Utilizing Virtual Reality Game Design to Improve Problem Solving and Logical Thinking Skills

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Abstract. In an ever-changing society, educators are constantly looking for new ways to engage and stimulate students. To that end, games have been used as a tool to develop problem-solving and critical thinking skills to make learning interesting. The key to making a game that effectively serves this purpose is rooted in tenets of proper game design. A primary component is the contrast between the appearance of the end goal and the path a player must take to reach it: the goal should always be clearly defined, but the way forward does not need to be readily apparent. This requires the player to carefully solve the problem step-by-step as if the task was designing a procedure or program. However, another major component is the difficulty. While provoking thought is paramount, the game should never be unfair. A fair, yet difficult game retains the player, but lacking either fairness or difficulty will result in frustration or boredom, respectively. To further advance game design, we look to Virtual Reality (VR), which has come into prominence in recent years at the forefront of interactive technological experiences by allowing users to immerse themselves in said experiences. VR has the potential to greatly advance the academic, gaming, and recreational landscapes, allowing for new and unique experiences that can revolutionize how we learn about and interact with the world.

INTRODUCTION

Education is the process that shapes human society, allowing it to grow and change as time progresses. However, despite the near-constant changes that society goes through, education itself has not gone through the same level of evolution, leaving the system nearly identical to how it started, but sans the level of result it once achieved. The current educational system was never designed to emphasize student engagement, leaving students, especially kinesthetic learners, increasingly uninterested and frustrated as literacy rates plummet and withdrawal rates rise [1].

To combat this phenomenon and revolutionize the educational system, educators have found themselves turning to digital games and activities for teaching. The psychology behind this is simple and has been a long standing belief throughout humanity: valuable lessons are learned by children at play [2].

GAMES IN EDUCATION

Within recent years, games have become a prevalent part of modern education, appearing in classrooms around the world, regardless of subject. From PowerPoint Jeopardy to Family Feud to Kahoot [3], teachers have used games as a form of information reinforcement, disguised as a friendly competition among the students, to substantial success. While this technique is traditionally applied with younger students, students in higher education have demonstrated that games and active learning create positive results in all levels. In a study for the *International Journal of Teaching and Learning in Higher Education*, students responded positively to five classes where active learning approaches replaced the traditional lecture format. The study reported that the students expressed that 51% of a class being lecture-based, as opposed to the actual average of 67% of a class being lectures, would be beneficial to their learning, data which is reinforced by trends in corporate and professional training [4]. This study shows that students and professionals alike prefer to take a more active role in their own learning processes, instead of simply being talked at by the instructor(s), as well as that they feel more engaged by active learning techniques.

In addition to increased engagement, using games and active learning also allows for facilitation of understanding and teamwork among student populations. In the aforementioned examples of Jeopardy and Family Feud, classrooms are often split up into teams and rely on each team member's individual strengths, while covering for individual weaknesses. This creates an environment where the students are able to learn from each other, as opposed to learning solely from the teacher. The advantage to this method is based in the idea that each student will glean information from the instructor differently, emphasizing different points and ideas than those emphasized by any other student in the class, simply by virtue of varying interests and learning styles [5]. Therefore, student teams create a melting pot of information, where Student *A*'s knowledge of topic *X*, combined with Student *B*'s knowledge of topic *Y*, etc., come together to paint a complete picture of the lecture material.

However, despite these advantages, traditional games as applied in an educational context are not without challenges. Notably, these games tend to emphasize a "drill and practice" approach to learning, which reinforces many schools' emphasis on rote memorization practices [6, 7]. In addition, organizing and implementing these games takes time for an instructor, which, in addition to the time it takes to prepare and deliver lectures, makes constant active learning unfeasible for a traditional classroom setting [4]. In response to these challenges, teachers have taken steps to implement digital games in their instruction, which are able to better address these shortcomings – a move that has been met with a barrage of skepticism.

THE MOVE TO DIGITAL GAMES

Shortly after the Sputnik launch in 1957, scientists combined the popularity of Hollywood with typical school subjects to create documentaries, which were then broadcast on primetime television, in an experiment known as "Operation Frontal Lobe." The purpose of this experiment was to use the most popular form of entertainment at the time as a learning mechanism; exactly what teachers are doing with digital games today. Video games are arguably one of the most ubiquitous forms of entertainment in society today, exactly as television was in 1957. According to a survey done among MIT students in 2003, 75% of the freshman class played video games at least once a month, and 60% of the entire MIT student population played at least an hour a week [7].

Addressing the Challenges of Traditional Games

Given the fact that so many students are, and have been, playing video games well into college, the move to digital games seems like a natural step to take. Using digital games as a form of active learning directly addresses the major challenges with traditional, in-class games. Firstly, digital games are not designed to focus on rote memorization and "drill-and-practice" techniques that traditional education places a huge emphasis on [6]. They instead tend to focus on practical critical thinking skills and the solving of unique problems. This allows students to diversify their thinking beyond exactly what they learned in class by applying their knowledge to different scenarios, all within one gaming experience. In addition, based on game design principles, these digital games also introduce necessary knowledge for the player to use in solving the problems presented, allowing students to learn new information as well [2].

Digital games also work to take the demand off of teachers. Unlike traditional games, digital games do not need to be re-prepared before every use. Instead, digital games are completed once, and as material is gradually introduced throughout the course, students are able to complete more of the game. In addition, with web-based digital games, students are no longer restricted by having to wait for classes to do the activities, and can do them on their own time. This also alleviates the issue of limited class time, as the instructor can teach in class and use games and active learning as reinforcement both in *and* out of the classroom [2]. Therefore, these digital games could benefit both students and teachers by lowering the teacher attrition rate [1].

Applying the Strengths of Traditional Games

Besides simply addressing challenges of traditional active learning, digital games also build upon the strengths that traditional games bring to the table. For example, digital games still produce a strong, if not even stronger than traditional games, level of engagement among student populations, as well as facilitation of understanding. Due to the large number of students that play video games, many of them are already familiar with games that can be applied to

education in ways they may not have though of. For example, Kurt Squire cites *Civilization III* in an article for *InSight* Journal as a popular game that can portray school material in a new light. In his article, Squire writes that "*Civilization III* players encounter history not as a grand narrative but as the product of several dynamic interrelated forces. Students might learn about the role of horses or the interplay between economics and foreign policy. Students can use the game as a form of transgressive play, playing out fantasies of overturning established social orders. 'What if?' questions can motivate further reading or discussion, helping them to refocus on why the actual events unfolded the way they did" [7]. In this example, Squire takes an extremely popular game (one of the most popular among MIT students at the time as well [7]) and demonstrates a way that educators can utilize it in their education. Historical inaccuracies such as the famous "warlord Gandhi" feature aside, the *Civilization* series allows for players to understand that historical events did not suddenly happen, instead focusing on the causes that happened in real time and how seemingly insignificant events could have major consequences, all while the students play a game they were going to get absorbed in anyway.

With digital gaming becoming a more prevalent form of educating students, the logical question to ask becomes the following: what is next? Where can gaming in education go, and where can it be improved upon? These questions can be answered succinctly with one subset of interactive technology: Virtual Reality.

VIRTUAL REALITY (VR)

Virtual Reality (VR) is a form of interactive technology that aims to fully immerse the user in the simulated environment and allow them to interact with the environment in a realistic way [8]. The concept is simple: the user puts on the VR headset, and the world is projected right in front of their eyes, creating the illusion that they are really in the simulated world. People use VR for a variety of different purposes: watching videos, exploring far-off locations, playing games, and more.

VR in Education

Due to the immersive nature of VR environments, VR can provide a unique experience that can be leveraged for education. VR has multiple advantages that can lend it to effective use in education, provided its use in education is explicitly developed for. While some of the advantages are still possible to achieve to a lesser extent with traditional digital games, others are benefits that are outside the ability of non-VR mediums to provide.

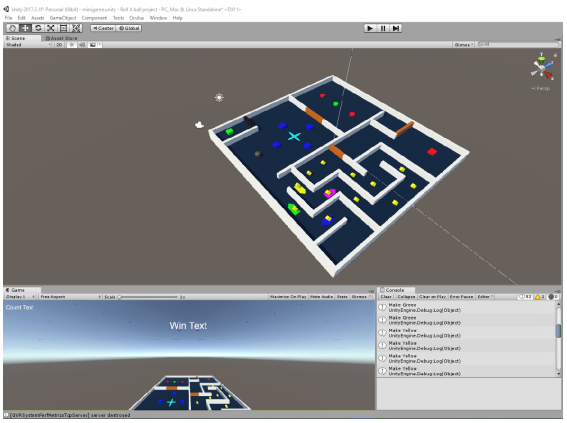

FIGURE 1. Our puzzle maze game in VR

One distinct advantage that VR environments have over traditional digital game environments is the intuitive method of control. While kinesthetic learners can benefit from non-VR game environments, the simulation of the environment in the same "space" allows the students to have additional layers of context provided in front of them, expanding the opportunities for them to learn. The VR motion controllers can be used to simulate actions like grasping objects within the digital environment. By giving a student the illusion of depth and the motion of the camera being tied to the movement of the student's head, the student has an opportunity to gain tactile experience with concepts that would be too difficult, costly, or dangerous to provide in a normal classroom experience. Additionally, as VR headsets limit vision outside of the virtual environment, students, who have issues focusing, may be able to more easily stay attentive, which could be amplified by headphones to allow the students to further immerse their senses, eliminating more distractions that would otherwise be difficult to prevent.

Although all digital games and most traditional non-digital games have the capacity to immerse a student in an environment where they cannot, under reasonable circumstances, physically experience anything (such as a period of history, other countries, or a relatively dangerous part of the world to travel to), VR environments have the advantage of allowing for deeper interaction and meaningful physicality to those settings. As a result, VR could be used to help

students, who may otherwise struggle with the concepts pertaining to the physical world, with a better understanding through such a unique experience.

Furthermore, while the upfront cost of many VR systems is still relatively high, institutions that can afford VR systems may be able to simulate a large number of kinesthetic learning experiences without consuming more physical space than what is necessary for the hardware. This has the potential to be particularly helpful for instructors and administrators, as traditional educational settings often provide limited space for instruction. In addition to mitigating an issue of space needed for kinesthetic learning environments, the long term cost of buying programs is likely to be lower than buying disposable resources for specific setups or purchasing an equally extensive amount of reusable physical arrangements.

VR in Research

We envision that VR education games will be beneficial at not only immersing a player into a virtual world to discover certain periods of history or human's body structure but also develop critical thinking, deductive reasoning, and logical thinking abilities. We applied some of the known game development techniques to design a simple VR game with a purpose of improving problem solving and logical thinking skills. The game requires the player to move a ball around the obstacles and solve puzzles on its way in VR as can be seen in Figure 1. Similar projects can be done by undergraduates as capstone and research work, shifting education into an age where it is infused with kinesthetic-based VR processes. More research is required in this area to draw definite conclusions on the effectiveness of such VR-based approaches aiming at improving the overall posture of the education environment.

CONCLUSION

Student engagement is a key component of an effective education. Although students need not be constantly entertained, it is generally more difficult to teach a student when the methods to do so do not engage them mentally. Despite their strong potential as engaging instruments to study complex topics, the market for sophisticated educational experiences through digital games is largely undeveloped. Furthermore, the emerging market of VR is unexplored in and of itself but it could significantly bolster the existing educational tools when utilized. By being able to grab students' focus effectively, reduce long term costs and storage issues, and provide students with the resources who are otherwise marginalized by current educational practices, VR games have the capacity to be a valuable asset to educators and students of diverse backgrounds.

With kinesthetic-based educational VR games development at larger scales, experiences tailored to sophisticated subjects in secondary and post-secondary education may be made more accessible to students who would otherwise have a difficulty with certain topics. However, developing those games at such a scale will require more extensive research into educational and game development practices to carry out in a proper manner, integrating the psychological and sociological support and making the experience as seamless as possible. Although it would be a relatively extensive undertaking, laying the groundwork could expand markets and, as a result, give students who would have limited options a greater ability to participate in classes they may struggle to meaningfully participate in.

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