Virtual Reality (VR) Technology Integration in the Training Environment Leads to Behaviour Change

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Abstract: Virtual Reality technology provides a more effective, cost-saving learning solution to firms, however more research is needed to understand how VR technology transfers to real world behaviour change. Current studies measure the impact of VR technology in a training environment without integration of adult learning theory that benefit all learning styles. To measure the effectiveness of VR technology in the training environment, industries like healthcare and aviation are studied at a greater rate because of their knowledge management systems and high stakes need for learning. A flight attendant study conducted within a training environment takes a new approach measuring the impact of VR technology on behaviour outcomes. This study relies on post-training behaviours rather than survey or assessments. With over three years of VR integration blended into a formal training environment, early evidence supports the utilization of VR technology to teach flight safety to flight attendants. Initial findings show an improvement in new flight attendant scores measuring behaviour change in a series of safety tasks performed post-training. In addition, early research provides unanticipated evidence of the impact on knowledge transfer when some workers are not utilizing VR technology and others do utilize VR technology in the same environment.

1 INTRODUCTION

Knowledge is a competitive advantage for organizations, and virtual reality (VR) technology is increasingly a source of knowledge transfer in firms (Ahn & Chang, 2004; Kuah & Wong, 2011; Alfalah et al., 2019). In 2018, Wal-Mart utilized VR technology with over 1 million employees (Incao, 2018). Verizon has utilized VR technology to teach safety to retail workers in case of armed robbery. Stanford tested VR technology with football players to help them understand player movement on the virtual field (Noguchi, 2019). As the usage of VR technology spans new fields and training environments, more testing is needed to understand how VR technology is utilized.

VR technology requires higher upfront costs with long-term cost-saving. As a learning solution to firms, research in VR technology is relatively new and more research is needed to understand how VR technology transfers to real world behaviour change (Gabajova et al., 2019; Jia-Ye et al., 2021). The gap in current VR technology research in the training environment is the lack of comparison to equally sophisticated learning environments. Current studies tend to compare poor training to enhanced training with VR technology rather than comparing robust training environments where VR technology is integrated into an already sophisticated knowledge transfer training program. Before proving the impact of VR technology, researchers must understand the nature of the training environment, how adult learning is maximized in the training environment, and the benefit the current training environment brings to different learning styles.

2 REVIEW OF LITERATURE

2.1 Adult Learning Theory

Investigating VR technology in the formal training environment requires an understanding of adult learning theory. For adults to accept knowledge transfer and allow the knowledge to impact behaviour, they must be given the opportunity to learn beyond the explicit knowledge resources. Adult workers transfer tacit knowledge through

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socialization, experiences in the training environment, and problem-solving interactions to build new tacit knowledge (Knowles, Holton, & Swanson, 2005). As firms incorporate more adult learning practices into the formal training environment, they improve knowledge transfer.

Training in firms relies on the proper execution of adult learning theory, which determines an adult's willingness to learn and change behaviour (Kolb, 1984; Rosellini, 2017). Adult learning, as in Kolb's model of experiential learning, considers the need of adult learners and providing training that allows results in behaviour change. Through concrete experience, Kolb identifies the need for workers to perform tasks while also allowing time for reflective observation. As reflective observation becomes abstract conceptualization, the adult worker applies learning by experimenting new behaviours to create concrete experiences on the job.

2.2 Learning Styles

The reviewing the literature of VR technology and its proven success in the literature, Jai-Ye et al. (2021) identified that more research is needed to understand how knowledge transfer is impacted with the different learning styles that interact with VR technology. Learning style is the behaviours that a person adopts to navigate the learning environment, as shown by their habits and preferences (Messick, 1976). Gardner's (1985) work became associated with identifying seven learning styles that he called *intelligences* through the theory of Multiple Intelligences. Gardner saw a problem with intelligence testing in schools in that they historically measured school success, rather than addressing all types of intelligence success potential. Born from Gardner's work, the seven learning styles identify individuals' preferred methods for the learning and processing information. Identifying learning styles allow trainers in knowledge management systems to tweak or adjust training to reach the highest number of learners.

The learning styles are: interpersonal, intrapersonal, kinesthetic, visual, logical, and auditory (Gardner, 1985).

Throughout the remainder of the study, the term *sophisticated training environment* is used to describe a training environment that utilizes adult learning theory and one that integrates all learning styles into its training environment. In the next section, multiple studies cite proof of the superiority of VR technology throughout knowledge transfer systems.

2.3 Virtual Reality Technology

VR technology is defined as a computer simulated three-dimensional environment that creates a virtual world (Garb, 1987). Virtual Reality studies are concentrated in the medical field with some application across manufacturing, academic and other industries (Salsabeel et al., 2019; Chang et al., 2019). VR technology is superior to other training approaches because of its ability to impact different learning styles (Sitzmann, 2011).

The end of this section will include a review of VR technology in the medical and aviation field, and other industries.

2.3.1 VR Technology across Industries

In the manufacturing environment, Gabajová et al. (2019) completed an assembly study with individuals who were aided by an instruction manual compared to individuals aided by VR technology. On average, VR technology saved individuals 36.16% of the seconds required to complete an assembly task. Gabajová et al.'s study inadequately describes how limited printed materials impact adult learning prior to VR integration. The VR technology is capable of appealing to all seven learning styles in a way the instruction manual cannot. Comparing VR technology with an instruction manual does not demonstrate superiority of VR technology. Rather it shows the ineffectiveness of instruction manuals in adult learning and knowledge transfer. (Gabajová, et al., 2019).

VR technology shows evidence of improved knowledge transfer in the medical field (Chang et al., 2019; Salsabeel, 2019). Chang et al. (2019) conducted a nursing study where students in Taiwan received either VR technology or an instructor-led training with video instruction to learn childbearing techniques. The study found that VR technology increased knowledge transfer because the students were better able to gain a well-rounded experience that was not provided with a two-dimensional video and instructor-led training. Results from the study showed that the nursing students who received training through VR technology demonstrated greater expertise post-training than the students receiving instructor-led and video training.

The comments of participants in the Chang et al. study shared that video instruction lacked the inclusion of multiple video angles to allow learners to visualize the full anatomy and childbearing process, proving that all learning styles were not considered in initial training.

A mining study introduced a VR-based game to train workers on safety hazards, proving that VR technology is more effective than previous training methods that include training manuals and videos (Liang, Zhou, & Gao, 2019). The mining study provides another example where VR technology is compared to a training environment that does not consider equal learning styles.

2.3.2 VR Technology in Healthcare

The medical field adapts superior training. VR technology in the medical field provides more accurate studies of the effectiveness of VR technology due to the high quality of the training environment pre- and post-VR implementation. Medical studies prove that VR technology best transfers skills when health professionals interval train for short periods over an extended time (Gallagher et al., 2005).

A study out of Jordan that simulates a heart provides a more accurate comparison to how groups might benefit similarly from VR and simulation. The virtual model received higher satisfaction from medical students implying greater learning; a limitation of this study is that effectiveness is based on survey rather than behaviour change (Salsabeel et al., 2019).

Kyaw et al. (2019) conducts a meta-analysis of virtual reality technology studies educating health professionals. The cumulative review of research spanning 1990 to 2017 found that VR technology shows evidence of improving knowledge and cognitive skills in health professionals. Behaviour change is not reviewed or understood as to how it is impacted by VR technology.

A Hong Kong study develops VR technology as part of an interactive training program to aid in procedures related to patient diagnostics. The study finds value in the VR technology to transfer knowledge, but like many studies before it, fails to measure behaviour change post-training (Tang et al., 2020).

New research in the medical field provides the possibility of measuring brain activity during VR technology simulation to understand how the brain responds in virtual worlds Gillian, 2019). The immersion of this technology provides additional data points to measure the effectiveness of VR technology, however post-VR technology performance is still a critical step in understanding how VR technology in the training environment aids in behaviour change post-training. Unfortunately, VR technology studies in the medical field continue to present a gap from effectiveness in the training environment to proven behaviour change in the field (Papanikolaou et al., 2019). Before discussing behaviour change in greater detail, the next section investigates current VR technology studies in the aviation industry.

2.3.3 VR Technology in Aviation

The aviation industry, like the medical field, adopts sophisticated training that includes testing and verification of the training environment to maximize knowledge transfer. In a study of 310 aviation students across ten United States institutions, students identify VR technology as useful, enjoyable, and positively impacting learning (Fussell & Truong, 2021).

A 2017 study chronicles the efficacy of different VR technology display screens utilized in the aviation training environment to understand the effectiveness of VR technology (Buttussi & Chittaro, 2018). Regardless of VR technology utilizing two-dimensional or three-dimensional images through either a desktop monitor or head mounted hardware, Buttussi and Chittaro’s study finds that knowledge and self-efficacy improve utilizing all types of VR technology regardless of monitor type through rigorous examination of workers prior to training, post-training, and two weeks after training (2018).

A German aviation study compared VR technology flight simulation to hardware flight simulators to compare speed and accuracy of pilots in the two environments. In this study, pilots spent more time in VR technology to engage cockpit instrumentation than they did in the hardware flight simulation (Oberhauser et al., 2018).

More recent studies on aircraft pilots determine the efficacy of VR technology as a training tool. A pilot training study shows VR technology leading to higher test scores for pilots (Dymora et al., 2021). Another pilot study demonstrates that VR technology is effective in measuring cognitive ability, situational awareness, and prospective memory (Van Benthem & Herdman, 2021).

In both pilot studies, the data did not compare similar training environments: one with VR technology and one without VR technology, which would have allowed the VR technology to serve as the true differentiator in the success of the training.

Throughout aviation studies, recent analyses link the time spent in VR technology and the ability of the firm to integrate the VR technology as factors in effective utilization. Time spent with VR technology requires further study, but there is evidence that firms who better integrate the VR technology into their training environment see enhanced results of VR technology utilization (Buttussi & Chittaro, 2018; Oberhauser et al., 2018; Dymora et al., 2021)

2.4 Cynefin Framework

Use Snowden's (2002) Cynefin Framework provides perspective of how to view the growing issue with VR technology studies that compare sophisticated VR technology with poor training in an unsophisticated learning environment. In many of the studies discussed here, the control group functioned without VR technology in an environment that did not implement adult learning theory, nor benefit an equal number of learning styles.

To better understand the current problem with VR technology, the Cynefin Framework (Figure 1) is reviewed through different domains to identify where current studies lack the perspective of how to make decisions and understand the full impact of VR technology.

The virtual reality studies examined here reflect a Simple (bottom domain) approach to the impact of VR technology in training. Ranging from surveys where workers preferred VR hearts versus physical replica hearts to manufacturing a product through VR versus an instruction manual, the studies take a linear approach to understanding the impact of VR technology without considering the whole environment or the needs of stakeholders. The Simple domain accounts for linear cause and effect relationships which some VR technology studies claim. The assumption that VR technology can be proven by comparing current status of training to adding a VR technology is an oversimplification that does not investigate the learner behaviours or state of the environment where VR technology is inserted.

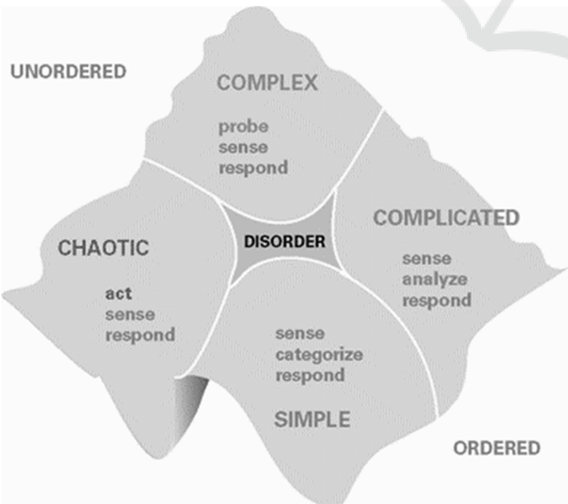


Figure 1: Cynefin Framework from *A leader's framework for decision making*, by D. Snowden & M. Boone, 2007.

The Complicated domain (right domain) represents an issue or decision that may have several paths to the correct answer. It is possible that VR technology in training is complicated in nature. While several paths forward may exist qualifying how VR technology should and should not be used, the sense-analyze-respond steps do not ring true in this context. The initial understanding of VR technology should include a more thorough investigation before sensing can take place. The failing of current studies is the lack of investigation into understanding the training environment before the insertion of VR technology.

In the Chaotic domain (left quadrant), no relationship exists between the circumstances, which does not apply to the effectiveness of VR technology in the training environment.

The Complex domain (top quadrant) is where the VR technology issues lie in most firms. In order to form a more complete understanding of how VR technology stands to benefit the firm, probe and analysis must first take place to decipher the level of adult learning theory in place with the current training as well as the learning styles that benefit from current training. Once a thorough understanding of the training environment is reached, researchers can sense the best path forward to measure the impact of VR technology and act.

2.5 Behaviour Change

In the automotive and airline industries, previous studies integrated knowledge management models and synthesized them into the Knowledge Transfer Measurement Model (KTMM) (Figure 2). KTMM demonstrates the different ways firms can measure the success of knowledge transfer while identifying direct relationships between training and business results (Rosellini 2017, 2019).

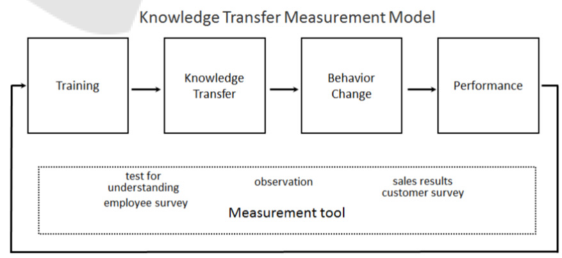


Figure 2: Knowledge Transfer Measurement Model from *Knowledge measurement model to measure the impact of formal training on firms,* by Rosellini, 2017.

Formal training environments provide learning to workers in a way that allows them to capture both explicit and tacit knowledge, then put the knowledge into practice through behaviour change. KTMM outlines measurement tools that help measure the progress of the knowledge transfer process. While assessments are valuable tools to understand if knowledge has been transferred, observation of behaviour change is a superior measure of success for knowledge management systems (Rosellini, 2019; Rosellini & Hawamdeh, 2020).

When measuring safety over sales, the current study utilizes observation by a third-party to answer the following questions: How does the addition of VR technology impact post-training behaviour in identical environments that adopt adult learning theory? How does the VR technology's impact change over time?

3 METHODOLOGY

At a U.S.-based airline, flight attendants are spend time in both VR technology and in-person instructor-led training to learn essential safety behaviors. This particular airline was selected because of the superior training environment provided to its workers. Details of the training environment cannot be shared in this study, in order to maintain the confidentiality.

This study is presenting new data at the early stages of analysis. Data sets include flight attendants scores from three time periods: 2021-2022 represents results for both a non-VR and VR flight attendant scores; 2019 represents the same populations; 2017 represents scores prior to VR launch.

3.1 Sample Size

To protect company data, the population of total flight attendants is not shared publicly. The sample size is statistically significant and includes over 26,600 flight attendant scores from drills assessed by a supervisor.

The pre-VR technology data set includes a statistically significant population of flight attendant scores to compare flight attendant behaviours prior to and after introducing VR technology into the training environment (Table 1).

Table 1: Population Comparison of participating flight attendant scores in VR Technology study.

Date Range	Control Group (no VR)	Test Group (with VR)
October 2021 - February 2022	543	8,332
January 2019 - December 2019	5,370	6,633
January 2017 – December 2017	5,723	-

The second time frame selected (2019) was shortly after VR technology integration began. Except for the VR technology, control groups and test groups receive the same training in the same time frame. The third time period includes flight attendant drill scores prior to VR technology integration.

3.2 Testing

After the completion of flight attendant training and prior to completing flight attendant certification, the airline assesses flight attendants on a series of behaviour drills. The behaviour drills are measured one-on-one by a member of the training staff. Behaviour drills allow the firm to assess the capability of the flight attendant to pass safety and regulatory behaviours required to complete certification. Based on KTMM, testing of the research questions includes observations of behaviour change post-training, rather than survey or assessment. The benefit of studying behaviour change post-training is that firms can begin to understand the outcomes they can expect from VR technology integration.

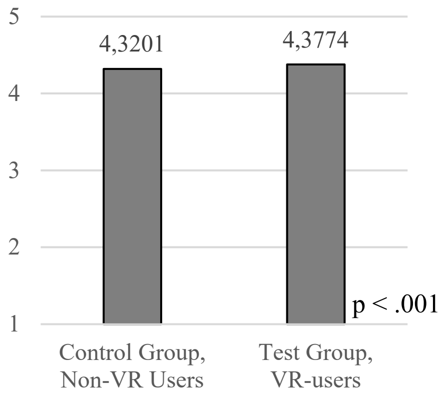
To test the impact of VR technology integration in a sophisticated training environment, this study utilizes an Independent Samples Test of the one-on-one observation scores of behaviour drills. The behaviour drill scores are compiled in three different time periods: prior to VR technology integration, upon initial adoption of VR technology integration, and after two years utilizing VR technology. For the time periods when the firm is utilizing VR technology, both a control group and test group were used to compare average scores both with and without VR technology integration.

The scores of behaviour drills include a 5-point range where scores of 4-5 are considered passing scores. For seasoned flight attendants with in-flight experience at the airline, scores of 3-5 are considered passing.

4 RESULTS

The results of the Independent Samples Test show an increase in behaviour outcomes with VR technology integration in the learning environment. The sample size of the population tested immediately after VR technology integration provides the greatest significance into the effectiveness of VR technology integrated into the sophisticated training environment.

Graph 1: Population Comparison of Flight Attendants scores with non-VR integration and VR integration.



4.1 VR Technology Impacts Behaviour Change

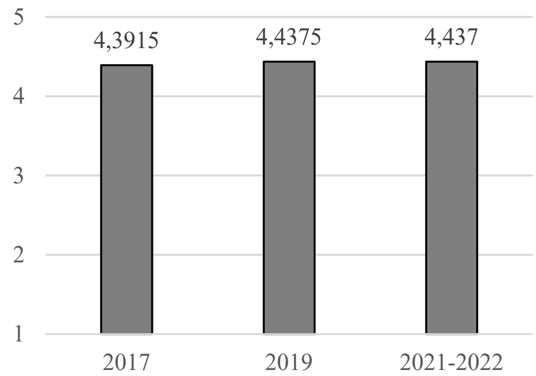
As a result of VR integration, the scores of behaviour drills increased in the test group. Graph 1 illustrates the increase in score from 4.3201 with the non-VR technology users to 4.3774 with the VR technology users. With a p value < .001, the mean score of VR-users compared to non-VR users is statistically significant.

4.2 Behaviour Stabilizes Post-VR Technology Integration

According to previous research, firms benefit from the utilization of VR technology over time as they learn to integrate the software into the current training environment. In the experiential training environment that utilizes adult learning theory and integrates learning styles, VR technology results in an increase in knowledge transfer behaviour change. Graph 2 shows how the population scored prior to VR technology integration with timeline comparison of how average scores changed with initial VR technology rollout and two years after VR integration.

Although this study is early in analysis, initial findings illustrate how the populations' average scores improved with VR initial integration, then maintained similar average score after two years of utilizing VR technology in the training environment. The initial results point to consistent results of VR technology improving behaviour change regardless of the firms' experience with VR technology.

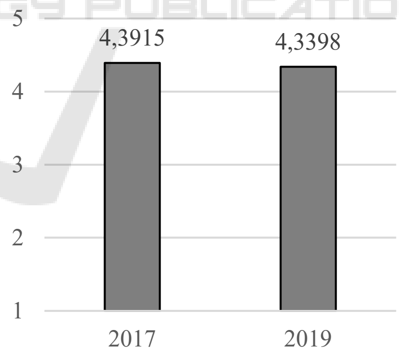
Graph 2: Comparison of flight attendant scores prior to VR integration (2017), immediately after VR integration (2019), and 2 years after VR integration (2021-2022).



4.3 Firm VR Technology Integration Produces Mixed Results for Non-VR Users

An unintended result of this study was decrease in average score of non-VR users after the firm integrated VR technology into the training environment.

Graph 3: Mean Score Comparison of non-VR participating Flight Attendants prior to VR technology integration (2017) and post-VR technology integration (2019).



In the populations of Graph 3, all participants completed experiential training and did not participate in VR technology integration. Despite no change in the flight attendant group's training, the later group experienced a decrease in average scores after the firm integrated VR technology with other flight attendant groups. More analysis into this anomaly will be conducted and this decrease is discussed more in the Conclusion.

4.4 Limitations

The study is not intended to compare the capability of different VR technologies, rather to explore how a experiential learning environment compares to a virtual experience. Failing to explore how the different VR technologies play a role in learning, while intentional, is a limitation of this study.

In the control group, the control group that did not integrate VR technology included flight attendants that had the most in-flight experience and whose previous training did not include VR technology. The years' experience is a limitation in the study because the years of in-flight experience is significantly different between the control and test groups. The test groups were new flight attendants in the firm, attending training at the airline for the first time. While it is possible members of the test group worked for other airlines and had some in-flight experience, the significant difference in years' experience is a limitation of the results of the study. Additional limitation of the control group is that the control group in the seasoned VR technology timeframe represented less than 7.0% of the total population tested, limiting the usefulness of data from this sample population.

The study was unable to compare and measure the work history of flight attendants in the test groups. Additional research should be conducted to understand how previous in flight experience impacts of neutralizes the effectiveness of VR technology when integrated into a sophisticated training environment.

Lastly, a limitation in this study was that flight attendants were not surveyed to understand their previous experience with VR technology. It is possible that the consistent results of training with VR integration is also linked to the average age of the test group and likelihood that they have previous experience with VR technology. Further testing will enable researchers to isolate previous VR technology experience either in leisure or a professional setting to understand its impact on VR technology integration in the training environment.

5 CONCLUSIONS

The integration of VR technology blended with sophisticated training allows firms to maximize the learning styles of individuals while improving overall behaviour change of workers. Given the concentration of VR technology research in the last five years, more data must be collected and analysed to understand how VR technology impacts behaviour change to a greater or similar degree to classroom simulations.

5.1 Implications for Knowledge Management Systems

The implication of knowledge management systems is that VR technology continues to spread in new industries, but how it impacts knowledge transfer and ultimately behaviour change must be considered in light of training environments that are its equal in how they adapt to different learning styles. Current studies lead practitioners to believe that VR technology improves learning and knowledge transfer. There is not sufficient evidence to support that VR technology is more effective than Kolb's model of adult learning theory utilized in the training environment; however, the study suggests that VR technology when used in tandem with a sophisticated training environment results in improved knowledge transfer behaviour change.

An unexpected result of the initial analysis was the decrease in average scores of non-VR users when VR technology was integrated into the firm. A possible explanation is that training resources in the firm were deployed to support the new VR technology, changing the training environment in a way that decreased knowledge transfer and resulted in decreased learning. Further research into the data and follow-up with the firms is critical to understand what changed for non-VR users when VR technology was integrated into the training environment.

As learning technology increases in the aviation and other industries, the benefits in behaviour change provide a positive indication of the future use of VR technology.

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