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THE USE OF VIDEO GAMES IN EDUCATION

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Programi për Shkenca Kompjuterike dhe Inxhinierise

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Ky punim është përpiluar dhe dorëzuar në përmbushjen e kërkesave të pjesshme për Shkallën Bachelor

Abstract

Education is a very important aspect of our lives, a proper education system is linked closely to a better and easier life. Therefore, enhancing the education system should have a high priority for many people. A high number of lives can be improved, given the right tools to reach a desirable level of education. Many variables impact the education process, from social conditions, to mental conditions and motivation. Mixing games with education can reach many of these variables in different angles, easier for learners to grasp.

This thesis provides more information to the limited research of how games can be used to enhance the education process. This thesis will discuss the effect that games can have to improve the education process, how learners can be motivated to spend more time learning while having fun at the same time.

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Introduction

As of 2018, there are more than 2.3 billion gamers in the world according to [41]. The industry is growing very rapidly, and with so many people interested in video games, a lot of research is aiming to analyze how gaming can impact the education process besides being only entertaining. Educational games have been spread on multiple platforms, including mobile devices, therefore according to a study made by "project tomorrow" [6], 48% of teachers in USA are using game-based methods in their classrooms. This statistic shows us the importance of studying and researching educational games, in order to optimize them for more practical uses. It is very important for a game to meet certain criteria when it comes to pleasuring, challenging, developing creativity, etc.

Being driven by the need to make the educational process more enjoyable and encouraging, this thesis tries to contribute on the integration process of game-based environments. This thesis will be divided into two parts: Part 1 (Review and comparison) and Part 2 (Design and implementation of a prototype). The first part will contain the reviews of various researches and tests, trying to get more information about best practices on building a game-based environment, effects it has on players/learners, and what we can do to improve the education process. The second part will contain the design and implementation procedures of an educational video game, and it will explain how the best design practices from different studies were tried to be implemented.

1. LITERATURE REVIEW

1.1 Definitions

Prior to digging deeper into this research, it is important to provide some definitions on what a game really is? How did they start? What connections that can be made between games and learning? Moreover, three relevant concepts will be discussed on the upcoming chapters: Gamification, Games based learning and Edutainment.

1.1.1 What is a game?

A game is a very broad concept, over time many definitions came by. Roger Caillois [17] , who provided maybe the most accurate definition by stating that "A game is a voluntary interactive activity, in which one or more players follow rules that constrain their behavior, enacting an artificial conflict that ends in a quantifiable outcome." Take chess for example, it is a voluntary interactive activity, there are rules and constrains on how you move, and what moves you can't make. However, what happens in a game of chess is not real on everyday life. Two friends will be enemies on the game, but they are still friends after the game is finished. Therefore, Katie Selen and Eric Zimmerman [18] added another element to Caillois definition "quantifiable outcome". They stated that "A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome." Meaning that a game will have a set number of outcomes.

1.1.2 History of games

The existence of games can be argued to be as old as the existence of life. The common belief is that humans are the first creatures to have played games, however different types of games can be found among many other creatures such as: dogs, cats, dolphins, etc. Since humans have evolved more through time, games also have evolved simultaneously. Games have branched out in many ways, and one of them being video games, for which we can say that are games that can be played on electronic devices. Or, how Nicolas Esposito [19] defines video games in the following statement: *"A videogame is a game which we play thanks to an audiovisual apparatus and which can be based on a story."*

Nowadays games have become a crucial part of our lives, and they can be found on many daily activities. The positive impact of interrelating education and games can be seen throughout a school day, where a Professors can evaluate a student's performance without withholding the entertainment that is provided through video games.

1.1.3 Learning

Learning is the process of gaining or modifying knowledge or skills. Many everyday actions can be used as a lesson, and there are different ways a person can learn. Learning by experience is the most common way of learning new things. Peter Brown [20] defines learning as *"acquiring knowledge and skills and having them readily available from memory so you can make sense of future problems and opportunities"*. Everything a person does, is perceived by the brain as a good or bad thing, useful or not useful and then those experiences are used to help people make better decisions. In one hand, a way of learning something can be by reading, researching and learning from others' experience. These elements are part of what is considered as the "traditional" way of learning, which is the most common way that is also used by schools and other educational institutions. On the other hand, the modern way of learning and the one which this thesis will be dwelling deeper is, learning by playing. With the evolution of electronic devices, the possibilities of making new video games that can be specialized on learning certain topics have increased, therefore, providing more opportunities to facilitate the learning process. Kindergarten is full of games that help children learn simple things like the alphabet, counting, adding and combining letters to create words. If these games were proven methods to keep children engaged and learning, can we make games for elementary school, universities or even adults to keep them engaged while learning?

1.1.4 Gamification

The term gamification was coined in 2002 and was registered in 2008 in education technology literature [1]. By gamification the tasks of everyday life are described to the system of gamifying. Kai Huotari and Juho Hamari on their attempt to define gamification [22] referr to it as: "*a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation."* While [23] defines gamification as "*a process of game thinking and game mechanics that engages users and solves problems"*

Study [7] claims that using elements like experience points (progress measurement unit), levels (progressively increased difficulty), leaderboards (ranking of learners), challenges and badges (rewards when a task is finished) increase students' engagement and participation in class.

In [21] Brian Burke writes from his experience how gamifying certain actions increased the number of people that participated in those actions. The skiing center where Burke worked, handed pins to people that skied more than 50,000 feet in a day, and it proved to have an increase in skier's motivation to not give up before completing the challenge. In this case, badges were used as a gamification method. Badges are not new; they have been used by the military for centuries. Gamification elements are also used by Khanacademy.org. Khan academy is a learning platform where each lesson, task, test, or course finished gives the learner a number of points, and when a set number of experience points is gathered, you increase in level, therefore, giving the learner a feeling of satisfaction. You can compare your level with other players using the leaderboard. Challenges like "correctly answer 40 problems in a row in a single skill" encourages the learner to answer more problems, while encouraging focus on a single topic. Completing the challenge rewards the learner with a badge that can be shown on the profile page, which signifies the mastery of the player, just like military badges signify a highly skilled individual.

Gamification and video games are similar in a few ways [21]:

- They engage "players" voluntarily.
- They use game mechanics such as points and levels.
- They are interactive.
- They incorporate progression to move players to the next level.

1.1.5 Edutainment

Edutainment is a mixture of words education and entertainment. It is mostly used to describe an educational game or video game in particular [16]. It shows how edutainment fits a bigger scope than just video games. With the right perspective, all games can be educational, like chess that teaches you strategical thinking and risk-taking, Monopoly teaches you money management and the importance of investing. Colace, F & De Santo, Massimo & Pietrosanto, Antonio & Troiano, Alfredo. [16] defines edutainment as "a type of entertaining which is designed with the aim of

educate by including entertaining variety such as multimedia software, internet sites, music, films, video and computer games and TV programs in order to exhilarate in addition to educate". According to Nalan Aksakal [26] Edutainment is "entertainment and interaction which is thought missing in education, attracting learners' attention because of being in nature of the game." and she also believes that edutainment lowers the barrier of difficulty on certain subjects while simulating and adding visuals to the learning methods.

1.1.6 Game-based learning

With learning being a crucial part of life and games being involved on everyday life, the idea of game-based learning is born. Sara de Freitas [25] defines educational games for learning as: computer-like applications and video games created to fulfill specific learning goals, outcomes and experiences by being engaging and enjoyable.

Marina Papastergiou [24] suggest that *"digital game-based learning is at least as effective as or even more effective than conventional instructional media in positively influencing young people's health-related knowledge, attitudes and behaviors."* Papastergiou also states that assuming game-based learning promotes enjoyment and this definition is more appealing to young people than conventional instructional media.

1.1.7 Discussion

I believe that edutainment and game-based learning are very similar to each other, as no study of comparing these two. However, from the studies above a small difference between edutainment and game-based learning can be found. Edutainment can be defined as the process of learning through any entertaining activity, games, sports, music, TV, etc., it can be stated that game-based learning only includes games, with games being interactive activities with restrictions and a certain goal. However, gamification can be considered the opposite of edutainment and game-based learning. While game-based learning and edutainment work by adding learning concepts to games or entertainments, gamification works by adding game elements to the learning process.

It can be concluded that there is a lot more information available about implementing gamification than edutainment or game-based learning. In one hand, with the available knowledge, gamification can be considered as easier to be implemented, since some of the elements needed to

make an activity gamified are well known and studied. On the other hand, with edutainment and game-based learning, the chance to implement learning concepts to a game or activity that is owed by others is more difficult, therefore, for that to be achieved, a new game or activity should be created and then add learning elements to them. Creation of a game or activity requires great creativity and technical skill. Field of usage is a lot broader for gamification, basically every activity can be gamified, as long as some of the gamification elements (experience points, levels, leaderboards, challenges and badges) are added correctly. As for game-based learning, from the definitions above, it was concluded that game-based learning is learning through games, so its scope are only games and video games. More emphasize is put on video games for the fact that they are easier to access, can be played alone and generate more income. As for the edutainment, as understood from the definition, the scope is limited to all entertaining activities. The scope can also be supported with the other fact that the goal of edutainment is to make entertaining activities useful as learning tools. If an activity is not entertaining, there would be no point in adding learning elements to it. Gamification like every other method, is not perfect, and it has its own technical limitations, but with more studies on gamification, these limitations are likely to change. All three methods concepts represent interactive activities, but their interactivity level is not the same. Gamification is not highly interactive, as the learners don't interact directly with the gamification elements, but with the learning process itself. Games are considered highly interactive activities, since they used will be focused most of the time on the game, so games being the only medium of game-based learning, makes it highly interactive. As for edutainment, since it covers a large medium, the interaction level depends on the activity. Starting from no interaction mediums like TV and music all the way to highly interactive activities like games and sports, they all make edutainment's interaction level unclear. With the current knowledge on gamification, it can be said that the elements that make an activity gamified, also make gamification limited to only those elements. Excluding rare cases, almost every gamified activity uses and is limited to: experience points, levels, leaderboards and challenge and badges. With game-based learning's only medium being games, design limitations are basically unlimited. With limitations being on technology and social conditions. As for edutainment limitations, since the scope is broad, its limitations depend on activities. Some activities like video games are limited to technology and social conditions, and sports having the problem of accessibility to some people. So, how do these three methods keep learners using their mediums? Games and entertainment activities main goal is to entertain people

using their medium, while in most cases also being challenging. Entertainment and challenge are good ways to keep people engaged. So, it can be conclude that game-based learning and edutainment, both use entertainment and challenge as engagement methods. While motivation can also be found in game-based learning and edutainment, the whole idea of gamification is to motivate learners into staying engaged and completing their tasks and challenges. A tabular comparison can be found below on Table 1.

Table 1. Comparison between gamification, game-based learning and edutainment.

Concept	Gamification	Game-based learning	Edutainment
Implementation difficulty	Medium	Hard	Hard
Scope	All activities	Games	All entertaining activities
Interaction level	Low	High	Depends
Limitations	Experience points	Technology	Technology
	Levels	Social conditions	Social conditions
	Leaderboards		Ability to perform certain activities
	Challenges and badges		
Engagement method	Motivation	Entertainment	Entertainment
		Challenge	Challenge

1.2 Game types and analysis

There is a distinction between different types of games. Not every game suits the purpose of education the same. Different subjects require different type of games in order to add gameplay compatibility. The following is a list containing some of the most popular game types and the area of education they can potentially cover.

1. Puzzle
2. Simulation
3. Adventure
4. MMORPG
5. FPS
6. RTS
7. Action
8. Casual
9. Board

Puzzle

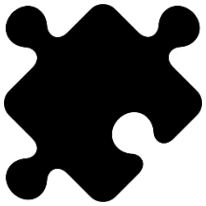

Figure 1. A puzzle icon

(Icon made by Gregor Cresnar from www.flaticon.com)

As the one of the first video game genres, puzzle games are often used to learn problem solving skills. With so many different kinds of puzzles, they can achieve to train different concepts. Games provide an environment in which one can develop a variety of thinking and problem-solving skills that are useful in both non-game and game environments [38]. An example of a well-designed puzzle video game is *CodinGame.* Starting from the firsts steps it, it teaches you step by step programming concepts while making it mentally rewarding at the same time. Problems are the main focus why puzzle games can be used in education

Simulation

Simulation video games are the closest we can get to experiencing a real life situation and experimenting on it without risking anything. Simulation games are used very often as training tools on areas like: Driving, plane flying, surgeries, etc. and can be used for basically everything, as long as we know how it works. Physics simulation games are a good way on teaching kids how physics reacts in the real world. Experience is the main reason why simulation games can be used in education.

Adventure

Figure 2. Zelda II: The adventure of Link game character

Our main focus on this research will be in Adventure games. As we will be developing an adventure game prototype, I will go deeper into explaining what an adventure game is. Adventure games most of the time have puzzle elements to create diversity on challenges. There's where the educational part we seek can come from. Instead of just random puzzles with not much back story to keep the player engaged and feel rewarded it has mechanical challenges to keep them entertained. Adventure games makes a mix of these elements into a more open and interesting world.

MMORPG

MMORPG stands for "Massive Multiplayer Online Role Playing Game". MMORPG are considered games that have an open world, where players interact with one another. These players create "groups" that cooperate together to finish the story of the game. With each player having its own role, the player is "forced" to learn to cooperate in the best way possible. Krotoski, A. [29]

suggests that MMORPGs have positive on interpersonal skills such as interaction and involvement, flexibility and mastery, which all are considered good attributes. MMORPGs are heavily based on teamwork, which enhances communication and teamwork on people playing them.[39]

FPS

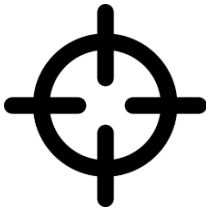

Figure 3. A corsair representing FPS games.

(Icon made by Freepik from www.flaticon.com)

FPS better known as “First Person Shooter” is a genre where player perspective is the perspective of the character in the game. It’s hard for FPS games to be educational, since the player will be mostly focused on the shooting part, unless there’s a really deep story that can keep you interested. Because of the FPSs fast paced nature, it is safe to say that it enhances the ability to make quick thinking, strategies and decisions. FPS games also improves hand-eye coordination since you controlling the character’s hands directly with your mouse.[40]

RTS

Figure 4. Two swords representing RTS games.

(Icon made by Freepik from www.flaticon.com)

RTS better known as “Real Time Strategy” can be described as war commander simulation. You control a faction, build the town, the army and try to win by either destroying the enemy or making them surrender. Ben Thomas on his blog post [30] has stated that RTS game have enhanced 4 skills important for startups:

1. The importance of timing perfectly
2. Prepare your countermeasures in advance
3. How to chunk repetitive tasks into making them easier to work on
4. Optimize, but only once you’ve got something worth optimizing

Action

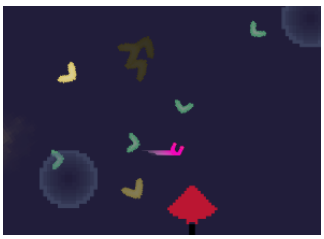

Figure 5. Magenta Magnet screenshot.

(A work in progress game made by the writer of this thesis)

Action game is a game genre that focuses on physical challenges, hand-eye coordination and reaction-time. There are many action-game subgenres including platform games, shooter games,

survival games etc. In a study where Nicole H. L. Wong and Dorita H. F. Chang compare attentional advantage for action video-gamers versus non-games, they cite on [42]: “Action video game experts exhibit an attenuated attention blink relative to non-experts.”

Turn-based strategy

Turn-based strategy game are games that players play in turn. You can compare it with Chess, where one player cannot play until the other has finished his move.

Casual games

Casual games are games that are directed to a broader audience, unlike hardcore games, these games target gamers that find gaming more as a relaxing thing and not highly competitive. Casual games as a theme doesn’t offer any automatic learning, but it can be used as a tool to engage people on leaning. For example Chemtrix, is a fast-paced puzzle game where the player must remember chemical combination to form molecules and atoms as seen described on the article [31].

Board games

Figure 6. The knight from Chess representing board games.

Board games are very common on our society. Board games were one of the first types of games, and are played with physical assets and are not considered video games. They have an older audience since the new generation are turning to video games. Board games include games like chess, monopoly, scrabble, etc. Board games target different areas of education, with chess teaching strategy, monopoly focusing on finance, while scrabble’s all focus is on reading and writing.

Why adventure game type was chosen for this thesis

Most authors had claimed that adventure games are only good for social interaction, (Craig, Podmore, Atmore, & Ashworth) [33] had noted that adventure games are also good on enhancing language skills. With many doubting that adventure games can be used to improve problem-solving skills. But, Bell & Scott on their research [32], stated that students become better problem-solvers following exposure to adventure games.

Review of Vim adventures and Ruby Warrior

I have decided to review these two popular adventure games that use elements of game-based learning, and apply on their game. These reviews will be focusing on three important concepts: Aesthetics, dynamics and mechanics, which we will talk more on chapter 2.3.

Vim Adventures [34]

Figure 7. Screenshot from Vim Adventures

Vim adventures is a commercial adventure game, where you control a blinking cursor. The purpose of this game, is to teach you how to use the Vim text editor. Vim was always considered a very hard tool to learn, by making an interesting adventure game, it became open to many new users. Vim adventures adds element of challenge, entertainment and curiosity to learning the tool. It starts with the very basics stuff like moving around, to programming logic.

Aesthetics of this game are very friendly. They give you a feeling of wanting to start playing right away, a feeling of discovery. The maze, chest and the key, gives you a sense of fantasy. And a big camera, where you will take too much information at the same time, gives you a sense of challenge.

Vim adventures, at first glance doesn't look like a game of a high dynamic nature, but it has implemented some challenging aspects. For example, if you don't make it through the maze in 45 seconds, the game sends you at the beginning. That alone gives you a sense of urgency, which forces you to practice until you learn how to make the movement using your muscle memory.

Mechanics of Vim adventures are pretty uncommon for a video game. You control the cursor with very uncommon controls: H-left, J-right, K-up, L-down. Every action you take, will involve commands used in vim text editor that are taught through the game.

The commercial status of the game is not reasonable since you are learning a tool that will be used professionally and that is always a good investment.

Ruby Warrior [35]

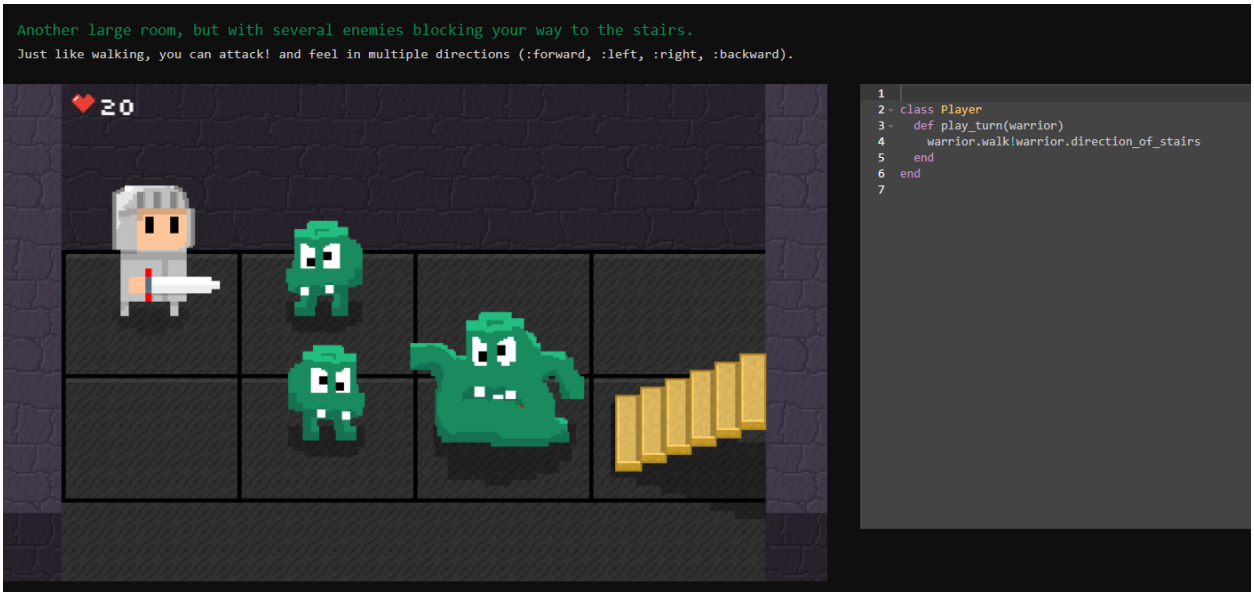

Figure 8. Screenshot from Ruby Warrior.

Ruby Warrior is a web based game designed to learn Ruby. Every level you have to write a script to instruct the warrior on moving around and fight the enemies, until you climb the top of the tower. The game has flavors of artificial intelligence in it, since you can't always predict what move the warrior should do at each moment. There are two versions of the game. The code of one is open source and can be found on GitHub [27]. The other one does not have a public source code and can be played through browser [35]. While the gameplay is completely the same, their differences are on aesthetic and technology.

The open source version is a command-line game and it has very basic ASCII aesthetics. Can be hard to understand and cannot be not that enjoyable for players. While the web version has a 8-bit art style, with appealing background music and overall more enjoyable to the player.

Ruby warrior is not dynamically high game, you have infinite number of tries. In some cases this is a bad thing because you can brute force through every level without thinking much and not learning as much as intended.

Mechanics of the game is only a text field where you type lines of code, there are hints which you can use and the syntax will be shown at all times.

Ruby is overall a great game to learn ruby and programming logic in general, but it has its flaws when it comes to deeper logic and object oriented programming concepts.

1.3 The various approaches of gaming in education

Games doesn't always mean to play with something. The term gamification was coined in 2002 and was registered in 2008 in education technology literature [1]. By gamification we describe the system of gamifying the tasks of everyday life. They are mostly used to motivate people completing certain tasks. In order to better understand the concept of gamification, we have to first clarify that gamification does not employ games for non-entertainment purposes, as serious games, but rather it affords elements of a game experience to improve retention.

In [1] are applied principles of analysis for synthesize existing research, identify issues of controversy, uncover areas that future gamification research should investigate. The attention is focused on gamified learning, in order to investigate what happens when gamification is introduced in class, especially on student's motivation, engagement and performances. The focus is gamification, challenges of using it in the classroom and its effects on students. Further the authors, used the literature method to analyze different definitions of gamification and experiments. Since the creating of the term, gamification had a lot of definitions, but in 2014 Gartner [21] redefined gamification as "the use of game mechanics and experience design to digitally engage and motivate people to achieve their goals". The experiments were separated on three different variables, concerning the effects of gamification in motivation, effect of gamification in engagement and effect of gamification in learning outcomes.

Hanus e Fox [2] divided a number of students on two courses. Results have showed that students that used gamification methods had less motivation. It was found that students that used gamification were extrinsically motivated to perform (from outside factors) other than being intrinsically motivated. Students that are intrinsically motivated are more engaged and retail more information. It proved that gamification varies effectiveness varies from person to person as some students didn't want to compete with their classmates. [2] stated that gamification focuses on the extrinsic way of motivation and it does not have the same effect on every student in the class [2].

Study [7] claimed that using elements like experience points (progress measurement unit), levels (progressively increased difficulty), leaderboards (ranking of learners), challenges and badges (rewards when a task is finished) increases student engagement and participation in class.

Overall the authors in [3] stated that effectiveness of gamification varies from person to person as some traditional learners scored the same as learners who had used gamification. There is a challenge to keep increased the engagement of the learners using gamification over time.

From [4] games are always seen as a tool of entertainment; they justify this statement that learners can use the joy from entertainment and add some learning principles. This approach can create a game that is used to offer learners motivation and enjoyment while learning new concepts. The authors [4] researched mainly the games on computer science education, specifically how to develop games that can facilitate the learning process starting from novice to expert level. Their research was divided in two different aspects, such as:

1. To provide a summary of existing digital games de- signed to enrich computing education and an index of where these games may fit into a teaching paradigm

2. To provide a guide to developing digital games designed to teach knowledge, skills and/or attitudes related to computer science.

During the research [4] there were selected 102 unique games to be examined. Each game was read the documentation, classified and played when available. The reviewed games genres were mostly Puzzle, Simulation, Adventure, MMORPG, FPS, RTS, Action and Casual. Likewise, the user interface varied from game to game and was not limited to command line, drag-and-drop, first/third person graphical and point and click. Finally, the games differ from the mechanics approaches, single player, PVP (player versus player multiplayer) or even CO-OP (multiplayer cooperative). Their results [4] emphasized that among 102 of the selected games, 16.6% of them focused primarily on computational thinking. Besides the programming and computational thinking, the other topics addressed topics, such as: artificial intelligence, architecture, circuits, data types, security, sensors and systems. The games were characterized also in terms of the e-Learning Goals. More than half (54%) of the games were had elements of education, 71% as “Perform Procedure Tasks and 54% as “Perform Strategic Tasks. As shown in Table 2. Within SDF (Software Development Fundamentals), as the topic reviewed the most (75.5% of all

reviewed games), 45.1% had Fundamental Programming Concepts elements, 24.5% Algorithms and Design and 18.6% included Algorithmic Strategies.

Table 2. Topics covered in the research [4]

Area	Percentage
Computational thinking	16.6%
Educational	54%
Perform Procedure Tasks	71%
Perform Strategic Tasks	54%
Fundamental Programming Concepts	45.1%
Algorithms and Design	24.5%
Algorithmic Strategies	18.6%

Top four games that were analyzed on their Aesthetics, Dynamics and Mechanics in more depth. The games below are: The Foos, Human Resource Machine, Lightbot and Picobot.

The Foos [12]

The Foos is a commercial game made by codeSpark, which focuses on teaching the player basic programming concepts to elementary age students. The Foos is a mobile game. The move orders are sequential, just like the lines of code on most programming languages. The character of the game must go through obstacles to get the donut. As the player progresses, the game becomes harder and more challenging. User interface is very welcoming for younger children and it does not require reading skills.

Figure 9. Screenshot from The Foos

Human Resource Machine [13]

Human Resource Machine is an education game published by Tomorrow Corporation. The game is available on PC (Windows, Mac and Linux) and Mobile (iOS and Android) and is targeted for players age 9 and above. The game aesthetics look a bit dark and not as friendly as the Foos. There are two conveyor belts, one marked “In” and the other “Out”. Numbers appear from the “In” belt, using the table on the middle of the room, orders from the right of the screen should be followed. Then the result should be placed on the “Out” belt until all commands are completed and the level is finished.

Figure 10. Screenshot from Human Resource Machine

Lightbot [14]

Lightbot is an education game created by Danny Yaroslavski. The game is available on mobile devices (iOS and Android) and as a flash game that can be played on browser. The logic and mechanics of the game are very similar to The Foos and Human Resource Machine. The player should give instructions to the robot in order for the robot to move. The goal of each level is to light up all the dark tiles on the screen by jumping on them.

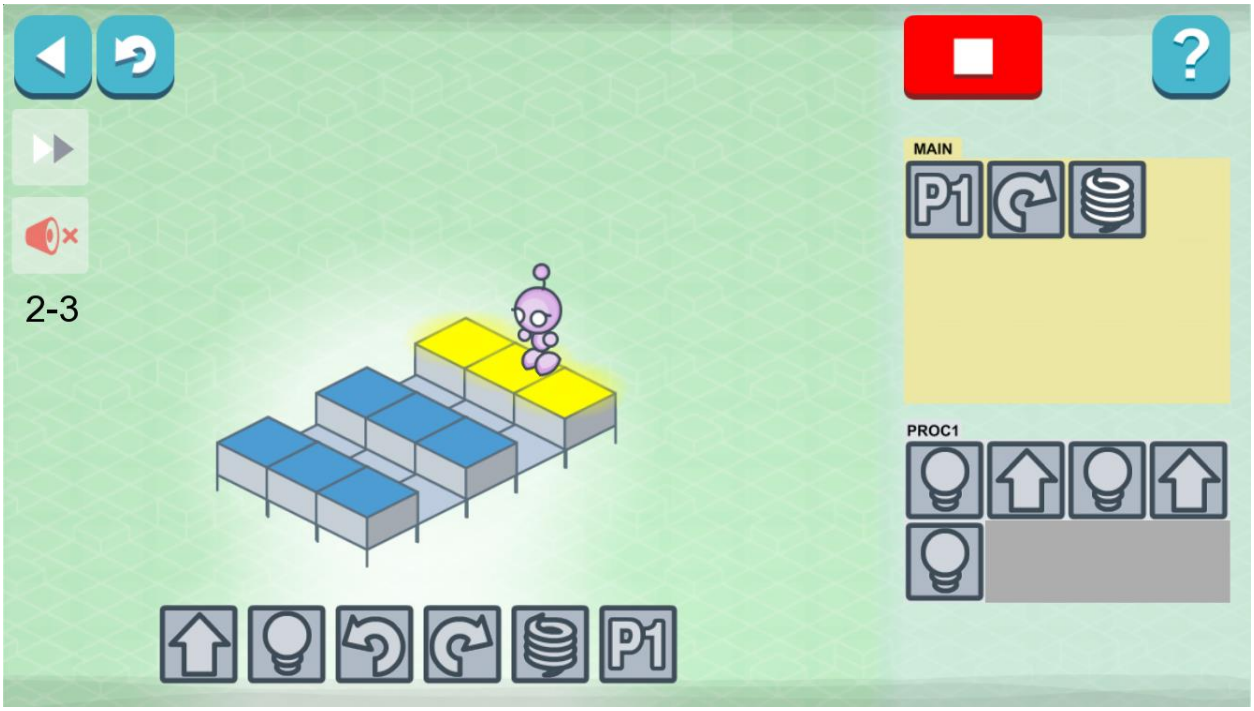

Figure 11. A screen shot from Lightbot

Picobot [15]

Picobot is a JavaScript game developed by Zach Dodds and Wynn Vonnegut. Picobot's complexity, aesthetics and friendliness is very different from the three games above. The player tells the Picobot on what direction to go using commands, and not by clicking buttons as the three games above did, making it more complex. On a 2D grid there is a maze that the Picobot (green

dot) should visit all the white spaces and turn them grey. The set of rules is given on the right part of the screen.

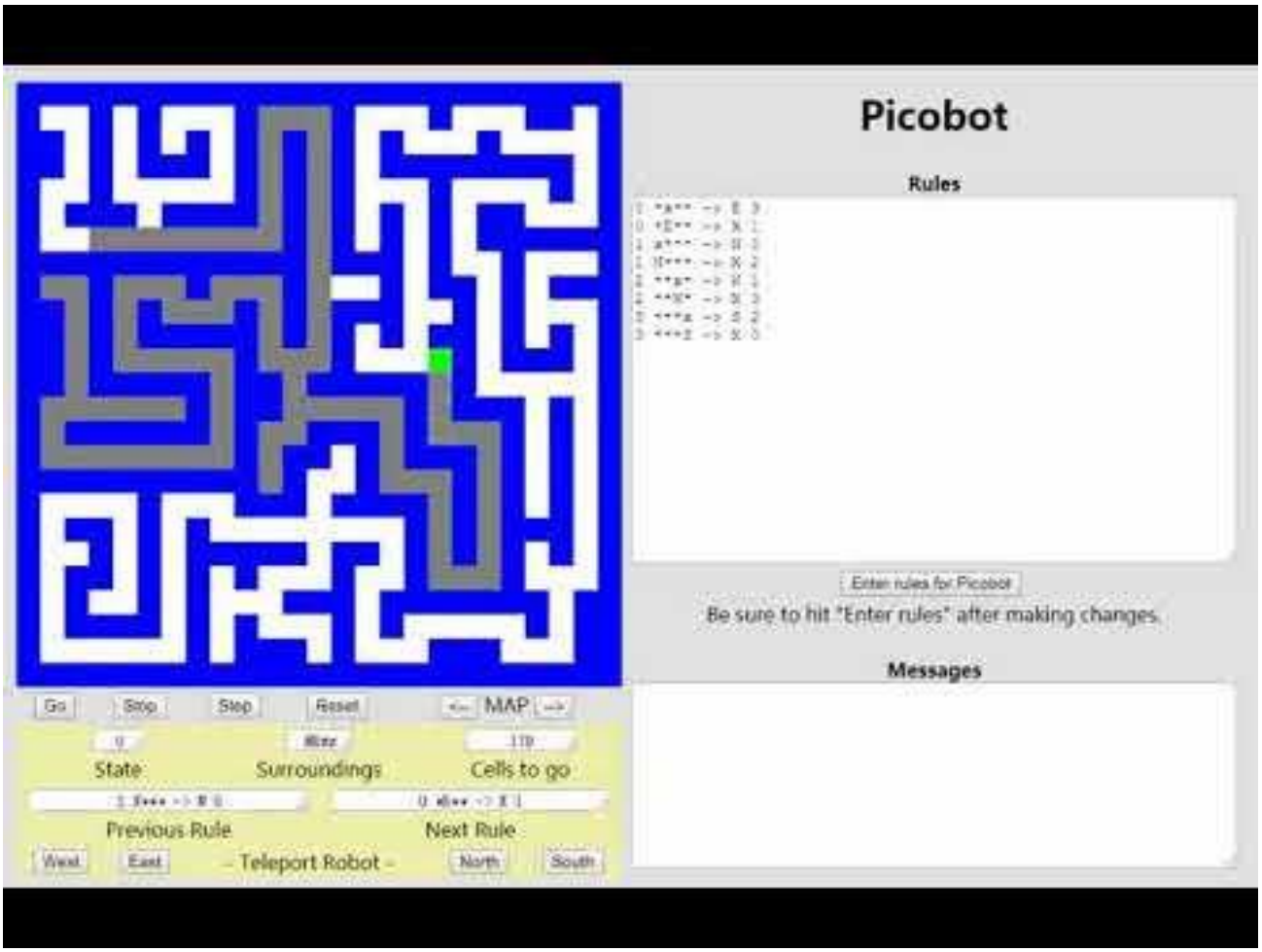

Figure 12. A screen shot from Picobot

From the player's perspective, a game is an aesthetic experience. Hunicke, LeBlanc and Zubek [5] suggest that we move away from words like "fun" and "gameplay" and follow the taxonomy for categorizing the user experience:

1. Sensation: Game as sense-pleasure
2. Fantasy: Game as make-believe
3. Narrative: Game as a drama

4. Challenge: Game as an obstacle course
5. Fellowship: Game as a social framework
6. Discovery: Game as uncharted territory
7. Expression: Game as self-discovery
8. Submission: Game as a pastime

For the purposes of educational games it could be added a ninth experience [4]:

9. Learning: Game as learning tool

A feel of sensation is given by all 4 of these games.

Fantasy can also be found on all of these games, since each of these has a world that is different from the real world.

Narrative can be found only in the Foos and Human Resource Machine.

Challenge is a crucial part of all 4 of the games.

Fellowship is hard to be created on single player games and none of these games have it.

Discovery and expression are important parts of the Human Resource Machine. They makes it more interesting to go deeper and discover more alternative solutions so the user gets hooked more into the learning process.

As for learning, these games are created as learning tools so we can say that all of these games are focused heavily on the learning aspect).

"Dynamics work to create aesthetic experiences."[5] Game dynamics varies on how the game presents its challenges, the feeling it gives you while finishing the challenge and after you finish it. These games create its dynamics with difficult puzzles and challenges.

Each of the game has difficulty progression. They all do a good job on interpreting the information to the player and encourage different approaches to the solution. Their focus is to encourage learners to think on a computational way.

Mechanics are a list of set rules or actions that can be used by the player. All 3 except Picobot have a drag and drop mechanic where player drags and drops the instruction to the finish of the goal. On the other hand Picobot has more complex mechanics. Player should write down the command in order for instructions to be executed, making it more prone to errors.

According to Eric Zhi Feng Liu and Po-Kuang Chen's study [8], the number of game-based learning researches has been increasing a lot lately, with most of them being on video games, Liu and Chen decided to study the effect of a card game called "Conveyance Go" on a group of 5th grade students. Lin and Liu [48] experimented by adding game mechanics in typing courses, creating competition between learners. In spite the fact that the learning pace was the same as before the introduction of game mechanics, learners were more engaged and would spend more time practicing typing than the other class.

The focus on non-digital game-based learning is in good benefit to children grown in poor families or poor countries, as they have limited access to electronic devices. So a lot of new card games targeting low-income audience are being designed in order to narrow the differences between families than can't afford electronic devices and those that can.

Edutainment is a mixture of words education and entertainment. It is mostly used to describe an educational game or video game in particular [16].

In the study [8] participated 18 students, of which 10 were male and were 8 female, with relatively big age distribution, from third graders to sixth graders.

The basic concepts of the card game that was created for the study, were taken from a fourth graders science text called "Means of Transport and Energy". The goal of this subject was to teach students of efficient transportation and energy. The subject's way of learning was then divided into 7 parts:

1. Remember – Factual knowledge
2. Remember – Conceptual knowledge
3. Understand – Conceptual knowledge
4. Understand – Meta-cognitive knowledge

5. Apply – Procedural knowledge
6. Analyze – Procedural knowledge
7. Evaluate – Meta-cognitive knowledge

Game design was evaluated based on five indicators presented by **Lin and Liu (2009)**:

1. Whether the game information is in accordance with the game descriptions of the learners and the game includes a learning theme
2. Whether the pictures in the game are associated with the learning theme and can arouse student interest
3. Whether the structure of the game is simple and operations are easy to learn
4. Whether the overall content of the game is interesting and include many pictures for presentation
5. Whether the game provides instant feedback.

Satisfaction scale was also tested among the students, to evaluate if students accepted and liked to learn through card games. The survey was separated into 4 parts: Perceived usefulness, perceived ease-of-use, attitude towards usage and intention to use.

The experiment showed positive results on all aspects, especially on perceived usefulness and nnstudents are generally more open to learn through card games then traditional methods.

The results also showed good results on effectiveness of game-based learning by being tested with the pre-test mean being 83.33 and the post-test mean rising to 92.13. According to these results, learning card games can help students to gain more knowledge in some areas and subjects.

According to [9] there is a big difference on the methods people learn now and how new generations will learn. The unwillingness of media to transmit the importance of these changes is going to be an upcoming problem. Rogers and Sharapan [**Rogers & Sharapan (1994) cited in Sharon DeVary (2008)**] backed the importance of introducing play concepts into our learning methods.

"Play is a very serious matter. It is an expression of our creativity; and creativity is at the very root of our ability to learn, to cope and to become whatever we may be"

The purposes of research paper [8] was:

1. To identify how edutainment can affect the student's achievement.
2. To identify whether edutainment can increase student interest to study in class.

Sixty (60) students of third (3) grade took part in the study. Divided into two groups with the same average IQ level. One group used traditional methods while the other game-based learning

Two surveys were chosen as the main tool of the study, given after the learning process. First one containing questions about student's background, while the second one contained questions about student's understanding.

Both groups learned letters and numbers. The first group used traditional teaching methods, while the second group used a software as a learning tool.

The experiment [9] showed positive results, with the traditional group having a mean growth from 4.17 to 4.47, while edutainment group had a mean growth from 4.10 to 5.07.

96.7 % of the edutainment group said that using edutainment methods helped them learn English subject, 93.3% believe that edutainment software increases their understandings towards the teaching topic. 90% of the students also agreed that the Edutainment software gives them more control to what they want to learn and makes it easier for them to find the information they want. 86.7% of the students stated that edutainment encourages them to attend the class more.

Minecraft is the most popular online video game to ever exist. Minecraft represents a virtual world just like Sims, where you can create your own home and sort of a simulation of a real world. The advantage of Minecraft is that it has infinite possibilities. You can build everything from a small lake, to a water pump. Or something computer related, like the guy that built 16-bit ALU. [11]

Anders Nordby [10] believes that a good way for children to broaden their learning perspective, is instead of just playing games, to start modifying them or even creating their own. Many children are limited to the tools they can use in real life, some of them might be expensive, others dangerous. Therefore, games like Minecraft are perfect examples of video games that is open to experimentation and creating everything yourself. The topic the research [10] will be discussing is

how we can design a learning environment where learners use the same amount of energy into learning as they do for gaming.

Subjects of the study come from 3 different bachelors: Interactivity, Animations, Arts and Game Technology. Around 70 students aged from 18 to 25 years old attended this experiment.

The purpose of this course was teach them game programming or computer programming in general, so they had to create their own video game. The task was divided into smaller problems each taking 1-2 weeks to finish. Their initial tasks were more about art, designing and animating a character. After finishing this task, students were very excited to make their character interact with the world (move etc.). This needed some programming and so on.

Many new concepts needed to be learned during the development process, especially in mathematics and physics. For example, in order for the character to move, you have to apply force, for that you need to learn about acceleration and deceleration, friction, air resistance. Subjects had to dig deeper on each subject they ran into.

Later they had to work with coordinates, angles, radians and probability. Eventually, learning trigonometry was necessary. Learning a math concept and applying it right away can be very beneficial and easier retained.

The course made its subject learn new things without making it seem like they are learning something they will never use against, since they are using every information while learning it.

To conclude, gamification should be studied and be used more in schools and other education workplaces. Thinking from the personal experience the results of gamification on different areas such as: programming, saving money and reading books differ when adding gamification component.

2. PROBLEM DEFINITION

2.1 Introduction

Games are known for motivating people, keep them engaged, make them socialize and dare them to solve puzzling problems. In [36] the results showed that the key variables of the games, such as excitement, engagement, motivation, stresses had a positive impact on the learning outcomes of the learners. Therefore, this thesis is analyzing a number of games based on the exiting research and trying to emphasize how people besides entertaining their self through gaming, they could also simultaneously gain knowledge.

The main problem identified through a number of research papers [1-4], showed that having a general game for all the players lack of having the same impact as having a personalized approach for different learners, different topics and different learners background.

2.2 Aim

The aim of this thesis is to offer a general view how gaming could have an impact to the learning process and how learners could increase their existing knowledge through gaming. This thesis also teaches the making of an educational game by explaining the design and implementation process of a prototype.

2.3 Objectives

1. Review existing games as part of the education process
2. Design and Implement a prototype based on the review findings

3. METHODOLOGY

This chapter is about explaining how the process of research and development of this thesis was planned. This study is divided into two stage, the research stage, and the development stage. This was due to the fact that having a prototype facilitates the concept proof at the end of thesis.

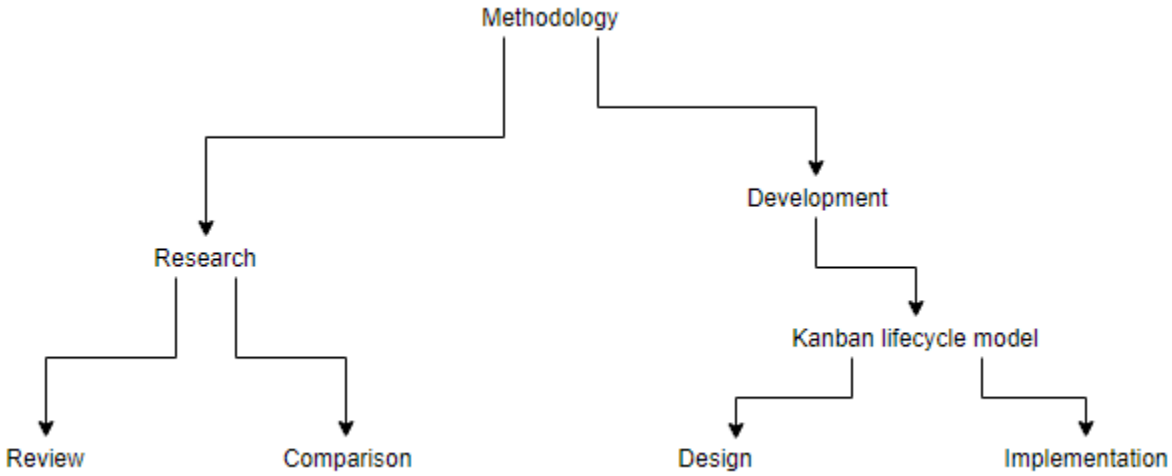

Figure 13 Project methodology/Workflow

Above we can see in Figure 13 the methodology structure used on this thesis. Research stage started by reading books, scientific papers and articles. To have analytic findings the research initially reviewed the main concepts of the gamification, game-based learning and edutainment and it continued with comparison between numbers of games that are used for education purposes as part of either gamification, game-based learning and/or edutainment. The comparison is focused on five variables: Implementation difficulty, score, interaction level, limitations and engagement.

As part of Literature review a number of definitions are listed, as well as, opinions and results of other researches on effectiveness of gamification, game-based learning and edutainment.

Development methodology

After the comparison process where the idea of game-based learning was established, development process started. As a lifecycle model is used Kanban agile methodology, since it provides the ability to change priorities after every consult with the mentor, unlike scrum where sprint are unchangeable. The development process was also separated into two steps. The first step was the designing process. Designing of the prototype was done accordingly to game-based learning

research made on the first stage. Second step was implementation process. Implementation was done using Unity video game Engine. Working accordingly to the chosen lifecycle model is important in order to manage the workflow, separate tasks and better estimation. Kanban work with the principle of the same amount of work reaches the finished state, must enter the work-in-progress state, making the flow of the project constant during its lifecycle. Both the design process and the implementation process had its own individual table, separating the work for easier management. In Figure 14 we can see design and implementation tables, with tasks separated into four columns: To do, doing, on review and done.

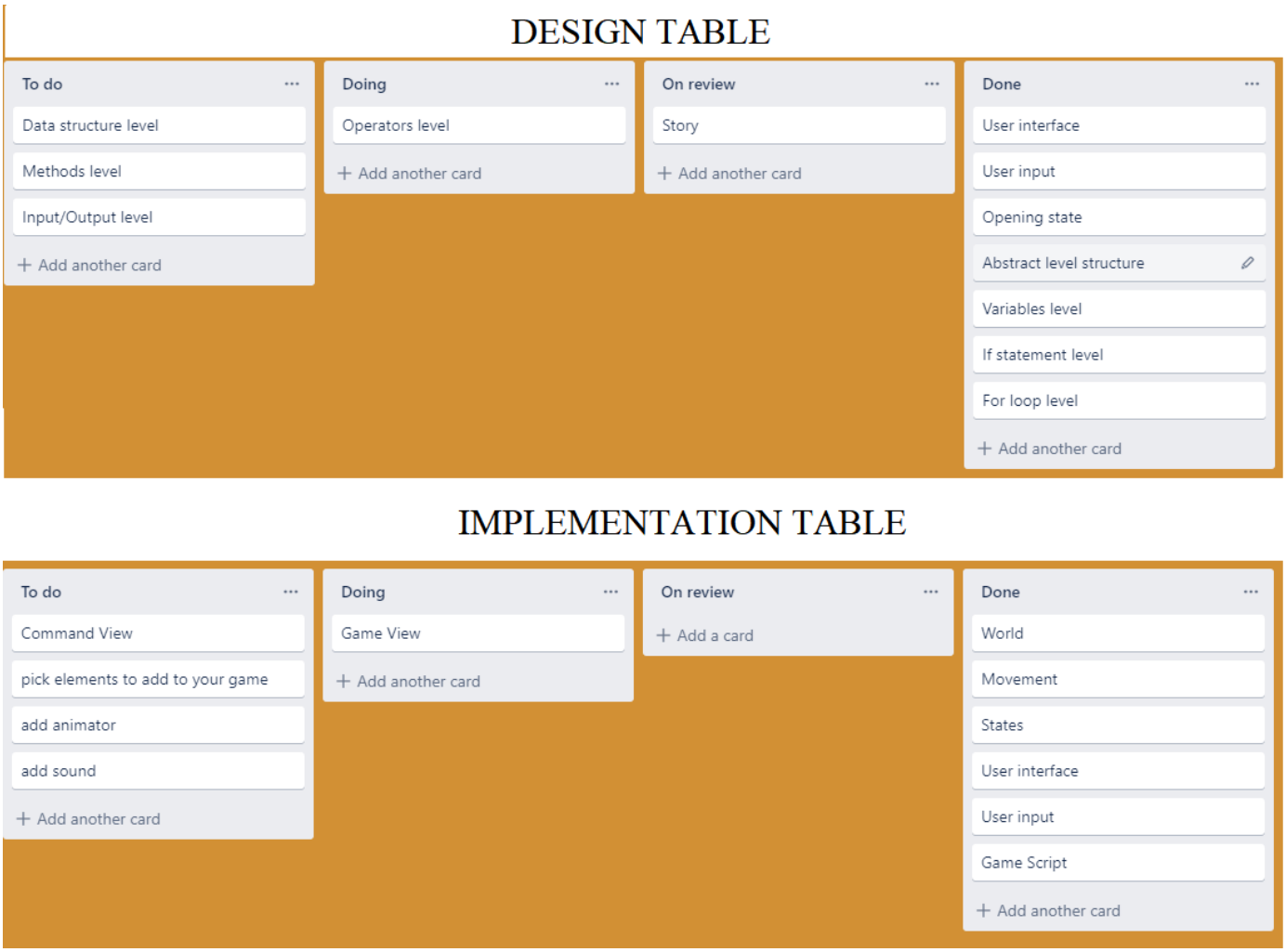

Figure 14. Design and implementation tables

3.1.1 Design

Design process was made accordingly to the research made beforehand. Design was focused mainly on the puzzle and story. Many design decision had to be altered because of the resources and experience of implementing prototypes. Mechanics are simple, since the prototype is text based. Dynamics are quite forgiving; a limited number of tries can be performed before receiving e punishment. Aesthetics have simple colors and animations, giving most of the focus to the story and puzzles.

3.1.2 Implementation

Implementation process was done with the help of Unity video game engine. Selection of the technology was highly made based on the experience on Unity. Because the implementation time was limited and the inexperience to implement suitable aesthetics, it was neglected to a point.

4. DESIGN AND IMPLEMENTATION OF THE "IMAGINARY DUNGEON" PROTOTYPE

The throwaway prototype "Imaginary dungeon" is created to investigate the best practices and theories of an educational games.

Imaginary dungeon is a text-based adventure game. The protagonist wakes up in a dark place and in ruins which will be called "dungeon". The only way he can move forward is by learning programming concepts and completing challenges, making the game educational. The objective of the game is to complete all challenges, reach the final challenge where, with the new skills, create a robot that helps the player get out of the dungeon.

The imaginary dungeon will be a 2 dimensional text-based game, meaning it will have simple graphics and simple animations. On its header the description of the current room the player is located. On the top part of the center rectangle, is the information of how the protagonist feel, what is thinking or what he is reading. And on the bottom part of the center rectangle, is the list of actions that can be done (see Figure 14).

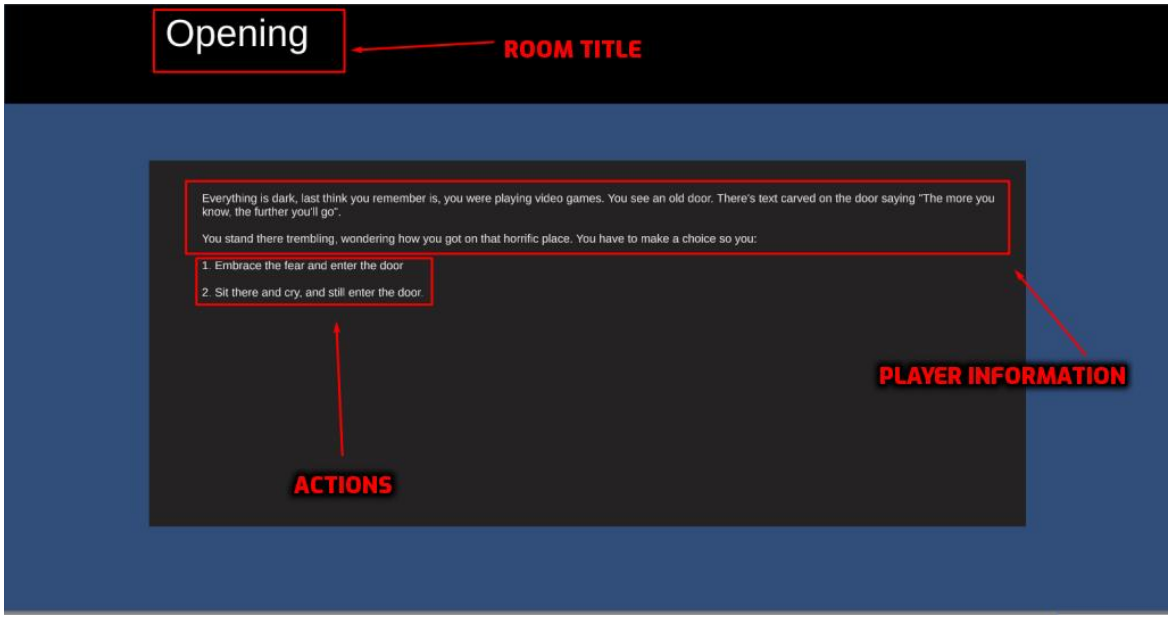

Figure 15 Screenshot from Imaginary Dungeon.

Game controls are simple as per text-based games. The player must choose between various actions by pressing the given key to that specific action.

The elements of game are: Health, hints and coins. With respect to Health – the health of the player is measured by health points. Player starts with a maximum health of three hit points. Every incorrect choice, the player loses one health. Every time the player does the right action on the first try, one hearth point is regenerated to him. On some rooms, on random places, the player can find hints that can be collected and be used on the same room or other rooms to make the challenge easier. Coins are received after completing each room. The more incorrect actions are made, the less coins are given. Coins can be used to buy items from the merchant. Merchant appears randomly. The player can buy items from the merchant. Coins will be spent to buy the items. List of items merchant offers contains:

- Health potions (restores one health)
- Hints
- Holy grave (player respawns once after death.

4.1.1 Story and plot

As part of the game, the world is modeled as it is in danger from an epidemic that will very soon destroy all living beings. Therefore, as part of the scenario, we proposed that a number of scientists have found that a time machine is the only way to save the world. These scientists created a game that sends the player in this virtual world, where the player has to learn programming and be able to construct a time machine to help the humanity survive.

The protagonist of this scenario tends to play video games, and while playing he suddenly finds himself in a dark room, where everything looks old, and in ruins. Very soon he realizes it's a dungeon. Panicking, looking for a way out, he starts finishing challenges given to him in order to open the door, just to find himself locked in another room. Finding hints on how to reach the next room, he finally reaches the last room where he has just one last challenge. Build a time machine.

4.1.2 Topics

As an educational game, “Imaginary dungeon” will focus on basic programming concepts and move further to more complex topics.

Topics that will be covered on the game are depicted below as we can see in Figure 14, where it starts with variables. This part of the game contains a brief explanation of variables, examples and a challenge

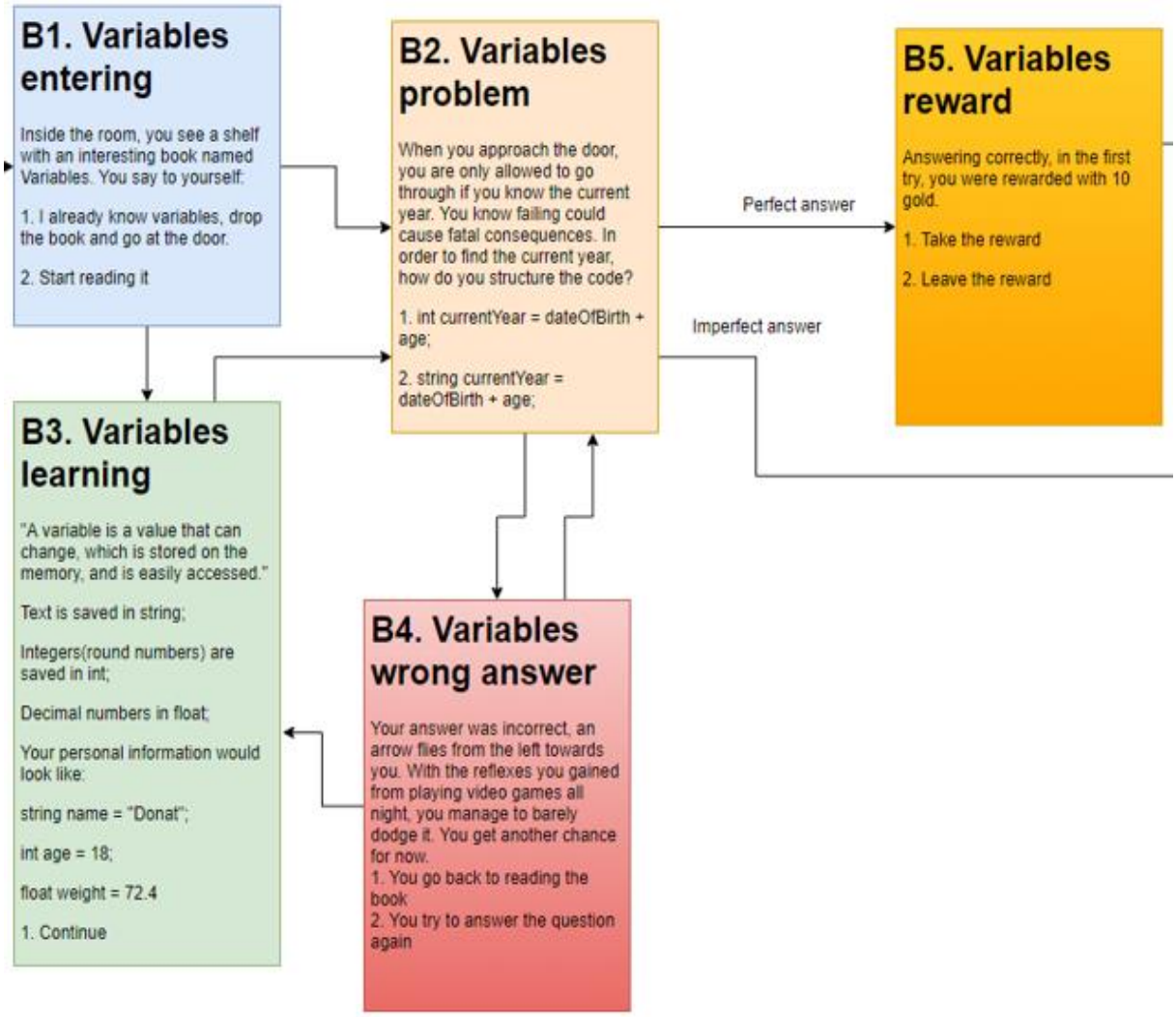

Figure 16. Variables topic story flow.

After variables, the game continues with if statements, as we can see in Figure 16. The structure of this topic is the same as the variables, starting with a brief explanation, examples and finishing with a challenge.

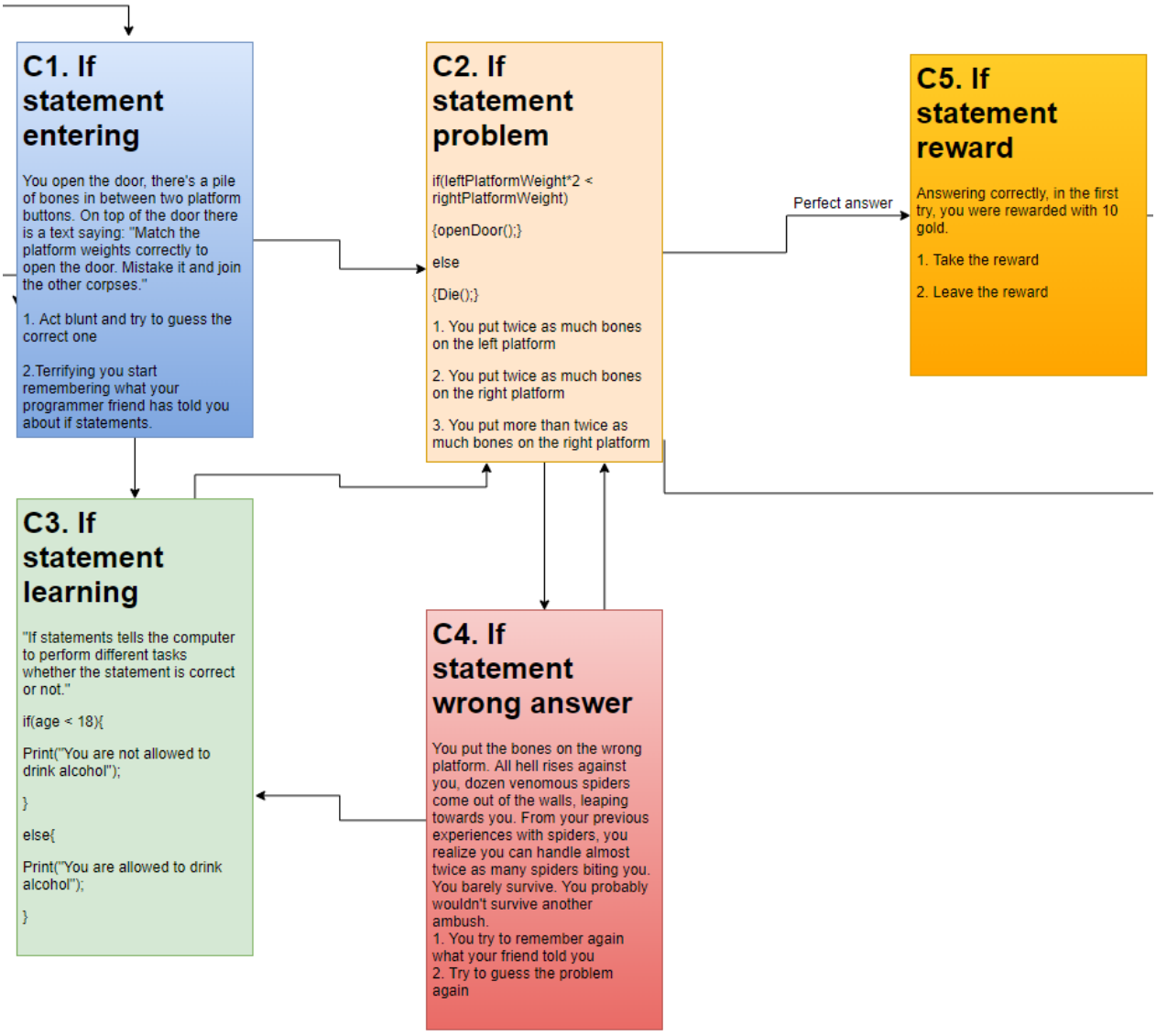

Figure 17. If statements topic story flow.

After that we continue with loops, for loop in particular as seen in Figure 17. Being more complex than the previous topics, it offers a broader explanation and gives the player the chance to view more examples for a better grasp of the topic, and finishing with a challenge as well.

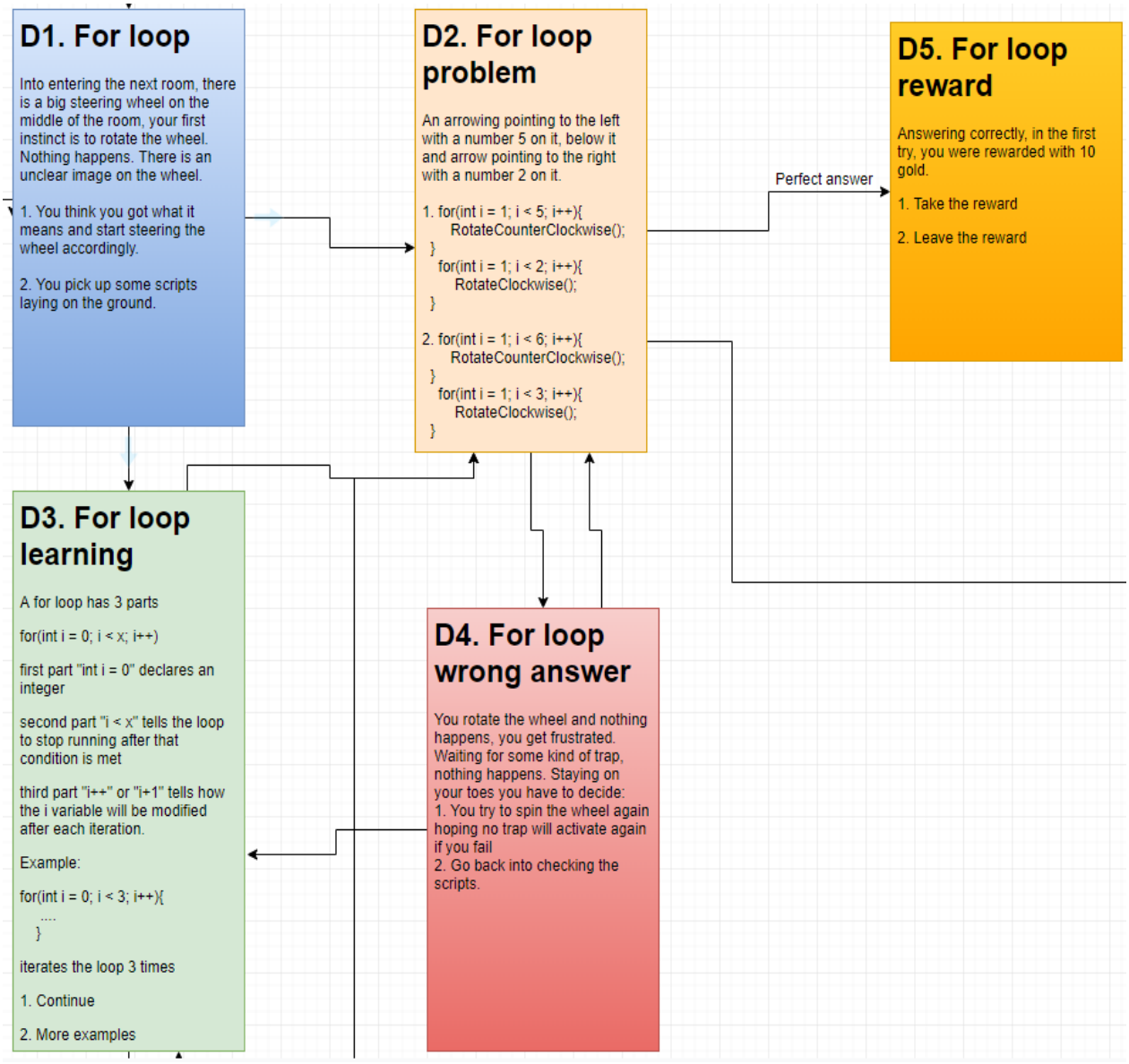

Figure 18. For loop topic story flow.

Sections that are yet to be designed are the following:

1. Operators
2. Data structures
3. Input/output
4. Methods/Functions
5. OOP
6. Objects etc.

4.2 Implementation

The implementation process includes the technology decisions, architecture and implementation procedure. Game engines are most commonly used for implementing video games nowadays, unless there are unique mechanics or behaviors. Unity as the most widely used game engine, was chosen to be used to implement the imaginary dungeon. It allows very easy implementation for new developers or fast prototypes, but it falls short to languages like C++ on versatility and performance. Unity offer a lot of versatility both in 2d and 3d, therefore this game is created using the Unity technology.

4.2.1 Benefits of Unity

Unity was created to make the implementation process of a game easier. To achieve that, it offers a lot of benefits to its users. Below is a list of most benefits offered by unity:

1. Easy to create project, with a lot of auto-generated files. This allows for the user to start working with it immediately without spending time on more than 2 wizards.
2. Team management. Using unity teams to make help teams work together efficiently.
3. Has its own integrated physics system. Enabling faster implementation and no need for more code or to include external libraries.
4. Has its own integrated animation system. Allowing the user to not learn new tools.

5. Easily upload able to GitHub using plugins. Encouraging users to backup the project on a repository.
6. Supports two highly used languages such as C# and JavaScript.
7. Cross-platform. Unity can easily distribute the project to 25 different platforms such as: Windows, Mac, Linux, WebGL, iOS, android, gaming consoles, etc.
8. Importing assets in unity can be done without any adaptation.
9. Threading is simple using coroutines.

4.2.2 Disadvantages of Unity

Every technology has its problems, Unity is no exception. Weak points of unity contain:

1. Limitations on custom physics behaviors and mechanics. Having its own physics system makes it also hard for custom behaviors, so a lot of work-around should be done in order to achieve something simple but different.
2. Project size becomes very large even or small projects. All unity default plugins will be added to the project in its creation whether they are used or not.
3. Memory management system is not optimized for large projects. Without the ability to manage the memory manually, optimizing a large project in unity is hard.

4.2.2.1 Version control system

Using a version control system is important on every project. It helps the team work together, will be used as a backup of the project, and simplifies the project version management. GitHub was the chosen for version control system for imaginary dungeon. The decision to go with GitHub came from the experience in using it, its simplicity and its integration with Unity.

4.2.2.2 Code and technicality

This section will explain the code and technical decisions made during the implementation.

Editor implementation

The project started with one scene, that being the main scene where all the content will be shown. A camera is added to allow the player what is being shown to the screen. A canvas was creating holding the user interface elements. The canvas contains the background, text fields and other elements shown on the screen. A game object called “game” holding and executing the scripts.

Every step of the player is separated into “states”. A state holds the information shown to the player, how many actions can be performed and what repercussion every action has. The game starts with the opening state and moves to the next depending on the action.

Scripts

Scripts are a huge part of game development. There are many things that engines don’t support on the editor that should be handled through scripts. Since Unity supports only C# and JavaScript, we decided to write the code for the imaginary dungeon in C#. With the prototype being very simple and since we had not much time to implement more features, only two scripts were needed to get to this point of the project, “State” script and “Game” script.

State script as seen in Figure 18 represents an object that stores the information of each state. It includes storyTitle, storyText and nextStates (on what states action inside that state can send the player).

```
using System;
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

[CreateAssetMenu(menuName = "State")]
public class State : ScriptableObject
{
    [SerializeField]private string storyTitle;
    [TextArea(14, 10)][SerializeField]private string storyText;
    [SerializeField]private State[] nextStates;

    public string GetStateTitle()
    {
        return storyTitle;
    }

    public string GetStateStory()
    {
        return storyText;
    }

    public State[] GetNextStates()
    {
        return nextStates;
    }
}
```

Figure 19. Screenshot from State class.

Game script shown on Figure 19 works as a controller of the game. First three functions initialize the text fields with State attributes. ManageState() functions handles key presses, determining what the next state will be.

```
public class Game : MonoBehaviour
{

    [SerializeField] private TextMeshProUGUI titleTextComponent;
    [SerializeField] private TextMeshProUGUI storyTextComponent;
    [SerializeField] private State startingState;

    private State state;

    // Use this for initialization
    void Start ()
    {
        state = startingState;
        titleTextComponent.text = state.GetStateTitle();
        storyTextComponent.text = state.GetStateStory();
    }

    // Update is called once per frame
    void Update () { ManageState(); }

    private void ManageState()
    {
        var nextStates = state.GetNextStates();
        if (Input.GetKeyDown(KeyCode.Alpha1))
        {
            if (nextStates.Length > 0)
            {
                state = nextStates[0];
            }
        }
        else if (Input.GetKeyDown(KeyCode.Alpha2))
        {
            if (nextStates.Length > 1)
            {
                state = nextStates[1];
            }
        }
        else if (Input.GetKeyDown(KeyCode.Alpha3))
        {
            if (nextStates.Length > 2)
            {
                state = nextStates[2];
            }
        }
        titleTextComponent.text = state.GetStateTitle();
        storyTextComponent.text = state.GetStateStory();
    }
}
```

Figure 20. Screenshot from Game class.

5. DISCUSSION

The purpose of this thesis was to research about effect of the games on the education ecosystem, and learn how to design an education game using those findings. Relying in the reviewed papers [1] shows that this conclusion of the results could vary on individual bases. This makes us believe that different approach should be offered on different kind of mindsets and not ditch the general concept of gamification. For example, taking into consideration the other approach of learning through game-based learning [4], video games in computer science education is going to play a huge role during the learning process of learners. However the key challenges is the design concept that will be offered so the learners experience the learning process indirectly while simply playing a particular game and simultaneously enjoying the game.

But, considering the concerns in [37] where The World Health Organization (WHO) officially recognizes gaming disorder and also social conditions that could be dominating in various families [8], we can add the game components to learning process also while omitting the technology. For example, learning by using card games, can avoid both gaming addictiveness and social condition barriers, while benefiting from game-based learning.

Currently edutainment is more useful on younger children specified by N. Mohamed Zain [9]. Despite the many risks, games have been shown to engage players. Players are very vocal, share positive experiences with a wide audience and are eager to form new relationships with games and others. When the gamified topic exceeds the player's expectations and delivers added benefits, it can lead to a huge amount of success.

To conclude, a good example that learners could increase their knowledge while being part of an enjoyable game could be mentioned the Minecraft case [10]. This approach was favored from a number of learners, since the game is not limited to its scope and does not make you rigidly follow a specific sequence of steps.

As part of the aforementioned cases, the design decision applied to the game "Imaginary Dungeon" is made according to the literature review, and what failed to be included for various reasons. Going with the top-down approach, we start from the type of game.

1. Trying to match Vim Adventure's simple aesthetics and graphics, which in Imaginary Dungeon was designed to have limited distractions on its aesthetics.

2. Further, mechanics of the prototype are designed to be very simple in order to reach a broader audience and not only gamers.
3. As claim in [4] that a big problem in game based learning is for player to enjoy the process of game while learning from it, in the prototype life system was introduced to make Imaginary Dungeon more challenging and engaging. Giving the game a sense of urgency and discouraging the player to brute force through it.
4. As suggested in [8] that card games or board games have more value since they can reach people with worse social conditions. However the prototype was designed to be a video game since this thesis is being written for the computer science Faculty.
5. We also aimed to follow the suggestions in [10]for creating sandbox games which then can increase creativity and scope of educational topics but in our case because of the limited resources, the Imaginary Dungeon for the initial phase is created in a more rigid environment.

CONCLUSION

This thesis offered a brief analysis on education process and the connection it can have with games. Integrating games into educational system will be a challenge as a game is considered a fun activity and a waste of time. Sandbox games have been determined to be the most effective game type, as it has infinite amount of content that can be added, and each player can experience it differently. Experimenting with the game, increasing creativity and learning same concepts from different angles and methods. Adding learning elements on a game and not making it obvious to the player that he is learning something is a challenge people involves in game-based learning are facing. Designing an educational game is challenging for the fact that education games are new and have not been tested enough on a larger audience. All the problems aside, according the literature reviewed on chapter 2, we can conclude that the three concepts, gamification, edutainment and game-based learning are beneficial to the education process.

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