3D Interaction for Computer Science Educational VR Game

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Abstract. We propose a full immersion 3D environment in the form of a video game. The environment offers the player the opportunity to explore basic Computer Science (CS) concepts without removing any of the entertaining aspects of games. We believe in creating a software that can be enjoyed by anyone regardless of age and at the same time can increase CS awareness. We developed a complete 3D game emulating an Escape Room. We aim to capture the attention of not only teenagers but also adults. The solution to each room is presented as puzzles based on the background concepts of computer science. These concepts are in the form of every day decisions to bring familiarity into the game play. The games aim is to be inviting and fun. Ultimately, giving each player the opportunity to be engaged into computer science concepts as they go thought the game and sparking interest towards CS.

Keywords: Virtual Reality · Education · Computer science education

1 Introduction

Every year more and more companies are in search for individuals that can understand and write code. Big companies like Google, Microsoft, Facebook, Code.org and others, support the creation of programming courses as early as middle school [1]. The Department of Education has also joined the efforts to bring Computer Science into the classrooms [2]. However, even with all these combined efforts from society, companies, the work force, and the government, the question still remains as of why we don't see a substantial increase on the amount of students enrolling and graduating from higher education institutions with a degree in Computer Science or related fields. In recent years, statistics show that even though there has been a surge of students registering for CS majors, the graduation rate is much lower [3]. Moreover, the diversity of the field is minimal, bringing minorities to the lowest proportion of the population on universities. Accounting for one-fourth of all the enrolling students on the field [4].

Even with the advance of technology, higher education institutions still offer traditional stand up and deliver methodologies when teaching CS courses. Every year, more and more diverse students fill the classrooms, this diverse population requires a deeper approach for delivering meaningful education. Some of these students may require extended time, visual and/or hearing aids, one on one tutoring, or other options. These are options that traditional techniques do not offer [5]. Computer Science requires that students develop skills such as problem-solving, math literacy, ability to understand abstract concepts, heavy science background, and adaptability to ever-changing field. These among other skills can still be taught to and learned by students, but at the same time these same skills scare away students from enrolling in science, technology, engineering, or mathematics (STEM) majors [6]. If we go a step backwards, many K-12 schools offer free education but this not a guarantee that the students will graduate with a high school diploma, moreover this also does not ensure that students who actually graduate, will pursue or commit to higher education such as college or university [7].

Many individuals have started to come into CS majors thanks to all the incentives from companies and society. However, it is still important to create a sense of care and desire to pursue a career. As many more graduates start to feel proud of their education, it is important to translate this message towards younger generations. With the continuous growth of technology and the internet, it is important to denote that new ways of learning have emerged. Online learning has taken classrooms and moved learning into virtual rooms with the chance to reach even greater audiences. Virtual Reality (VR) and Augmenter Reality (AR) devices have enhanced the experience of learning by bring new visuals along with the regular theory. All these tools considerably enhance learning by using visuals rather than standard text and narrative [8].

Students that take CS classes get discouraged by the constantly "difficult" labeled classes. Areas such calculus, physics and programming. Many of the students become afraid of CS not because its is difficult on its own but because of the high complexity portrayal that is given to it by scholars and the media. However, when looked at with a different scope, in a more simplistic and individualized scenario, computer science is very graspable. Originally, computers were designed as an extension of human capacity and are always seen as the human mind. In other words, computers function in a similar way as the human brain functions; Actions triggered by decisions [9]. The game seeks to demonstrate this idea to the user. This idea that a casual environment can embody several Computer Science concepts [10].

1.1 What Is the Difference with CScape?

Alchemist Escape is the completed version of CScape. The software consists of a total of four levels, achievement system, menu, keyboard and game-pad controls, and metrics. Since we wanted the game to be as inclusive as possible, we used an environment that resembled a medieval house, also we made sure that the game can be played by anyone by providing different control modes, and lastly,

We ported the system into Virtual Reality. In this version, the software ensures the player experience is as smooth as possible by providing hints, clear user interface, challenge messages, reset buttons and sound effects. In comparison with the first version, the completed version presents a full software that allows us to use it for the original purpose of increasing Computer Science awareness in minorities [11].

1.2   Motivation and Challenges

High school graduation rates are low when compared to the total students that start. Moreover, the amount of students that pursue higher education is even lower. By taking a deeper look in those statistics, we can recognize that many of the students steer away from STEM majors. Looking even deeper into the distribution of students that choose CS (or any related fields) as their major, we can see minimal representation of minority groups.

When selecting a major, the early identification what they want could help future steps towards success. Not only the classes to take, but also the motivation to continue thought-out the major [12]. When looking for a suitable medium to generate interest, we recognized the motivational power that video games have on children, teenagers and young adults [13].

2   Background

When looking at education and even educational standards, many times they are associated with money and socioeconomic status. As high school students approach their senior year, they start to look for opportunities to help build their careers. At the same time they face the reality of expensive education and in some cases, not being able to afford it. Lastly, when you add the lack of learning or little interest to pursue the career, there is even smaller chances that the individual would successfully finish the major after enrolling. Ultimately, affecting graduation rates from universities as a whole [10].

Even though video games have carried stigma for influencing children and teenager into abnormal behaviors and sometimes even addiction due to the release of dopamine in the brain [14]. Recent research actually shows that they are beneficial for motor skills, concentration, and multitasking. Another important skill developed when playing game is quick decision making and improvement on problem solving skills. It can be seen that even with the many games being released constantly, the average player can play with ease new games, with a minimal learning curve, showing adaptation to change. Furthermore, games have been used in the medical field, rehabilitation, psychology, and training individuals [15]. By utilizing video games and including learning tools into them without compromising the games entertainment, we would not only be helping the individuals but also starting to change the stigma that games have [16].

It is also important to denote that video games are not strangers to the classroom. Many systems have been created to spark an interest in learning. Systems in the form of simulators or tutorial driven platforms that teach many of

these concepts. Even though it's a good a approach to the use these technologies, it does lack in one of the most important values brought by industry games: entertainment. The heart of every game is the ability to discover, have fun, get rewards, and be challenged. The sense of discovering something new, challenging and even sometimes surreal, is what drives many players to spend their time in a game. In other words, its paramount to maintain any and every entertainment factor that the video game industry brings to the table [17].

In the USA, the average house hold has access to computers, smart phones, and if the family has children, a high chance of owning a console or gaming device. Hence, by making a software that does not force the purchase of a new device (eg. VR headsets, Gaming computers, Projectors and sensors) there is a good chance to reach a large audience. Introducing CS concepts and the notion of how to use them from an early age, can spark more interest into the major as they grow older [18]. It is also proven, that children that are engaged and determined to pursue a "hobby" from early on, become stronger professionals in the same field on later stages of their lives [19].

3   Alchemist Escape: Discover CS by Playing

3.1   Objective

We developed a video game in the style of a escape room. Every game rewards the players efforts by providing some type of incentive. Alchemist Escape features a total of three different rooms. The player needs to solve a different kind of puzzle in each room, not only to proceed but also to finally reach the final room and to be able to finish the game. The concept of an escape room was adapted due to the popularity of it. Moreover, the urge to escape a room provides a better setting for problem solving and decision making [20] (Fig. 1).

**Fig. 1.** Alchemist Escape - main screen screenshot

3.2   Concept

The game was developed using Unreal Engine 4 as the game engine and Visual Studio as the IDE. For the logic of the system a combination of C++ and Unreal Engine Blue print system were utilized. The game is divided into a total of four consecutive rooms. The first 3 rooms hold locked doors that can only be opened by solving each rooms puzzle. The last room holds the reward for opening all the doors and then the game ends. Since the player is immersed in a 3D environment, there are also ambient effects that can help the player acknowledge when the doors have been unlocked. Lastly, with the use of the Unreal Engine, in-game physics are very close to real-world physics, giving the player a even more realistic experience when playing the game.

Prior to developing the game, a small survey was conducted to decide the proper theme for the game. The survey showed two different possible scenarios to be played (See Fig. 2). Scenario A was a highly realistic environment that mimics a modern home. Scenario B was a less realistic yet still detailed home that also displayed "magical" scenery in a sci-fi setting. The results showed that people would opt to play a game with Scenario B over Scenario A. This results also reflect one of the reasons many players want to play video games and it is to escape reality and unwind from society [21].


Fig. 2. Surveyed scenarios

Each room is equipped with a legend that aims to guide the player into solving the puzzle (See Fig. 3). The script on each room is cryptic enough to bring a challenge into the puzzle but not to the level of making the puzzle unsolvable. In case that the player feels the need of help, the system is also equipped with a help sub-menu that elaborates into the hint given at first. There is not a limit to the amount of times each puzzle can be tried. We are not looking for performance or efficiency, just for the experience.
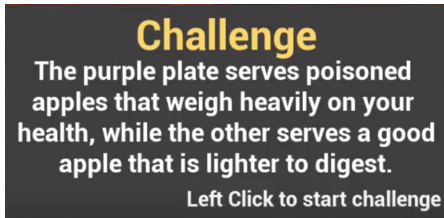

(a) IF Challenge
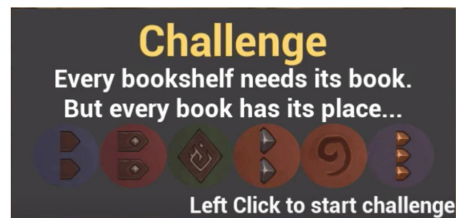
(b) ARRAY Challenge
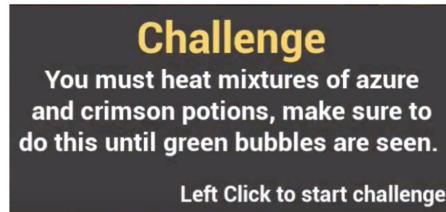
(c) LOOP Challenge

Fig. 3. Room challenge legends

When a player successfully completes the puzzle, a achievement badge is displayed on the screen. The badge can also be clicked and it shows what he or she has unlocked (See Fig. 4). on this screen the player can see the explanation of the puzzle and the logic that sits behind the puzzle. The achievement explanation helps reinforce the puzzle's CS concept.
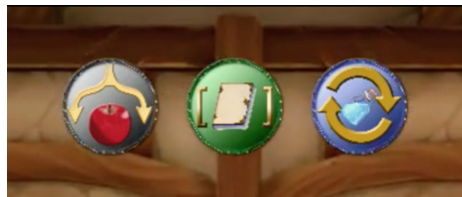
Fig. 4. Achievement badges

3.3   Puzzles

The first room is a two part puzzle. Both parts require the use of the same concept: IF STATEMENT.

On the first part of the puzzle, the player needs to move around the room and look for the apple that weights the most from the bunch (See Fig. 3a). There is a total of seven apples in the room but only one weights more than the others. The room has an old scale that the user can utilize to solve the puzzle (See Fig. 5). Once the apple is found, the player needs to set the apple on top of the purple plate. After completing both steps the first door opens giving access to the second room.

Fig. 5. Scale - used to solve first puzzle

The second room consists of a single puzzle that is divided on 3 sub puzzles. This puzzle concept is ARRAYS.

The player needs to arrange a set of books on the pattern that is shown in the hint as he or she enters the room. each sub puzzle has a verification mechanism, once the correct books have been set on the bookshelves, a green light will illuminate the shelf, if not a red light will show instead. Once the three shelves have been correctly solved the door to the next room will be opened (See Fig. 3b). This room also offers the option to reset the puzzle, allowing the player to start from the beginning. The reset feature also sets the books on its original position as how they where once the player entered the room.

The third room consists of a single puzzle. The concept behind the puzzle is LOOPS.

As the player enters the room, the player is confronted with a cauldron and a total of eight potions. Four potions are blue and the remaining four are red color (See Fig. 3c). As the hint reads, the player needs to proceed to put the correct potions into the cauldron in a set order. Even though the action seems similar to the previous room, this time around he has to repeat the same action on the same medium. As the player places the correct potions, the cauldron sparks change color progressively.

Once the last puzzle has been solved, the final door opens to show the player the prize and finally exiting the game. The player screen is also equipped with a room counter. At the top right corner, the player can see a counter of 0/3. As the player progresses to the rooms and successfully solve the puzzles, this counter will increase. By adding this feature, the player can keep track of his or her achievements and how close the goal is.

3.4 Controls

The current system offers the player the ability to play with either a keyboard or a game-pad. Both of these devices are very well known among players. We also took into consideration any new players. By keeping the amount of interactions and controls needed for the user to choose from down. For the keyboard W Key and Up-arrow move forward, S Key and Down-arrow key move backward, A Key and the Left-Arrow key to move to the left and D Key and the Right-Arrow key to move to the left (See Fig. 6). If the user decides to use the game-pad, for the movement the player only need the left D-pad to control the same motions as the keyboard.
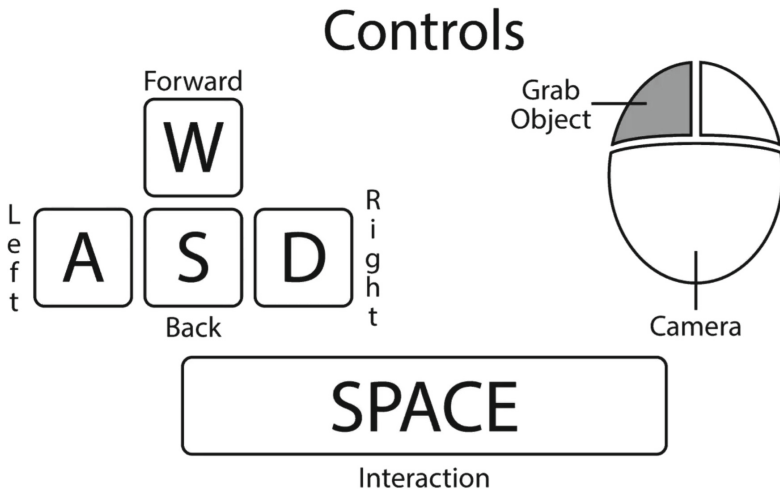
Fig. 6. Basic keyboard control system

To maintain the simplicity of the system and ease-of-use for the player, only limited actions are required to interact with the system. The Grab action allows the player to freely move objects from its original position to the new desired position. Grab can be activated using right click with the mouse if the player is using the keyboard setting, or by pressing X button on the game pad. The next action is the Activate action, it can be used by pressing space-bar in the keyboard and left trigger on the game pad. This action allows to reset the puzzles

or activate the props throughout the game. The last key is the Escape key on the keyboard and the start button on the game pad. This option lets the player access the Menu system. Note that the HTC Vive controllers are also available.

3.5   Menu System

The game contains a simple menu system with a total of five buttons: Resume, Controls, Hints, Achievements, Quit Game (See Fig. 7). Resume and Quit Game are a single action buttons that allow the player to go back into the game or quit the game respectively. Controls, Hints and Achievements are a single screen options that displays the information of each menu respectively. We designed the menu system with the same style as the controls, by keeping the options to a minimum the user experience is enhanced, specially to a first a time player.

Fig. 7. Menu system

3.6   Camera View

The camera chosen for the game was set to first-person. When in first person, the player can have a greater immersion into the game. At the same time, the settings for camera movement in the game are set to low to minimize any motion sickness or motion blur caused by moving the character. At the same time, this camera can be reused for the VR version of the game. The current version is created for desktops/laptops so everyone that has access to a computer can play the game. VR systems do increase interest into games by their novelty, but they also limit the amount of people that can use it due to its current market value.

3.7   Metrics

The system is equipped with a simple metric collection method. As the player goes through the game, the game collects the movement path coordinates. Also, the time the player takes to solve each puzzle, from the moment he or she crosses the door until the next door is opened. No personal data such as gender, name, nationality, or level of education is collected.

4   Virtual Reality Mode

Even thought having access to virtual reality headsets is still difficult due to the steep prices. We realized that by porting the system into VR, we will have a greater reach. With the increase of technology people are drawn to test and explore the new devices being created [22]. VR mode gives the player an even more full immersion. Aside from the first person camera provided by the headset, the game remains the same as the desktop version. We utilized the HTC Vive device, and the controls were kept to only grab and teleport. Since the headset controls the camera, the player does not need to worry about pressing many buttons to move around the map. Ultimately, we kept the system as simple as possible so it can be played by anyone.

5   Future Work

In future work, we first want to run an experiment to evaluate the success of the system. We want to see if the system does spark interest into CS when played by people without any prior CS knowledge. After conducting the experiment, we would like to use the feedback collected from the users to enhance the system. After running the initial experiment, we will run a control group with CS students and will use the results to compare the metrics between both groups.

Furthermore, we want to see the how the game contributes towards the inclusion of minorities. Mainly if the game sparks interest into considering CS as a major by women. Current women representation on STEM fields is low [23], Also women population is known to not be interested on playing video games as much as men do [24].

6   Repository

The final version of this game is freely available at (including source code) at: https://github.com/OpenHID/VRForEducation.

7   Conclusion

We propose a video game themed as a escape room. This game is designed to spark interest into Computer Science. With the combination of simple game play along with an inviting game mode, The player will not only be enjoying the experience just like any other game, but subconsciously will be learning concepts of Computer Science. Each achievement reached by the player, will present a new concept of Computer Science. It is the purpose of the software to create interest into Computer Science in as many people as possible. Effectively reaching High School students pursuing a higher education, and also minorities, specially women.

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