

Lego-based Game as a Way to Improve Student's Physics Education

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Abstract—During the pandemic, most students are having difficulties interacting with one another. Despite being under quarantine for more than two years due to the global pandemic, remote learning has not been an efficient way to continue education. Most of them are struggling with specific subjects during online classes. Furthermore, students have trouble in all their classes, and Physics is the most difficult subject, according to news reports and statistics on education. The results of all the studies and interviews with the qualitative respondents indicate that educational games might improve students' academic performance. As a result, puzzle-game physics was developed to help students.

Keywords— Education, Games, Design, Puzzle, Lego

I. INTRODUCTION

The problem contains two aspects that collide with each other; the two-year ongoing global pandemic and the lack of one of the difficult subjects. Being in quarantine, the effectiveness of remote learning is becoming lesser as they struggle to understand any of the materials regarding the subjects. Also, one of these subjects that should not be underestimated, is physics is one of the hardest branches of Science due to containing difficult methods for students' development of strong analytical and mathematical skills in them. This concludes with a game that could educate them in a way for them to gain more benefits in both learning and having fun.

Therefore, the game project is directed to the design of a Lego-based puzzle room game (Fig.1), we're focusing on physics study to accomplish the next level. Games will help them to learn basic physics and use physics methods to practice cognitive, motoric, and creative skills. And also learn to think of the solution while they are able to explore and walk around and interact with a surrounding player during the game in creating strategic plans and understanding the thing that they need to complete.



Fig. 1. Lego-Based puzzle room game

II. LITERATURE REVIEW

A. Implementing Games into Education

“Learning can be defined as the form of acquiring knowledge by studying and gaining experience” [1].

Everything always starts with learning to know and understand something or anything, which is important for people to carry on with their lives on their own through such obstacles. However, most educational activities would be a bore which leads to losing interest in a certain topic and having difficulties processing because of the education procedures. Approaching through games can be an alternative way to attract students to study and learning easily. Perhaps through games also be able to interact with students with subjects much more conveniently and enjoyable.

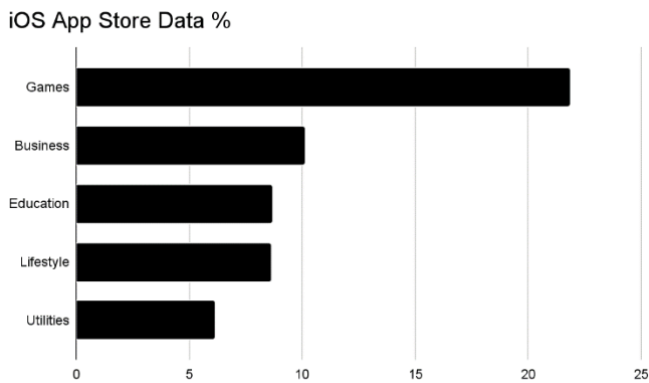


Fig. 2. Categories of the app store

Based on the data of app categories in the iOS App Store (Fig.2), it reveals that games have three times more on average than other categories including education. [2] Since games attract people more than education does, this implants the idea to create an educational game.

B. Puzzle Theories

Puzzle is also known as a game, but its mechanism or the way it works are specifically different. As a puzzle maker, it requires a powerful strategy because when the strategy is weak or the player being able to know it in an instant leads to lack of fun to reach the goal. Also, a puzzle is a one-time play because those who have solved it before can easily solve it in a short moment of time. Therefore, most puzzles cannot be considered as games. (Sala, 2014) However, for one-time play is worth playing because challenging games can be a learning experience. “When a person faces a challenge and then overcomes it, that person has learned something. It does not matter if that challenge is in a math textbook or in a computer game.” (Rouse,2011)

B. Enigma Effects

Enigma is something that is hard to understand and to be solved. The puzzle itself is not based on game mechanics, it is based on a challenge or something that keeps players using more time to solve. In other words, having Enigma Effects in a puzzle result in an interesting difficulty to be solved (Fig.3). This motivates them because the puzzle is about solving a problem that involves the result of those who solved it and those who could not solve it; Such as when the player solved it they feel satisfied, but when the player could not solve it they feel frustrated. In other words, a puzzle involves the inspiration between the player and the challenge. (Sala, 2014)



Fig. 3. Enigma Effect

B. Puzzle Design

The children always start with simple puzzles that can develop their understanding and skills; such as a jigsaw puzzle or Rubik’s cube, the most well-known basic puzzle to start. Although the jigsaw does not have to be the top puzzle to be played, any puzzle can bring simple understanding to them because what matters is what they learn by engaging with the puzzle.

“What are the learning objectives and educational purpose of using puzzles? This is not a simple question and does not have a unique answer. The hallmarks and characteristics of puzzles cited in our earlier discussion lead us to suggest that puzzles are helpful to students in Several ways. It is clear that in solving problems and puzzles a student needs to take personal responsibility; adopt novel and creative approaches, making choices; develop modelling skills; develop tenacity; practice recognition of cases, reducing problem situations to exercises.” [3]

Similar to a puzzle game having Enigma effects, the outcome for them to succeed is to increase their confidence in problem-solving and having more practice in solving problems would expect to become better.

C. Game Design

Isometric vs Top-Down vs Third Person

“Because of the isometric view the game uses, a view which can sometimes be confusing to look at, a strictly top-down view in which the designer could edit his level could have been quite useful in the placing and manipulating of units and other game elements.” [4]

Both have the opposite pros and cons to each other. Isometric contains a better perspective view but is complicated and confusing to design, while top-down is simple to design (Fig.4) but the view is not



Fig. 4. TopDown

as good as isometric (Fig.5) Based on each aspect, they still can be viewed as good equally depending on the content.



Fig. 5. Isometric

A third perspective, also known as a third person (Fig.6), works at its best on viewing every perspective around the targeted character which gives the player a comfortable wide view. However, it is often difficult to see the elements due to distant views and not completely compatible if the stage atmosphere is crowded.



Fig. 6. Third Person

D. Storyboard Design

All the specific assets are purposely used in each specific scenes to design the game, but a story must be present to visualise the key flows of the game

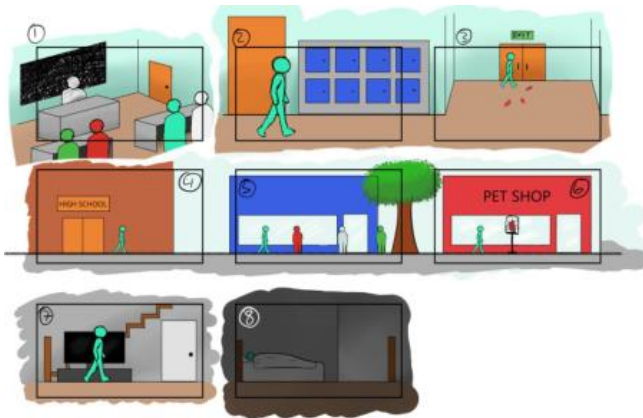


Fig. 7. Storyboard

(Fig.7) shows how the game begins before the player jump into the actual game, and it also gives the understanding of how the actual game begin. The story shows that the player is a student who is having the lack of Physics understanding, ongoing event the player always encountered a clue-looking red parrot everywhere to his home. As the player goes to sleep, his/her mind are set focused on a red parrot and the Physics on that day leads to a strange dream. An escape-

room-looking dream, an opened place where it locates in the middle of the sky, and a familiar looking creature is there to guide the player. That familiar looking creature is the red parrot.

E. Scene Design Mapping

The MindMap of the game (Fig.8) has been finalized and improvised as the storyboard has been added, acting as “Story”. Since the game is prototype, the game only consist of one content of the game feature which is called the Solid Stage. In complete version, there are also Liquid Stage and Gas Stage, which indicate the difficulty in each stages in order.

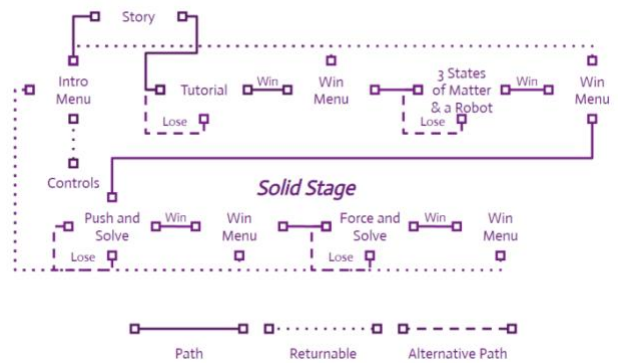
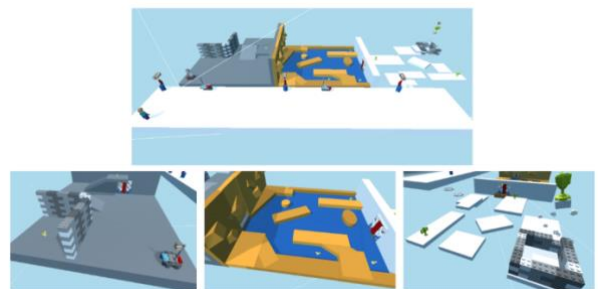


Fig. 8. Scene Design MindMapping

F. Puzzle Design

The level design consists of many different components to become a whole game area. It is like a jigsaw puzzle, in level designing a level is resembling a piece of a puzzle (Fig.8). There are three gameplays, which are engine, art, and core; The engine gives a suitable frame rate, the art gives the scaling and rendering for every asset in the game, and the core is where the fun begins in the game and where the content plays its role.

“Some would say that all puzzles are keys in the end, but this misses an important point and opportunity for more compelling gameplay. More sophisticated variants on the switch/door combination can be situations that require players to actually figure something out in order to progress. Perhaps a laser beam needs to be refracted around a series of corners in order for players to move on. In order to refract it correctly, players will need to move several reflective plates. Players must understand the simple physics of the situation that governs how the beam will



behave when reflected in different ways.” [4]

Fig. 9. Puzzle Resembling

If either one of them fails, it will lead to disaster by showing unpredictable behavior. In Puzzle solving instead of the level that involves finding a path to the next level, the level may involve figuring out what they need to accomplish to open the next level.

Games will be applied using LEGO as a building-block toy or game that has popularity among children, this includes adults as well. Based on video games, LEGO consists of lighthearted humor due to friendly content. In a term of tragic scenes such as where the character got their hands cut off, in LEGO the character’s hands are popped off without adding gore effects intentionally. In addition, it became a joke where the character is physically harmed but unharmed based on the context

III. EXPERIMENTAL

Some experiments were made before the actual project was started. There were many unknown programs and tools, which have many possibilities between being able to create the work of project flow well and encountering errors based on colliding with objects and functions; they are *BrickLink Studio* and *Unity*. By using *BrickLink Studio* to create the object while using *Unity* to give the objects specific functions, it was the most challenging process in the project because this affected everything throughout the project. This is the reason why the experiment was made before the actual project Authors and Affiliations

G. Importing Assets

- After creating a lego-based object from *BrickLink Studio*, exporting using .ldr and .io.
- Through *Unity*, an experiment began with importing two different file types mentioned before with settings.
 - Colliders; Connectivity; Static; Lightmapped; Randomize Rotation; Prefer Legacy; LOD. (Fig.6)

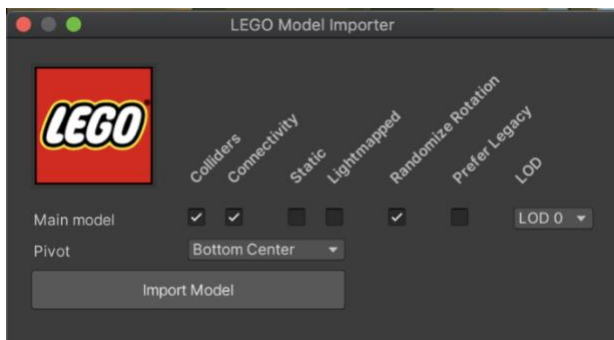


Fig. 10. Model importer

Out of all the options in the setting, the Collider must be turned off if the object contains a huge amount of Lego bricks in order to avoid lags and high memory usage and disk usage.

H. Adding Functions

There are many functions, also known as behaviors, to use for the specific objects with specific roles, such as giving the role of the object to collide and destroy the other object which contains a different role to be destroyed. A combination of one behavior and another was tested to examine the effectiveness of its work because only one behavior was once tested and it failed to work properly.

I. Final Design

Through the mind mapping with more asset designs, the prototype game is visually complete but more mechanics of each working assets to be fixed. The following scene shows how the interface looks like. Fig.11 is showing the menu introduction. Fig.12 showing the school scene during game play. Fig.13 is showing the street walk scene

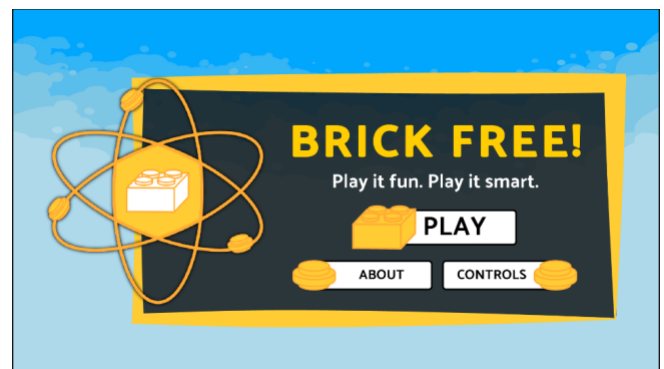


Fig. 11. Model importer



Fig. 12. School Scene



Fig. 13. Street Walk Scene

IV. RESULT IN DISCUSSION

After the experiment was finished and began the project along the way, the result of comparing before and after was a huge change. Before, Unity kept not responding due to the huge file size within the program because the Colliders on huge objects were enabled. In the after with disabled Collider, Unity took lesser time to load and progress. This was because the creation of this project was created based on limited specifications and tools. However, since the project is meant to be a prototype the project was a success with a minor problem which was the lesser-long loading scene still takes time to load.

V. CONCLUSION

There were many improvements that were required for the effectiveness of the game system workflow. The objective of this prototype was to bring education with fun, but also must deliver them effectively. The load of the game took a lot of time which could take about 5-7 minutes hence the memory usage problems. Before it was fixed, it took around 10-15minutes. Other than long loading and memory

usage situations, this affects texturing on the assets leading to a lack of enjoyment visually. There were many more flaws due to limited materials such as the specs on the tools used to create the prototype. The improvement that needs to be looked forward to for future research and prototyping was to learn more about the game engines used in order to understand what was required. As to the point based on the prototype, there were many assets and their aspects need to be improved in order to reduce the loading time because the cause of the long loading and memory usage problems are from the settings in all the assets.

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