Immersive Motivation: The Effects of Virtual Reality on Motivation and Learning

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Gamification in virtual environments is an avenue for learning and education. Users are tasked with an escape room scenario and asked to gauge their confidence in escaping. Comparing virtual reality to a standard desktop version of the program. By measuring the participants' self-rated confidence level at each stage of the puzzle, this research examines whether virtual reality has a greater impact on the users' ability to determine if they believe they are more or less capable of completing a task. The results of this test should determine that the full immersion of a virtual reality environment generates a greater level of confidence in participants, as compared to the desktop environment.

CCS Concepts: • **Human-centered computing**; • **Applied computing** → *Education*; **Computer-managed instruction**; Computer-assisted instruction;

Additional Key Words and Phrases: virtual reality, motivation, game theory, learning, education

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1 INTRODUCTION

In recent years, virtual reality (VR) head-mounted displays (HMDs) have become more affordable to the public, increasing their influence in private and public domains [14]. VR can refer to many different technologies, including some which are not immersive [18, 22], but for this paper we will focus on VR HMDs. HMDs, including the Meta Oculus Quest 2, HTC XR Elite, and Neo Pico Eye, are more robust and sophisticated than their predecessors [19]. These technologies consist of many elements, including simulation of various scenarios that can be used to train workers in performing certain tasks pertaining to their careers [29].

Augmented reality, a technology that incorporates virtual elements into the real world, is similar to virtual reality in its applications. Its interactive simulation model allows users to practice learning delicate tasks with less risk, from

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printer repair to brain biopsy [5]. The technology that is used for augmented reality is similar to the technology used for virtual reality. Advanced AR usually involves the use of a head-mounted display that is see-through [4]. Other options, such as using a handheld display, which uses a mobile device or tablet, or a spatial display, which can rely on a desktop computer, a projector, or a spatial optical combiner, exist [7].

Some of the concerns for AR technology are the same as those for VR technology, such as latency and tracking, and some are exclusive to AR, such as environmental sensing [4]. Augmented reality, like virtual reality, has many applications for teaching. Lessons conducted using AR are as varied as exploring the African savanna and its ecosystems to developing a cure for a disease outbreak [11]. Even when AR uses a mobile phone rather than a headset, there are many options. The CityViewAR app, for example, is a mobile app that uses augmented reality and GPS to identify landmarks and give the user the history of these landmarks [6].

With such technologies becoming ever more prevalent, it is imperative to know exactly what effect the incorporation of virtual and augmented reality has on learning, motivation, and confidence in completing tasks. This experiment aims to determine whether participants are more confident and motivated when completing tasks in a virtual reality environment versus when they are using more standard computer technologies to complete these tasks (computer monitor plus mouse).

In this experiment, we assessed the value of gamification when it comes to learning new skills. Gamification has already been shown to improve students' learning of new skills [3, 16, 23]. Gamification is also a helpful tool for training algorithms, particularly in reinforcement learning, which in part mimics how human beings learn [1]. In augmented reality systems, the virtual elements are incorporated into the real world, using a variety of different tracking algorithms to incorporate virtual objects into the scene. This way, the user's real life environment can be used for teaching skills, and a virtual environment does not have to be created [2].

This experiment involved applying the concepts of gamification to two different environments; an escape room style was used to stimulate learning and accurately assess confidence and motivation in participants. We hypothesize that, on average, participants who interact with an escape room puzzle through a VR HMD will report feeling more motivated and confident with the puzzle than participants using a desktop and mouse.

2 RELATED WORK

Virtual reality technologies have been on the scene for a long time. An article by Zheng et al. [29] from 1998 details the basic components of virtual reality. The most important components that these authors listed were real-time 3D graphics, total immersion, and dynamic response to user actions [29]. Shu et. al. found that visual stimulus and motion are qualitatively relevant parts of virtual reality HMD experiences [13].

Virtual reality and augmented reality (AR) are compelling options for teaching applications [9, 10, 17, 27]. They offer a visual and real-time model for tasks that one may have to complete without spending many extra resources [17]. Virtual Reality programs have been developed to help students learn about STEM-related topics in particular, from a program meant to teach about space relations to understanding the Earth's climate zones and 3-dimensional diagrams of animals' organ systems [21] VR/AR's utility has led to significant investments in this cutting-edge technology [18, 21]. Our experiment helps expand upon the current understanding of the relationship between students' learning and the presence or absence of these technologies to ascertain to what extent one should invest in them when devising a plan to incorporate them into educational establishments. In addition, it guages a user's confidence in using a VR HMD in contrast to a traditional desktop environment, with the understanding that a user might be more comfortable in an environment that motivates confidence.

Mahmoud et al. [17] explored immersive VR's effect on learning in contrast to a video capture experience. They performed a study on college students by giving one test group VR controls and the other test group a screen capture recording of the VR program. Both of these mediums demonstrated the same fluid dynamics principles. They found that not only did the immersive VR group significantly score higher on the quiz to assess the participants' learning but participants reported a statistically significant, greater amount of concentration and enjoyment than the video capture experience group. Our experiment also tested learning through a VR versus a non-VR experience, but both groups engaged with the environment while using different controls and displays.

VR has also been demonstrated to have a positive effect on spatial learning [20]. In a methodological approach, engineering and architectural students showed an improvement in their ability to retain information over a period of time. Given this, the virtual environment should provide a greater sense of approach ability and confidence in users, which our experiment addresses. Similarly, students under pressure to continue their education during COVID related that they felt more confident in engaging with a virtual environment, rather than a more traditional lecture style [23]. While this was presented as an alternative in an unusual learning environment, the students still seemed to find a greater amount of enjoyment from the gamified style of engagement.

Further reserach in immersion and its impacts on learning discovered that virtual environments were most effective when engaged in a high level of immersion. The full interactive experience of a virtual environment had a demonstrably stronger influence on participants' learning [24]. This was combined with the confirmed hypothesis that greater presence within the virtual environment would have a greater impact on learning.

In designing this experiment, virtual hands were added to allow for greater immersion in the virtual reality version of the program, and crosshairs were added to the desktop version, so that users have some greater sense of being connected to the program. In relation to Peterson's research [24], these features were added in order to further enhance the user's immersion.

However, in a pilot program conducted by Lynna Ausburn and Floyd B. Ausburn, some of the findings also suggested that the learning ability of participants was influenced partly by age, with younger participants showing greater gains than older participants [3] In a more broad sense, there is more room for research to be done in adapting learning techniques to different age groups. In our smaller experiment, this is less broad, as the subject pool is limited to college students, mostly from the Computer Science department.

VR is a good platform for teaching, especially through simulated experience and multimodal adaptations of scenarios. Previous works show that VR training could replace real training as this training offers not only an effective way to transfer knowledge but also provides a cheaper and shorter way to train a person on a job [18]. Other uses of virtual reality technologies that have been successful are as phobia therapy, in military training, and as entertainment [8].

One of the reasons why virtual reality works well as a training tool is due to the immersive experience it provides; traditional educational measures involve actively participating in an interactive activity, but education that uses VR is able to take it a step further and completely immerse the user in the experience [12]. Immersion can cause participants to enter a state of flow, where the user's concentration is focused solely on the task at hand, which further helps with learning [15].

Confidence in abilities obtained in a virtual simulation has also been researched in at least one longitudinal survey conducted among physiotherapy students. In a study using simulated patients, self-reported confidence increased among students using the simulation. However, their confidence decreased again at the beginning of each module. Students also showed an increase in competence, versus students in a traditional program [28]. There are some differences in this experiment; it is much smaller in scope and will not be run over time. However, we might expect to see some similar results in confidence levels among our virtual reality subjects.

Simpler 2D models have also been used in analyzing confidence. In research conducted by Yudong Tao, et. al., participants took a lengthy survey utilizing a Magic Leap head-mounted device. Their confidence levels could be measured by self-reporting, as this experiment does, as well as the amount of time taken on each question; longer time taken on a single question reflects a lower confidence level in the participant's answer [25]. In conclusion, Tao's research proposed conducting similar tests in a more complex 3D environment. This experiment attempts to accomplish exactly that, by asking participants to take part in a puzzle solving activity.

3 METHODOLOGY

The goal of this project is to determine whether the application of Virtual Reality/Augmented Reality technologies to already-gamified software increases one's motivation and confidence when dealing with complex tasks. In the world of education, gamification is implemented in computer programs. Gamification is the incorporation of elements found in games to enhance learning. These programs are designed to aid studying and help students learn. [21]

In both the control and the experimental group, our prototype was designed to use gamification to enhance one's learning experience. The independent variable between the two prototypes is the environment. Hence, the experimental group was given the version configured to a VR headset and the control group used a regular desktop computer.

First, each participant was given the Consent Form to read and sign before we commenced the experiment. This form ensured that they understood the purpose of the study and their rights as participants. Once they signed the form, they were each assigned a different participant number. After assigning participant numbers, we booted up the application inputted their number, and allowed them to proceed with the starting survey.

The application starts off by asking the participant the following questions:

1. Do you consider yourself a gamer?
2. On average, how many hours per week do you spend gaming in any format?
3. Do you have regular access to a head-mounted VR device? (Oculus, PSVR, SteamVR, etc.)?
4. Even if you do not own a device, how many hours per week do you spend in Virtual Reality environments?
5. Which game genres do you play the most? (ex: First Person Shooter, Action/Adventure, Puzzle, Racing, Horror, etc.)
6. Given your experience, how confident do you feel you can solve a puzzle in a 3-D environment?

Upon completing the initial survey, the simulation began for both the desktop and VR headset participants. They were instructed to solve a puzzle within a 3-D environment which allowed us to assess their problem-solving skills and adaption to different platforms. After successfully completing the puzzle the participants were then directed to another screen to answer the post-experiment survey.

The questions used in the end survey are as follows:

1. How difficult did you find this puzzle to solve?
2. How much would you consider you improved between the beginning and end of the puzzle?
3. How easy did you find the controls?

The end survey aimed to gather insights into participants' experiences and gauge their perceptions of the learning curve and difficulty connected with the puzzle and its controls. Upon completion of the end survey, the application would automatically close which signaled the end of the participant's involvement in the study. The participants were then offered a cupcake and thanked for their time and contributions. After that, they were free to leave at any time. Overall, the entire process was designed to be user-friendly and efficient while gathering valuable data on users' confidence and experience in both desktop and VR environments.

The puzzle itself took the form of an "escape room". [10, 26] These puzzles require one to pay attention to and interact with one's surroundings to figure out how to exit a room. For this kind of puzzle, we hypothesized that having access to the Virtual Reality headset would allow the user to better notice their surroundings, and hence users will, on average, be faster when solving the puzzle than they would without the headset.

The independent variable in this experiment was whether or not the version of the prototype subjects used is configured for VR. This experiment used a within-subjects approach to measure motivation and confidence between the two prototypes. The dependent variables were reported motivation, the time between tasks in the puzzle, and confidence when handling tasks within the program. Initially, our plan was to track subjects' learning through tasks, but since a longitudinal study of this caliber is out of the time scope of this class, we instead decided to measure how confident subjects are when learning with VR versus without VR.

The puzzle consisted of a cylindrical room with eight doors lining the wall and a cauldron in the center. Fig. 1 and Fig. 2 show screenshots of the environment.

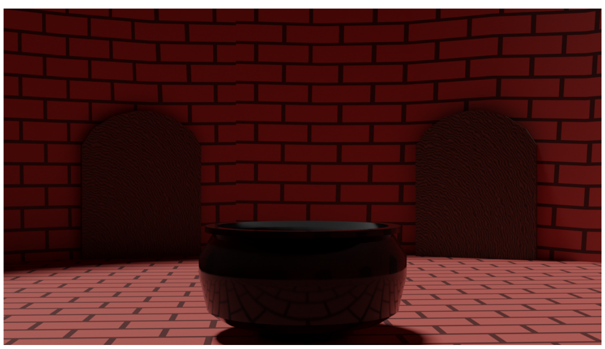

Fig. 1. User view of the first level. Created in Blender. Assets by Sophia Girard (https://drive.google.com/file/d/1gqC7niJWbHKXwep6VMvGeb8tZ0z4omwC/view?usp=share_link).

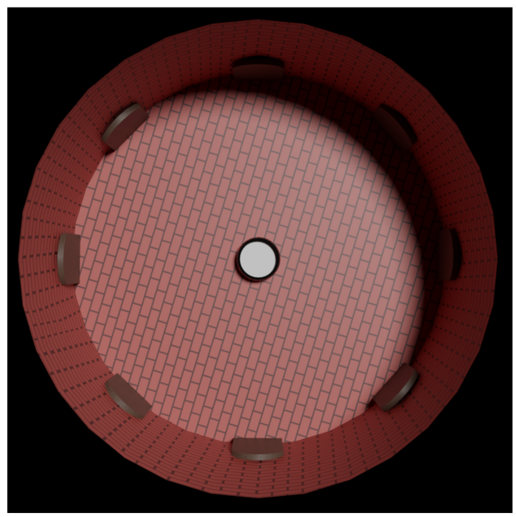

Fig. 2. Bird's-eye view of the first level. Assets by Sophia Girard (https://drive.google.com/file/d/12d1jHWMlpj5Wk3-TP-Q5hmh3d0j-AZ2X/view?usp=share_link).

In order to escape this room, the user must look into the cauldron. There they find hints about which door to go through first. As the user opens each subsequent door, they are given more hints as to where to go next. Eventually, they are guided to a door that offers the exit, ending the puzzle. Fig. 3 shows what the environment looks like in Unity with colored point lights serving as guides for the user.

This study aimed to explore whether the incorporation of virtual reality technologies into computer-based learning improved learning more so than learning with a desktop computer via boosting participants' motivation and confidence. Our study examined a person's motivation and confidence in completing a series of tasks in Virtual Reality versus on a

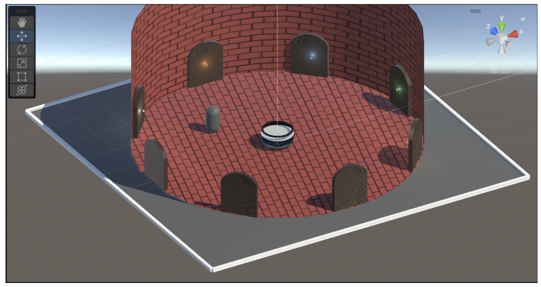

Fig. 3. Depiction of the room in Unity with point lights as door markers.(https://drive.google.com/file/d/1IG7w6pk8MtTYnLvDdzDdoqgv7Ss0Tbea/view?usp=share_link)

Table 1. Average Scores for Desktop and VR Environments

Average Scores									
Hours		**Environments**		**Score**		**Confidence**		**Time**	
Desktop	VR HMD	Desktop	VR HMD	Desktop	VR HMD	Desktop	VR HMD	Desktop	VR HMD
3.444	5.125	2.333	3.5	6.222	9.875	6.778	5.875	3:46.5	8:04.3

desktop. We staged this study in an escape room solver program where we surveyed the participant on their confidence before and after and measured how quickly they solved the puzzle on the given platform.

4 FINDINGS

We conducted this experiment with 17 participants in total. Because participants were chosen at random to complete the task in either the virtual reality or desktop version of the program, one unanticipated environmental factor was access to a virtual reality headset. In this small sample, over half of the virtual reality participants answered that they had regular access to a VR device, while none of the desktop participants reported that they had access.

The VR participants also then reported a higher number of hours spent in virtual environments (an average of 5.125 hours, versus 3.444 hours among desktop users). They also tended to score higher overall in virtual environment exposure. However, their average reported confidence levels were actually lower than Desktop users (Table 1).

Times were gathered when users finished the in-program exit survey. The functionality of the program that would have more accurately determined the time did not accurately record times, and so these surveys are used only as a stand-in. Although less accurate, these do give a sense, at least, of how quickly users progressed from the opening survey to the end of the closing survey, with the majority of the time spent on the puzzle. On average, VR participants were about a minute faster than desktop users. Because of the ambiguity of the question asked regarding the controls, it is difficult to ascertain if this was a contributor to the time difference; this question was asked using a slider bar inside the program, with 1 labeled as "Very easy" and 10 labeled as "Very difficult". Future designs of the prototype would have to correct this question with a simpler input method. In conclusion, after careful analysis of our findings, it appears that our initial hypothesis was unfortunately not supported by the results obtained from the study. Despite the observed differences in completion times between VR and desktop participants, the ambiguity in the controls question and potential confounding factors prevented us from drawing a definitive conclusion.

There were some difficulties in gathering all of the needed data, and this is a relatively small sample size. Given those constraints, the varied responses are spread equally among the two groups. For future iterations of the prototype and study design, it would be essential to refine the questions and input methods to enable a more accurate assessment of the relationship differences between the controls and user performance on both VR and the desktop. Once these limitations are addressed, we hope to gain a clearer understanding of the factors influencing user experiences in desktop and VR environments.

5 DISCUSSION

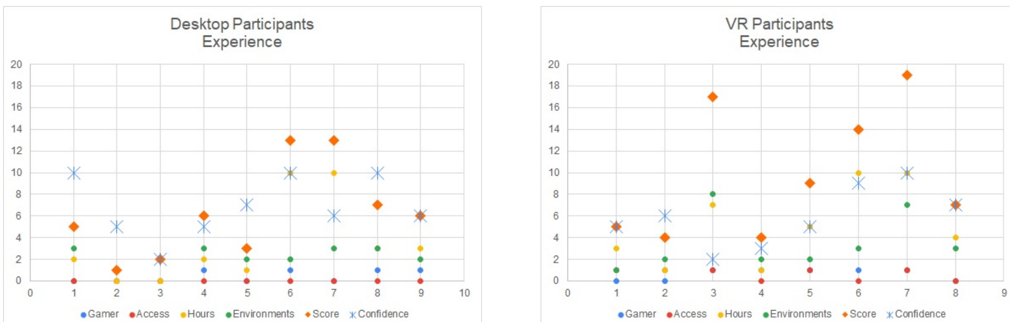

Fig. 4. Experience scores and confidence levels between the two groups.

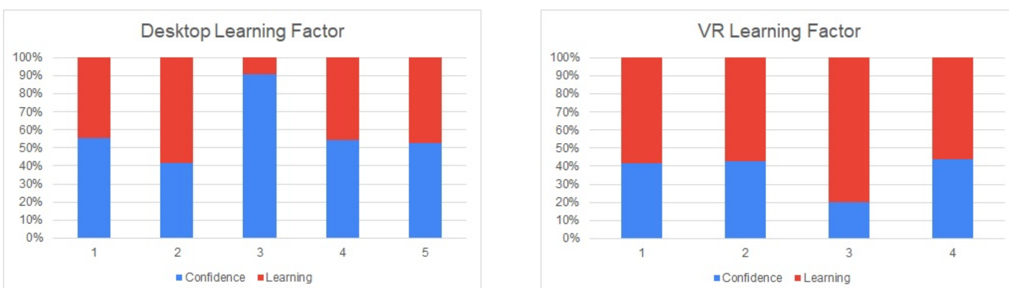

Fig. 5. Learning levels in Desktop and VR groups

The information from participant surveys provided data on gaming, virtual reality, and 3D-environment experience. Positive answers to the questions of whether the participant was a gamer and had access to VR equipment was counted as one point. Another point was added for each gaming environment the participant chose in the survey. The number of hours spent in virtual environments was also added to compile a final score, shown in Figure 4. This score can then be compared to the participant's reported confidence level in completing the task.

Learning factors between the two groups was similarly varied, although VR participants tended to report lower confidence levels, with relatively larger learning through the experiment (Figure 5).

The data was collected between subjects, with individual participants using either the desktop or VR version of the software. A one-way ANOVA revealed that there was not a statistically significant difference in reported confidence between desktop users and virtual reality users ($F(1, 16) = 0.5333$, $p < .5$).

Another one-way ANOVA showed also that there was not a statistically significant difference in learning between the two groups ($F(1, 8) = 0.034$, $p < 1.0$). There was some data loss in this category, so results are only reported on 8 participants.

The same survey that asked about learning levels was also used to collect time changes; from the time the user submitted the first form to the time they submitted the final form could be recorded. Using these time differences to conduct an ANOVA, there was no statistically significant difference in times between the two device types ($F(1,6) = 0.094$, $p < 1.0$).

6 CONCLUSION

Even though the experiment was designed to randomly distribute HMD VR and Desktop participants, they were not queried prior to the experiment's beginning about their VR experience. As a result, the results were not entirely randomized; none of the Desktop users reported owning a VR HMD device, which might have skewed the results. One possible conclusion is that the desktop users had no significant amount of HMD VR experiences to compare. With a greater expansion of the prototype, a within-subjects experiment might reveal a greater variance (each participant would be able to compare the VR and desktop experiences directly).

With the prototype as it exists, no significant difference was shown in confidence levels or learning. This was in spite of the VR group having an average greater amount of experience in gaming and 3D environments. This would imply that confidence, at least as reported by users, is not necessarily an extension of experience within an environment. Further testing could be designed to determine other factors in a user's confidence, which is not within the scope of this experiment.

There were a few limitations in this experiment that likely had a significant effect on our results. We could have measured learning more accurately had we conducted a longitudinal study, but due to the short amount of time that we had and the amount of time it took to create the puzzle that we used, that option was not feasible. Motivation and confidence were also impossible to gauge without participants self-reporting, which is subject to error. We did gauge the amount of time that it took participants to finish the puzzle, but that data does not paint a complete picture of what the data that we intended to collect.

Overall, self-reported confidence and learning levels found no statistical differences between VR HMDs and desktop environments between different subjects. While this was only a prototype study with a small group of test subjects, the conclusion reached is that 3D environments are as likely to allow users to learn and interact regardless of whether they are delivered on a 2D desktop display or a head-mounted virtual reality display.

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