Implementation of Digital Gamification and Digital Game-Based Learning into STEM Related Subjects

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Abstract

Gamification is a concept that has been utilized as a supplementary tool in and out of classrooms since before video games, and even its own definition, were as established in mainstream conversations today. Gamification is a common tactic used in educational, workplace, and commercial settings to promote engagement of participants, otherwise known as "players." A term coined in 2002 by Nick Pelling and later redefined in 2014 by Gartner, gamification refers to the integration of core gameplay mechanics-- such as rules, level progression, challenges, and rewards-- and tends to result in an increase in engagement and investment in the different areas of activity it is applied to [15]. According to Gartner, gamification "focuses on enabling players to achieve their goals" by aligning task goals with "player" goals which leads to the consequence of the task being completed because of this alignment [16]. Gamification can occur in both digital and analog experiences, digital referring to engagement via the incorporation of computers, smartphones, and associated applications while analog references non-digital components such as loyalty cards or best attendance in a classroom. For the context of this team's goals, the focus was on the implementation digital gamification. Gamifying an everyday task or topic increases an individual's enjoyment and personal investment in a task because the incorporation of these gameplay elements breaks the mundanity of a simple activity and elevates it by adding a driving motivation of reward.

When applied to an educational context, enjoyment, engagement and investment in a subject have been shown to result in higher retention of the information learned [17]. Several studies have argued that gamification in education has a positive effect on learning and student achievements in classrooms [18]. By gamifying difficult subjects that have a tendency to be seen as "dry" and "technical" by younger participants, such as math and science, students have the potential to comprehend them at a faster rate. Digital game-based learning, a similar concept to gamification with the express difference of actually incorporating "learning principles into immersive video game environments into immersive video game environments in an effort to provide a new tool for education that is as modern and adaptive" according to Prensky [19]. Video games represent a unique potential for educators because of their interactivity, accessibility, and the format's tendency for modification especially in relation to the implementation of different curriculums across grade levels. The goal for this team was to encourage the incorporation of digital gamification of STEM concepts in K-6 educational settings through digital game-based learning. To accomplish this goal, the team set the objectives of conceptualizing and developing a digital, educational video game that can be further modified to incorporate different STEM-related curriculum and grade levels. This was completed utilizing Unreal Engine 4 to build and develop graphical and interactive components. The team also referenced the North Carolina Common Core Curriculum to develop educational questions to implement into the video game.

Keywords

Gamification, STEM, Unreal Engine, UE4, Game Development, Digital Game-Based Learning, Game Development, Game Design

Research Questions

Our research focused on four specific areas:

- What is Gamification?
- What is digital game-based learning?
- How can education and game development connect?
- What are the benefits of gamification and digital game-based learning?

Methodology

The game development pipeline follows a general pattern of procedure but is by no means a purely linear process. A typical game development pipeline is comprised of four major Milestones:

- Concept
- Pre-Production
- Production

Pre-Production

- Game title: "Alien Invasion"
- Game story: Aliens invaded the player's solar system and the player must reach their spaceship to defeat them.
- Target audience: 4TH graders
- Game mechanics: The player could solve the problems by interacting with the kiosk answer spheres and if the problem was right it would take away health, and if it was wrong the player would be taunted by the aliens and (2) when the player answered all of the questions correctly the aliens would leave the planet, resulting in player progression through the game.

Production

1) Developing the Shield Blueprint

After creating the game project, the team began developing the Shield Blueprint which would house the alien characters that the player needed to eliminate from the planet. A blueprint was created with a shield mesh that would be destroyed after certain conditions were met [fig. A.]. A representational health bar was created through a widget blueprint and connected as a component inside the Shield Blueprint so that the player could see when the shield's health was affected, indicating how many more actions must be taken for the shield to disappear and the aliens to be "banished" from the planet. Later on a box collision volume was added to implement functionality for story elements inside of the Story Robot Blueprint.

2) Developing the Shield Health System

The Shield Blueprint health system was constructed inside of the shield blueprint event graph [fig.B][fig.C].

3) Developing the Shield Blueprint

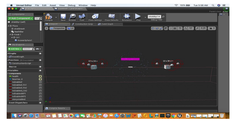
The Kiosk Blueprint was developed as an object that the player could interact with in-game that would affect the Shield Blueprint.. The problem hub displays the math problem that the player must solve and is always visible. The answer spheres are comprised of a sphere collision volume component, a widget component that stores the answer, and a sphere static mesh component.When the component overlap ends, the player key input is disabled and the 'is enabled 'x'' variable and widget visibility are set to false [fig. D] [fig. E]. For the 'true/correct' answer sphere, if key input occurs, the game will take away health as described in the 'Developing section Shield Health System [fig. C]. For the 'false' answer spheres, a print string runs across the screen saying 'is False' [fig. F].

4) Implementing Characters

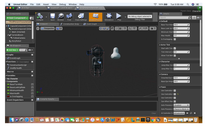
The player character model and animations were created in outside programs (Autodesk Maya and Mixamo, respectively) and then imported into the engine. UE4 already has a preexisting Third Person Character Blueprint available for use and the player character replaced the default character in this blueprint [fig. G]. A double jump was implemented into the Third Person Blueprint [fig. H] as well as custom animations for the player character.

5) Implementing Story Elements

The story functionality was employed into the game differently than some of the other gameplay elements by using a Blueprint Interface (BPI). A BPI is a collection of one or more functions - name only, no implementation - that can be added to other Blueprints" [14]. The team created a BPI called 'BPI Story Interface' with two primary functions, 'Pass thru Collision Story 'x'' and 'Left Collision 'x''[fig. I]. This BPI, when added to a blueprint in the Class Settings, allowed the respective blueprints (Story Robot and Shield Blueprint) to utilize nodes and create events based off of the functions inside of the BPI. The BPI is especially useful because it allows events to happen without having to initiate them in the level blueprint, meaning that the user can attach specific events to components within different blueprints as opposed to generally referencing the entire blueprint.



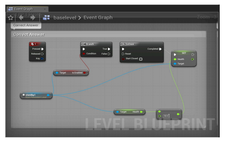
A. Shield Blueprint



H. Third Person Blueprint

B. Shield Health System

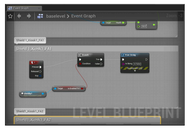
I. Collision Blueprint



C. Shield Health System

D. Kiosk Blueprint

E. Kiosk Blueprint



F. Kiosk Blueprint

Conclusion

In conclusion, the team found that it is possible to implement games in the classroom. In order for this connection to be effective, there must be an understanding of both the game development process, the curriculum of note, and how to implement the information in a meaningful way. As research mentioned before, teachers were the developers and forerunners as it pertained to the original execution of digital game-based learning and gamification in education. In the future, the intersection of the education and gaming worlds will be an ideal inclusion in common curriculums once the collaboration components are present. Based on our research, the gamification of STEM-related subjects would highly benefit students. The process would address students and classrooms in every way such as catering to multiple learning styles, creating challenges, keeping students engaged, and improving student learning.

Future Work

In the future, the team would like to further continue the development of the game to achieve a more immersive experience in terms of functionality, interaction, and aesthetics. We would also want to implement more game mechanics to increase the visuals and interaction of the game. The team would also push the game to alpha and beta versions. An alpha version would allow for quality testing within the development team. With a completed beta version of the game the team would collaborate with local educators to begin conducting beta-tests on a focus group of students. The team would develop a survey for the participants on the educational content and enjoyment of the game. Simultaneously, the team would collaborate with the educators to determine if the game strengthens and reinforces the participants' comprehension of the subject matter over time. Lastly, team would also continue modify their game by expanding the availability to other grade levels and incorporate more STEM-based curriculum.

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(For an extended list of references, please refer to the team research paper.)

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