VEs) can support trainees to learn through their experiences by offering rich, interactive and engaging educational content [5].

Various studies have focused on the effectiveness and applications of VR in education and training [6]. Constructivism theory suggests that humans construct knowledge and meaning based on their experiences. i.e. they build their knowledge upon the foundation of their previous learning [7]. Experiencing things and reflecting on those experiences is referred to as 'First-person experience'; 'Second-person experience' is described by someone else, while 'Third-person experience' is experienced through a person's interaction with a computer via the interface. However, the immersion and interaction via VR makes the psychological process of the third-person learner as the first person [3]. In skill development training, direct physical interaction between the object and the trainee is required. In this research, skill development training is defined through physical activity, a part of learning which entails moving one's body part to accomplish some tasks. The movement of hands, legs, and body muscle is required while performing any work. Skill development training is associated with the kinesthesia ability to sense motion of limb or joint, also known as sensation or perception of movement. According to the research on Kinesthetic memory by Clark and Horch, humans have a remarkable ability to

remember the position of their limbs quite accurately for long periods of time [8]. Our bodies detect how to perform a task and ultimately adopts the movements involved in performance of the task. The trainee moves his limbs based on the type of sensors and haptics utilized during the training through VR interactive content. Thus, the trainee is able to adapt the movement and recall the movements later. In industries, training constructs the proficiency of all the employees to perform the job in an effective manner. It supplies enough potentiality to the employees, holding future positions in an organization, reducing defects and performing effectively in job-related tasks. Training is also considered as a form of investment by corporations since it generates a lot of profit as investment returns and helps to establish its superiority [9]. This research will review VR projects and studies regarding the experiment to enhance the learning effects via VR in addition to analyzing their results. Six kinds of research were collected in four different areas and projects from 2009 to 2018. These projects show the use of VR in various fields of skill development training and their advantages. Those references are well described and have rich information to identify what should be learned from the projects. After the review, we suggest the benefits of adopting VR for skill development training, the field in which the project/research utilized VR for skill development training, and the factors for design consideration by comparing the training in the virtual and real-world in those projects.

2. VR Projects for Skill Development Training

2.1 Medical training VR

2.1.1 VR based simulators for training in Regional Anesthesia:

The methods of training involved in Regional Anesthesia (RA) include video teaching, ultrasound guidance and simulators [10]. The traditional training techniques of RA involves 'see one do one' method i.e., trainees work under the direct supervision of a senior and experienced surgeons which is time-consuming, costly, and variable in effectiveness [11]. In 2009, O. Grottko et al. developed a VR based simulator that allowed trainees to practice their technical skills via RA adopting various anatomies of patients in the virtual world [10].



Figure 1. Picture representing RA¹ simulator application with VR based setup. The trainee controls the virtual needle using a PHANTOM Omni Haptic device² [10].

The simulator application adopts several modules for collision detection, humanoids, interaction and visual implementation of the virtual toolkit ViSTA. A customized haptic input device is also implemented and utilized for palpation in order to localize the needle injection site realistically for needle operation as shown in figure 1. This application uses multimodal representations of both visual and basic haptics with intuitive interactions and a plausible simulation, creating a flexible training environment without endangering the patients. This simulator adopts a segmented algorithm allowing it to be used in different peripheral nerve blocks giving a wide range of anatomical variety of individual anatomy and for different anatomical regions.

¹ Regional Anesthesia: Anesthesia used to block sensations of pain given to a specific area of the body without making the patient unconscious

² Phantom Omni Haptic Device: It is a haptic device based on the work kinematic and dynamic consideration, conventionally attributed to robot manipulators [12].

2.2 Industry (Employee) training VR

2.2.1 Head-mounted display-based intuitive Virtual Reality training system for the mining industry:

The mining industry is a high-risk sector and requires plenty of training to ensure safety [13]. Drilling training for miners in the real environment is too risky. The drilling risks in regards to training include physical damage to equipment, physical harm to the trainee, loss of reputation in business etc. [14].



Figure 2. Picture representing RA simulator application with VR based setup. The trainee controls the virtual needle using a PHANTOM Omni Haptic device [13].

In 2016, Zhang Hui developed a Head-mounted display-based intuitive virtual reality training system for the mining industry [12]. This project was designed for underground mines drilling scenario training through employing an HMD [VR headset, a smartphone (Nexus 6P smartphone)] and a leap motion device with an HMD based intuitive type VR training system prototype. The user interacts with the virtual scene by moving hands and perform drilling activities. Sophisticated movements and gestures for drilling can be performed by the user inside the virtual environment, manipulating the virtual miner's hand as shown in figure 2. An experiment was then conducted with 10 trainees using both HMD and screen-based general training systems. The use of HMD based training was compared with the screen-based and subsequently the joystick and wearable sensors. The comparison conducted was based on the answers from questionnaires about the levels of immersion, intuitive, interaction, ease of use and ease of learning. The score of HMDs based training was higher in all questions. In the case of immersion HMD based training, it had a score of 4.5 out of 5 while the screen-based training had a score of 1.5 which made a huge difference. The comparison suggested that the HMD based training system using VR is intuitive, interactive, immersive and easy to use. However, the drawback was that the wearable sensors could not provide a sense of touch to the user.

2.3 Safety Instruction Training VR

2.3.1 Virtual Reality Simulator for Advanced Cardiac Life Support Training:

Advanced Cardiac Life Support Training (ALCS) is a life-saving matter which is a time-sensitive and clinical team-based procedure adopted by people with respiratory failures [15]. The real-life environment entail high stress and time-critical scenario and the training includes a lecture and simulation practice using devices like Heartsome and Anne Manikin [16]. Vankipuram developed a Virtual Reality Simulator for ACLS in 2014 [15]. It provides an inspiring, engaging and role-playing virtual environment for the trainee.

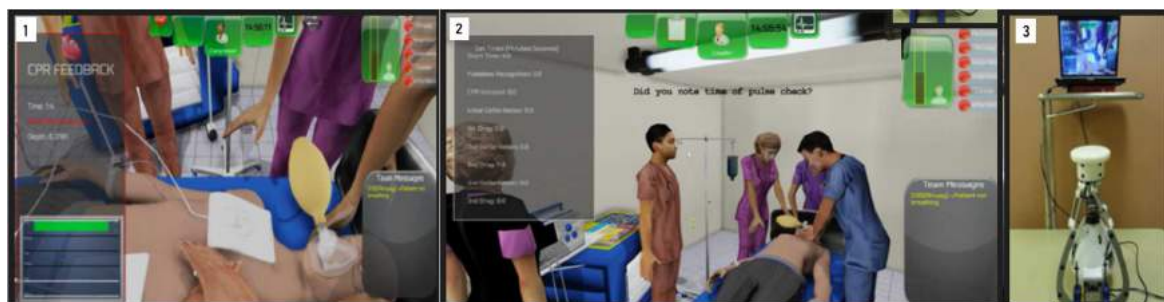


Figure 3. 1 shows the CPR role, 2 is the haptic joystick setup for CPR and picture 3 shows text-based feedback message black front (global message) and yellow font (team message) [15].

It is a time-critical and team-based medical scenario platform for guiding trainees in aid for respiratory failure. The project primarily focuses on distance training, coordination, teamwork, and leadership. Six trainees can participate at a single time. Each trainee has a specific role such as Leader, compressor, medication, defibrillator, respiratory, and airway manager. The team is required to perform activities that assist them to coordinate as a team in order to save the patient as illustrated in figure 3. For the usability testing of the system, 96 ALCS certified clinicians are recruited and organized into 16 teams of 6 people each. The 16 teams were further divided into two groups: one having persuasive features and the other with limited persuasive features. Likert scale was utilized to measure the mean score comparison 1-5 (1-strongly negative 5-strongly positive) based on easy-to-use and usability through use of questionnaires. The minimally persuasive group exceeds the level as compared to that of the persuasive group by $p = 0.00813$ and $p = 0.0944$, respectively. The disadvantages included distraction of user by the communication indicator and global message on the screen, the simulator does not inform the result that the patient is saved or not, and lack of real-time performance experience of the user due to the absence of validating scoring technique for ACLS procedures. However, this project provides immersion, and remote location.

2.3.2 Application of VR in Disaster Response Training (Fire Safety):

Despite the numerous training programs and schools for fire-fighters, fire safety drills for common people are rarely conducted and the available training mostly includes case studies, face to face lectures and fire drills [17]. In 2018, Rajit Pimpale developed a VR Application for Disaster Response Training [18].



Figure 4. Fire propagation series scene in the project [18].

The project was developed to adequately prepare a disaster response team compared to training in a classroom or instructional learning. It also assists to reduce trauma for the responder. This project is a game where the trainee (player) wears a VR device, and assumes the role of a person encountering a specific disaster (fire) as in figure 4. The trainee has the freedom to perform certain actions, which determines whether the trainee survives the disaster or not. There are also some non-interactive and visible interactive objects which interact with the player creating real-time experience of the disaster (Interactive objects are those which interact with the users' behavior). The trainee will face either consequences or benefits for their decision in the game which helps trainees to learn what they should do times of disaster and how they should handle the situation. This project concludes that apart from being immersive and entertaining, VR provides a better training platform for disaster management strategies giving realistic experiences to the user.

2.3.3 Effects of interface on procedural skill transfer in virtual training:

Lifeboat launching is a sophisticated process of transferring a tucked lifeboat to water that requires procedural skills, collaboration and synchronization of several roles thus, training is required [19]. In real life training, the subjects cannot always launch the lifeboat for safety reasons [20]. Traditionally, the training procedure entails instructional manuals, lectures, textbooks, and practical training in the real environment using real equipment [21].



Figure 5. Virtual training interfaces used in the experiment are shown: (a) monitor, keyboard and mouse, (b) head-mounted display and joy pad, (c) head-mounted display and wearable sensors. 2 is the sequential screenshots of the virtual training with guiding instructions. 3 is the evaluation of the VR training later in a real lifeboat [20].

The evaluation was based on comparing the ability of the participants to launch a lifeboat without mistakes in a real boat prior and after training. The technical skill scores of the participants using VR training with the wearable sensors group improved from 4.375 to 11.75 making it the highest. The conclusion was that VR training alone is enough for a training format involving short sessions (15-min sessions). However, for long sessions as a result of spatial representation of 3D text, there is a reduction in the information conveyance to the trainee.

2.4 Personal development VR

2.4.1 A VR dance training system using motion capture technology:

In real life dance training, it's hard to manage training, location and the precise time when the teachers and students attend lessons [22]. In the case where the teacher is absent, the trainee can also learn by watching videos, but there is lack of feedback. The conventional process of coaching the dance incorporates the handy tools for training dance artists. During the process of learning, the dance artists may end up injured and frustrated, which can be an overwhelming hurdle [23]. Choreographers would shout and scream when the trainee doesn't perform well, promoting fear in the dance studio among the students [24]. Consequently, decreasing the level of confidence among the trainees will hinder them from reaching their full potential.

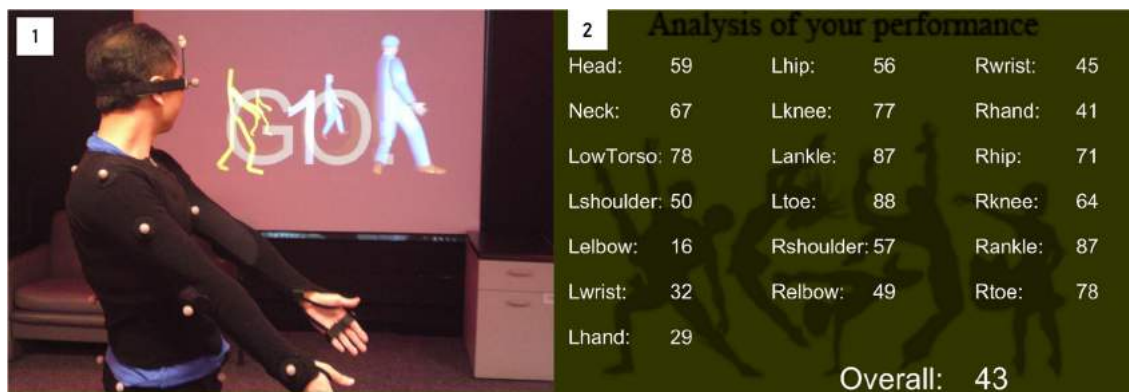


Figure 6. In 1 subject is learning a dance motion watching the virtual teacher and 2 is the score report [22]

In 2011, Chan et al. developed a VR dance training system using motion capture technology [22]. In this system, users should wear motion capture systems, and follow the movements of a virtual teacher, and then receive feedback on how to improve their movements. This project utilizes motion capture technology and motion analysis methods. This system conveys a complete analysis including the users' whole-body motion. After a successful comparative analysis between two motions, feedbacks are returned as shown in figure 6. During the evaluation, the students were asked to train in the system by watching the demo, practicing, and understanding the feedback. Teachers also made use of the system, assisting in the preparation of teaching materials by having their dance motions captured. 8 male students aged 21-30, who were students of the City University of Hong Kong were randomly selected to participate in the study randomly as the experimental and

control group, consisting of 4 people per group (Experimental group participated in this project; Control group utilizes self-learning by watching method). Achievements for the learning outcomes: The mean and standard deviation of the skills were tested. The increase in the mean suggests that the training system is effective in the case of learning outcomes. Arousing interest in participants: The question for whether the project was interesting achieved a score of 2 out of 4 and for recommending other students to try the program scored 3 out of 4 making the project interesting. Subjects made an evaluation that the project was useful in guiding the students to correct direction and encouraged them to learn more. Also, the experiment results showed that this system assisted the students better in learning compared to the traditional approach of “watching video”. In the future, there are plans to incorporate additional features like feedback based on emotion and HMD. This application does not evaluate emotion. There is no realistic background to provide better immersion. Because of the screen-based display, this project is not fully immersive especially when the user needs to turn, hence, the user requires a VR HMD in order to experience full immersion.

3. The Efficiency of Virtual Reality

In this study, training in the projects is compared with the real work environment and the differences between them are identified. After the analysis three factors from quantitative analysis, one factor from qualitative analysis, and three other factors added by the authors based on the nature of VR interface that has the telepresence [25] were identified. In Table 1 presents the Projects with their qualitative scores in specific factors. Similarly, Table 2 presents the comparison between the skill development training in the real and virtual environment based on the above key factors.

Table 1. Projects with their qualitative scores in specific factors

Quantitative Analysis		
VR skill training advantages	Evidence the researchers found	Supporting Key Factors
Immersive	In 2.2.1: Immersion improvement rate with HMD: 70%.	1. Preps.
Easy to use	In 2.2.1: Ease of use improvement due to HMD: 30%.	1. Preps, 2. Self-learning.
Easy to learn	In 2.2.1: Easy to use improvement due to HMD: 14%.	1. Preps, 2. Self-learning.
	In 2.4.1: Easy to learn improved by 40%.	
Learning effect	In 2.4.1: Score improvement: 10%, motivating: 20%.	1. Preps, 2. Self-learning, 3. Feedback providing.
	In 2.3.3: Improvement learning Technical Skill (contrast to lecture): 11% In 2.3.3: Improvement learning Technical Skill (contrast to lecture): 11%, (contrast to MON/KEY): 9.29	
Interesting	In 2.4.1: 10% more (contrast to control group)	1. Preps, 3. Feedback providing.
Interactive	In 2.2.1: Improvement in interaction: 24%.	1. Preps, 3. Feedback providing.

Thus, the results can be used to the advantage of VR application in skill development training and the points that must be emphasized to make the VR training more effective. The comparison is done based on the following factors:

1. Preps:

It deals with the kind of devices and equipment used in the project. Therefore, the types of devices used for the training are mentioned here.

2. **Self-learning:**
It visualizes the possibility for the users to undertake the training alone in the absence of an instructor. The self-learning functionality can also make the training system more effective.
3. **Feedback providing:**
This point is used to observe whether the system has feedback providing facility or not. Feedbacks makes the user evaluate his/her performance level and encourages him/her to expertise his skills. The feedback functionality makes the user learn more and evaluate themselves which makes them eager to perform better next time.
4. **Safety:**
This point illustrates the safety features of the training system and how safe it is for the trainee to perform.
5. **Location-dependence:**
This point is used to find out whether the project is dependent on the location for training or it can be performed anywhere in the area suitable to the user. The less location-dependent the training system is, the better as it helps in managing the training faster.
6. **Time-dependence:**
This point is used to observe how much time is consumed in managing the training. The less the time consumed for management, the better the training system.
7. **Reversibility:**
This explains whether the project is reversible or not. Generally, during the training process, lots of destruction and mistakes may happen. Some of them can be reversed to their previous form while others are irreversible. Therefore, it should be observed.

4. Result and Discussion

After comparison, the study derives a conclusion for every point explaining their role and effectiveness.

1. **Preps:**
In the real world the trainee uses various equipment and devices which might be large in numbers and sometimes impossible to manage. However, in VR the devices are virtual, and the trainee only needs HMD, haptics and sensors to manipulate those virtual devices. The haptics and sensors are comparatively easier to manage. The use of appropriate haptics assists in making the VR more immersive, interactive, interesting, engaging, easy to use and learn. It's very productive in learning technical skills but weaker in learning procedural skills as compared to keyboard and mouse. This is because Keyboard and mouse are common and familiar with the users, but the VR interactive contents are new and still under the evolution phase. Another drawback is that in real environment, devices have the feeling of touch, which cannot be replicated in a virtual environment.
2. **Self-learning:**
In a real environment the trainee has an instructor who instructs the user how to perform the task and is always there to guide. In the absence of the instructor, the trainee may conduct self-learning, which is too difficult. There are chances of trouble and accidents which might lead to massive destruction. Therefore, the trainee always needs to seek the instructor. However, this is possible in the VR environment since the application can guide, interact and evaluate the trainee and the results of learning effects, easy to learn and easy to use are successful.

Table 2. Factors to compare the projects in Real and Virtual Environments

	Medical training VR		Industry (Employee) training VR				Safe instruction training VR		Personal development VR			
Project	2.1.1 VR based simulator for training in Regional Anesthesia		2.2.1 Virtual Reality training system for the Mining Industry		2.3.1 Virtual Reality Simulator for Advanced Cardiac Life Support Training		2.3.2 Application of VR in Disaster Response Training		2.3.3 Effects of interface on procedural skill transfer in virtual training		2.4.1 A VR dance training system using motion capture technology	
	Real Life	VR	Real Life	VR	Real Life	VR	Real Life	VR	Real Life	VR	Real Life	Using VR
1. Preps	Needles, drugs, and other medical equipments and devices.	PHANTOM Omni Haptic Device. Simulator toolkit vista.	A lot equipments and machineries required for drilling hole in mine.	HMD (VR headset, a smart phone (Nexus 6P smartPhone)) and a leap motion device.	Devices and equipments required for ACLS.	UI: GUI, Headset (TeamSpeak VOIP API), Novint Falcon haptic joystick.	Fire Extinguisher and other safety materials for fire fighting.	GearVR HMD with android Device connected and controllers connected to android via Bluetooth.	Real Life Boat and appliances.	Headmounted display: Mobile VR and Wearable sensors: Leap Motion and Myo ambands.	Real life teacher and music.	Optical motion capture system with cameras and a suit with markers attached.
2. Self-learning	As the process is too risky shelf learning is almost impossible.	Not mentioned clearly.	Self learning is almost impossible as the training field is too risky for fault decisions.	Self learning may be possible. Not mentioned clearly.	Self learning is almost impossible.	As its a team role playing game shelf learning is possible but there must be 6 players performing together.	Self learning is almost impossible.	This project is a role playing game so the player will obviously can shelf learn by making decisions that are either correct or wrong.	May be the shelf learning is impossible because the training is dangerous requires safety and proper guidance.	It is possible as the user can just use the application and follow the guided instructions and learn the procedure by oneself.	Available by watching videos but really not effective for all trainees.	This project is especially designed for shelf learning. As there is virtual teacher who demonstrates movement and gives feedback.
3. Feedback providing	As instructor is always there in real life training Evaluation, Guidelines and Interactive Feedbacks are always possible.	Interactive feedbacks like collision detection during needle insertion.	As instructor is always there in real life training Evaluation, Guidelines and Interactive Feedbacks are always possible.	Interactive feedbacks like Character animation control and intercation.	As instructor is always there in real life training Evaluation, Guidelines and Interactive Feedbacks are always possible.	Evaluation feedback, Guidelines feedback and interactive feedback are provided.	As instructor is always there in real life training Evaluation, Guidelines and Interactive Feedbacks are always possible.	Evaluation feedback, Guidelines feedback and interactive feedback are provided.	As instructor is always there in real life training Evaluation, Guidelines and Interactive Feedbacks are always possible.	Guidelines feedback and interactive feedback are provided.	As instructor is always there in real life training Evaluation, Guidelines and Interactive Feedbacks are always possible.	Evaluation feedback, Guidelines feedback and interactive feedback are provided.
4. Safety	The process is challenging if done to a real patient its really too risky.	Safe Environment to learn and practice without endangering patient as its Virtual.	In real environment the drilling training is of high risk, too difficult, life chalangng sometimes almost impossible to practice.	VR environment makes it possible and safe.	If the training is taken with the real patient as subject then its risky and one simple mistake can be life thretening to the patient.	It is safe in case of the patients as the ACLS activity can be performed with the virtual patient and the mistake leads to no injur or death in real.	Classroom or instructional training/learnin g mostly not possible due to unsafe and regulation wise- disallowed.	The immersive VR environment with interactive elements made the training safe.	It is difficult to offer hands for safety on real training environment.	VR environment makes the training environment safe.	Dancing are generally safe until it comes to some stunt activities.	As its a dance learning project where there is no risk of learning they dont discuss about safety.
5. Location-dependence	Trainee should travel to a specific training location and also require good instructor, proper safety measures and equipments.	Training can be performed inside virtual world.	Drilling training is too difficult and can be life-threatening.	Trainee can perform drilling task inside the Virtual world anywhere in the presence of VR contents so it solves the problem of location dependent training.	It needs an specific location for training.	As the project is networked all the players can participate in the game from their own location. And perform inside the virtual environment together So its not location dependence.	Training requires an specific location and area of land even for mock drills.	The VR environment makes it location independence trainee can perform it any where he can manage to set the VR equipments.	The trainee should be in the particular location for the training. (eg: Ship and the lifeboats)	The application solves the location dependence problem as the user can perform the training in one room using the VR equipments.	Trainee has to go the specific training location to learn.	As this application is developed focusing the people who dont have time for dance class. The trainee can use this application in his desired location with VR equipments.
6. Time-dependence	Time is spent for searching instructors, expenses, tools, patient and location for training.	It reduces the time as it reduces the time spent for searching instructors, expenses, tools, patient and location for training.	Time is spent for searching large geographical location for safe training, expenses, tools.	As the time consumed for managing materials, staff handling, raising funds will be decreased so it will generally consume less time than in real life training.	Oviously consume a lot of time as the training location, equipments, instructors, standby safety measures and lot of other things must be managed which will consume a lot of time.	As the application doesnot require the time spent in managing training location, Staffs, instructors standby safety measures and materials will consume less time.	Its a common logic that these kind of mock drills will obviously consume a lot of time as the training location, equipments, instructors, standby safety measures and lot of other things must be managed which will definitely consume a lot of time.	The time spent in managing budget, staffs and collecting educational and training materials will be skipped. Thus, it saves time.	The mock drills consumes a lot of time as the training location, ships, lifeboats equipments, instructors, standby safety measures and lot of other things must be managed beforehand which definitely consumes a lot of time.	It will wipe out the time consumed in preparations required during the real life training so the only thing to focus is to install VR components and the application for the training.	Trainee spends times on travelling and searching the desired training center.	As the trainee can train at his desired location and doesnot waste his time travelling to dance classes, similarly the teacher can also record his movement once and then the students can learn any time any where. So It saved time.
7. Reversibility	Minor mistake can be risky for the patient which cannot be reversed.	Reproducible scenarios without endangering patients makes it reversible.	Minor mistake can be life thretaing and not possible to regain it.	The drills the user makes are virtual so the environment can be reproduced.	Any mistakes done during the training process like the death of patient is not reversible.	The trainees work with ACLS for a Virtual Patient in Virtual environment which is reversible.	In real life once there is a mistake the destroyed. We cannot get those things again.	In VR even if there is a huge fire and destruction. nothing is really destroyed everything can be regained.	Mistake may cause huge economic loss and also can be life thretaing which is not reversible.	The ship and the equipments are all reproducible Virtual objects.	There is nothing that needs to be reversed.	There is nothing that needs to be reversed.

3. Feedback providing:

In the real VR environment, the trainee gets feedback from the instructor which assists him to evaluate his overall performance. There are various kinds of feedback that are used in VR interactive content. These includes the evaluation feedback, guiding feedback and interactive feedback. Evaluation feedback is evaluating the skill of trainees based on their performance. It will encourage the trainee to try the training again in order to achieve better scores making him/her more addictive and evaluate their skill. Guiding feedback refers to the action of guiding the trainee to perform the task e.g. Text-based guidelines on-screen, Audio guidelines.

4. **Location-dependence:**
 Almost every training in the real-world is location dependent. Mostly a specific location for training is required, which is hard to manage at all time. Conversely, with the use of a VR training system the user can solve the location-dependent problem since the VR training system is not location dependent. The trainee can train in any desired location using the VR contents provided.
5. **Time-dependence:**
 VR projects solve the problem of time dependency as they reduced the time spent searching for instructors, tools, staff, safety and budget management that is present in real-world training.
6. **Safety:**
 The real environment has a lot of risks and chances of accidents. In the case of medical or surgical training, the subject (patient) bears the risk. Similarly, in other training, the trainee bears the risk which can be life threatening. In VR, the environment, patient and tools are virtual 3D meshes such that the accidents are just inside the VR game, which makes training in VR safe.
7. **Reversibility:**
 The real environment training, when the trainee makes some mistakes or damages during the training session it cannot be rebuilt, or the rebuilding takes time, but in VR everything is reversible since the objects are virtual 3D meshes.

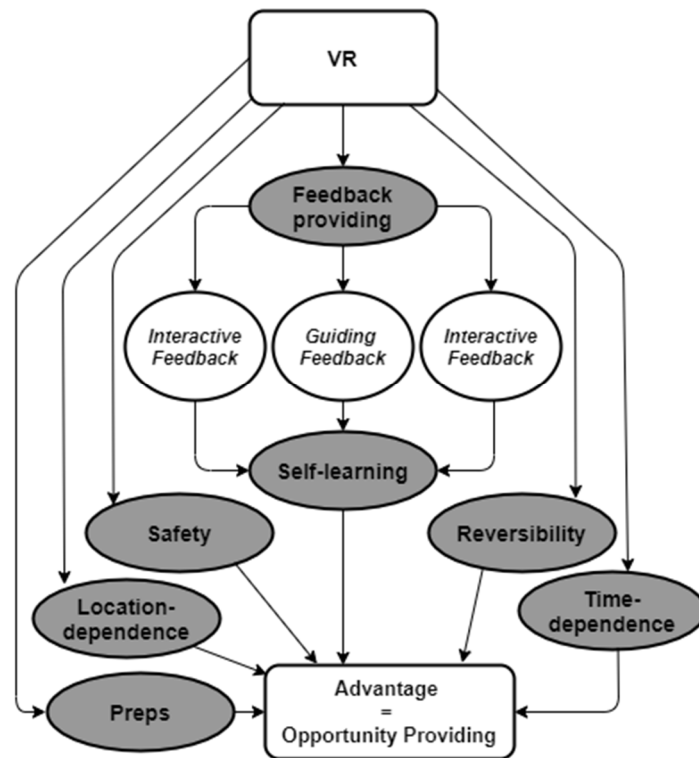


Figure 7. In Flowchart illustrating the advantages of VR

The training in the real environment provided less opportunities and had the problems related to self-learning, location, time, safety, reversibility and preps. However, the VR projects simplified the training. The tools and subjects are all 3D animated meshes thus, only the VR HMD and haptics are required for the training. The training can be conducted in any location inside the room safely. The training can be conducted in the absence of an instructor because the system provides guiding, interactive and evaluation feedback making the training more interesting, motivating, easy to learn and use, safe, reversible, timesaving and location independent. Therefore, every key factors of skill development training using VR serves as an opportunity provider as shown in figure 7.

4. Result and Discussion

In this paper, we reviewed the journal papers on VR based skill development training systems and related projects from 2009 to 2018, the advantage and the factors that must be emphasized prior to developing an interactive skill development training content were then highlighted. After observing all the projects, conclusion was then drawn that the common advantages of VR in skill development training include three factors: Preps, Self-learning and Feedback providing from quantitative analysis, Safety from qualitative analysis in addition to 3 other factors, Time-dependence, Location-dependence and Reversibility based on the nature of VR interface that has telepresence. Selecting VR skill development training system will help reduce the demand of tools, location, time, instructor as it applies 3d models and animated meshes and instead will require VR HMD and haptics. Feedbacks provide guidance and encouragement for the trainees to practice more, evaluate their skills and motivate themselves with an aim to perform better hence, repeat the process. Since the trainees can evaluate themselves, it also promotes self-learning. However, excessive feedbacks may distract the trainee from performing the task thus, the developer must have the endeavor to limit the feedback contents. Thus, when developing a VR project for skill development training that requires physical activities and stepwise procedural learning, the developer needs to focus more on the key factors such as Self-learning, Feedback providing and Preps. VR as applied to skill development training also has some limitations including: locomotion sickness when there is longer exposure to VR contents and lack of vision in regards to the surroundings while using VR. Therefore, developing a short-session VR training system will be productive. It is a novel interactive system with evolving haptic devices such that users require time to adapt to the system.

Making the VR training system more immersive requires addition of simulation via haptic devices. However, haptics only are not enough to give the users a sense of touch as the real object does. Therefore, it is crucial to develop more advanced haptics for more immersive experience which would offer a new research direction.

Conflicts of Interest: The authors declare that there is no conflict of interest regarding the publication of this article.

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