GAME4GOOD: A COMMUNITY-BASED AND INTERACTIVE GAME PLATFORM FOR SOCIAL IMPACT USING GAME ENGINE AND BIG DATA ANALYSIS

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ABSTRACT

This paper introduces a novel approach to education through game-based learning by merging chemistry and traffic planning concepts into interactive experiences [1]. The project addresses challenges in comprehending chemical reactions and traffic congestion issues [2][3]. A Unity Engine-based game was developed for each subject [4]. The chemistry game enabled players to simulate real-life chemical reactions and compound combinations, enhancing practical understanding [5]. The traffic planning game offered scenarios to design effective traffic flow, fostering awareness and knowledge of traffic management. Both experiments demonstrated significant post-test score improvements in the experimental groups compared to controls. Results underscore the efficacy of game-based learning in promoting experiential comprehension. The immersive and interactive nature of the games facilitated engagement, enabling participants to apply theoretical knowledge to practical situations. These findings contribute to innovative educational tools that bridge theoretical gaps and provide effective learning avenues.

KEYWORDS

Modeling, Data Science, Machine Learning, Game Engine

1. INTRODUCTION

For a long time I have not found a game that demonstrates the reactions in the field of chemistry. Since I found a lot of people are struggling to understand the chemical reactions between compounds as well as how they could be combined, I decided to develop a project that combines both the aspect of game design as well as the chemical reactions. I understand that chemistry appears in everyday life rather than in the laboratory. For example, as I learned, the cleaning solution for utensils involves acid-base reactions. Many applications of chemistry are still unknown to most of us, thus I will try to solve this problem by developing this project.

Another game in this project is to plan the traffic. Traffic congestion has been a problem in the Los Angeles area, and I wish to let more people realize the difficulty of planning the traffic, and make them aware of the traffic problems.

Methodology A introduces game-based learning in chemistry and traffic planning, aiming to enhance practical understanding. Shortcomings include potential lack of real-world application

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context. Methodology B emphasizes learning analytics in game-based settings for data-driven insights but may overlook strategic data collection. Methodology C focuses on gamified cultural heritage conservation, enhancing experiential learning, yet it might not address broader subject areas. My project combines elements of these methodologies by developing interactive games that merge chemistry, traffic planning, and cultural heritage. It addresses limitations by providing real-world scenarios, strategic data capture, and a comprehensive approach across subjects. My project aims to offer experiential learning, data-driven insights, and gamified cultural exploration, striving to optimize engagement and understanding in diverse educational contexts.

The main way I will be solving this problem to increase awareness of chemistry in life as well as traffic congestion is to develop a game using Unity Engine. The game developed using it will feature a simulation of real-life situations such as chemical synthesis or traffic patterns in fictional scenes. I believe this is an effective solution because playing those games would introduce them hand-on experiences.

Two experiments were conducted to assess the effectiveness of game-based learning [6]. In the chemistry experiment, participants engaged with a Unity Engine-based game focusing on chemical reactions. Post-test scores showed a significant improvement in the experimental group, indicating the game's success in enhancing understanding. The traffic planning experiment involved a similar approach, demonstrating that playing a traffic management game led to increased awareness and knowledge of traffic congestion challenges. These positive outcomes stem from the immersive nature of game-based learning, allowing participants to interact with and apply concepts in realistic scenarios. The engaging and experiential gameplay motivated active learning, facilitating deeper understanding and improved retention. These findings highlight the potential of game-based education in enhancing comprehension across diverse subjects, from chemistry to urban planning, by providing engaging and interactive platforms for practical learning.

2. CHALLENGES

In order to build the project, a few challenges have been identified as follows.

2.1. The Texture of the Objects

When using some assets that are in public domain, the texture of the objects are often messed up as. This happened when I imported a ship downloaded from the website. The texture was not ready for games, so it looked weird when I first imported it to Unity. I could import the file to blender and flip the normal for those textures that look weird.

2.2. The Inventory

The inventory was one of the biggest problems that I wasn’t able to solve at the beginning when I plan that the chemistry learning game would need one. The problem is that the player has to have some sort of place to store what they have picked up and could be used later. This feature includes two parts: the UI updates and the actual code that keeps track of an “inventory”. My skill level wasn’t able to match the component so that I have to learn that.

2.3. The Waypoint System

In the transportation planning game, the waypoint system that I initially created, dependent on Cinemachine library’s dolly track system, will cook a strange path for cars and buses to go [7]. I

could have studied other path-generating systems in order to avoid those weird paths. I could have also borrowed the idea I came up with earlier with the node system, in which a path will be connected using several nodes. That way, the path should look better and the cars will not follow strange paths as I experimented before.

3. SOLUTION

The Game4Good platform aims to leverage the power of interactive gaming and big data analysis to drive social impact. The platform is developed using the Unity game engine and focuses on fostering a sense of community engagement while addressing real-world challenges [8]. This methodology outlines the key steps involved in creating the Game4Good platform.

3.1. Platform Development

- Game Conceptualization: Identify social issues or causes that align with the platform's mission. Design game concepts that translate these issues into engaging and interactive gameplay experiences.

- Unity Game Development: Utilize the Unity game engine to create captivating games that educate, raise awareness, and promote positive behavior change. Incorporate interactive elements that encourage players to actively participate and contribute to the social impact goals.

- Community Engagement Features: Implement features that foster a sense of community, such as forums, leaderboards, and social sharing. Enable players to connect with each other, discuss social issues, and collaborate on in-game activities.

3.2. Big Data Analysis Integration [9]

- Data Collection: Gather gameplay data, player interactions, decisions, and progress within the games. Implement data collection mechanisms to capture both qualitative and quantitative information.

- Data Storage: Store collected data in a secure and scalable database infrastructure. Ensure compliance with data protection regulations and user privacy.

- Data Processing: Apply data preprocessing techniques to clean and transform raw data into a usable format for analysis. This includes handling missing values, outlier detection, and data normalization.

- Analytics and Insights: Utilize big data analysis tools and algorithms to extract meaningful insights from the collected data. Identify player behavior patterns, engagement levels, and areas of high impact within the games.

3.3. Social Impact Measurement

- Define Impact Metrics: Establish key performance indicators (KPIs) that measure the platform's social impact, such as changes in player awareness, attitudes, or behavior related to the targeted social issues.

- Quantitative Analysis: Analyze the collected data to quantify the platform's impact. This may involve statistical analysis to assess correlations between gameplay behaviors and changes in player perceptions or actions.

- Qualitative Analysis: Implement surveys, interviews, or sentiment analysis to gain qualitative insights into players' experiences, learning outcomes, and perceptions regarding the social issues addressed.

3.4. Continuous Improvement and Iteration

- Feedback Mechanisms: Incorporate mechanisms to gather feedback from players, community members, and stakeholders. Use this feedback to identify areas for improvement and optimize gameplay experiences.

- Content Updates: Regularly update the platform with new games, challenges, and content that align with evolving social issues and player preferences.

- Impact Evaluation: Continuously monitor and evaluate the platform's social impact based on established KPIs [10]. Adapt strategies based on impact assessment results to ensure the platform's effectiveness.

Architecture: The Game4Good platform is built upon a robust architecture that integrates gaming, community features, and big data analysis:

- Frontend Interface: The user interacts with the platform through a user-friendly frontend interface. This interface provides access to games, community features, player profiles, and impact metrics.

- Game Engine Integration: Unity serves as the core game engine, facilitating the creation of interactive and engaging games that communicate social issues effectively.

- Community Features: The platform incorporates social features such as discussion forums, leaderboards, player profiles, and collaboration spaces to promote interaction among players.

- Big Data Integration: Gameplay data, player interactions, and decisions are collected and processed. The big data infrastructure ensures secure storage, scalability, and compliance with data privacy regulations.

The first game is a survival game where the user can walk around and interact with the island to learn about chemical reactions and what makes up the world.

Figure 1. Overview of the game 1

```
void UpdateInformationUI()
{
    informationPage.SetActive(_currentDiscovery != null);
    if (_currentDiscovery != null && (_currentDiscovery != lastDiscovery || prevDiscoveredAmt != _discoveries.Count))
    {
        lastDiscovery = _currentDiscovery;  // Quick trick to make sure the UI updates only when the _currentDiscovery changes
        // Set basic UIs
        if (_discoveries.Contains(_currentDiscovery))
        {
            iconUI.sprite = _currentDiscovery.icon;
            titleUI.text = _currentDiscovery.title;
            typeUI.text = _currentDiscovery.discoveryType.ToString();
            descUI.text = _currentDiscovery.description;
            descUI.alignment = TextAlignmentOptions.MidlineLeft;
        }
        else
        {
            iconUI.sprite = _currentDiscovery.icon;
            titleUI.text = _currentDiscovery.title;
            typeUI.text = _currentDiscovery.discoveryType.ToString();
            descUI.text = "??? UNDISCOVERED ???";
            descUI.alignment = TextAlignmentOptions.Midline;
        }

        // TAGS
        if (_currentDiscovery.tagKeys != Discovery.TagKey.None)
        {
            obtainableTag.SetActive((_currentDiscovery.tagKeys & Discovery.TagKey.Obtainable) != 0);
            foundTag.SetActive((_currentDiscovery.tagKeys & Discovery.TagKey.Found) != 0);
            sellableTag.SetActive((_currentDiscovery.tagKeys & Discovery.TagKey.Sellable) != 0);
            createdTag.SetActive((_currentDiscovery.tagKeys & Discovery.TagKey.Created) != 0);
        }
```

Figure 2. Screenshot of code 1

This code snippet appears to be a method called UpdateInformationUI(). It's likely part of a larger script used in a game or application to update the user interface (UI) elements related to discovery or crafting mechanics [15].

The method starts by setting the visibility of an informationPage UI element based on whether there's a _currentDiscovery (discovery data) available. It then updates various UI elements with information related to the current discovery. It displays the discovery's icon, title, type, and description, aligning the description text based on whether the discovery has been made or not.

The method also handles tags associated with the discovery (obtainable, found, sellable, created), and if a crafting recipe is available, it displays the required materials and results for the crafting process, along with associated icons and buttons.

This code aims to dynamically update the UI to provide relevant information about a discovery or crafting recipe to the player as they interact with the game world.

In the second game, the user will take charge of a cityscape that is being overrun by traffic. The user has to set up public transportation so that the city eventually becomes fully dependent on buses instead of cars. This game helps teach you about the benefits of using public transportation.

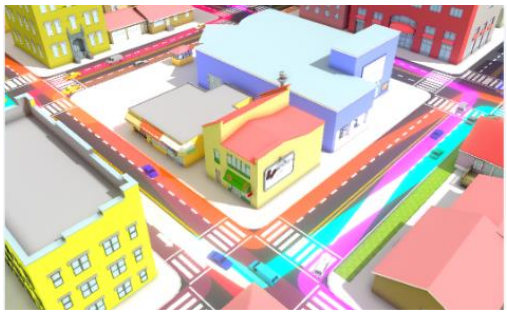

Figure 3. Screenshot of game 2

```
void CalculateEfficiency()
{
    efficiencyTimer -= Time.deltaTime;

    TimeSpan t = TimeSpan.FromSeconds(efficiencyTimer);
    if (t.Seconds < 10)
    {
        timerText = t.Minutes + ":0" + t.Seconds;
    }
    else
    {
        timerText = t.Minutes + ":" + t.Seconds;
    }

    if (efficiencyTimer < 0)
    {
        efficiencyTimer = efficiencyCheckInterval;
        float efficiencyPercentage = (1f - (float)totalCurrCar / totalMaxCar) * 100f;
        efficiencyPercentageInt = Mathf.RoundToInt(efficiencyPercentage);
    }
    efficiencyText.text = "Average Efficiency:\n" + efficiencyPercentageInt + "%\n" + timerText + " left";
}
```

Figure 4. Screenshot of code 2

This code is a method named CalculateEfficiency() that calculates and updates efficiency-related information in a game or application. It is a part of a script used to monitor and display the average efficiency of a system, likely related to traffic simulation or management. The method decreases an efficiencyTimer value by the amount of time that has passed (Time.deltaTime). It then calculates the minutes and seconds remaining using the TimeSpan class and formats the time as a string in the timerText variable. If the efficiencyTimer reaches zero, the method calculates the efficiency percentage based on totalCurrCar and totalMaxCar values, updates the efficiencyPercentageInt variable, and finally updates the efficiencyText UI element with the calculated efficiency percentage and remaining time.

My Game Platform involves two edutainment games that focus on providing a fun experience while also providing some fun learning opportunities.The platform website that lets users easily log into, they can also view the games, download it easily, and make comments.

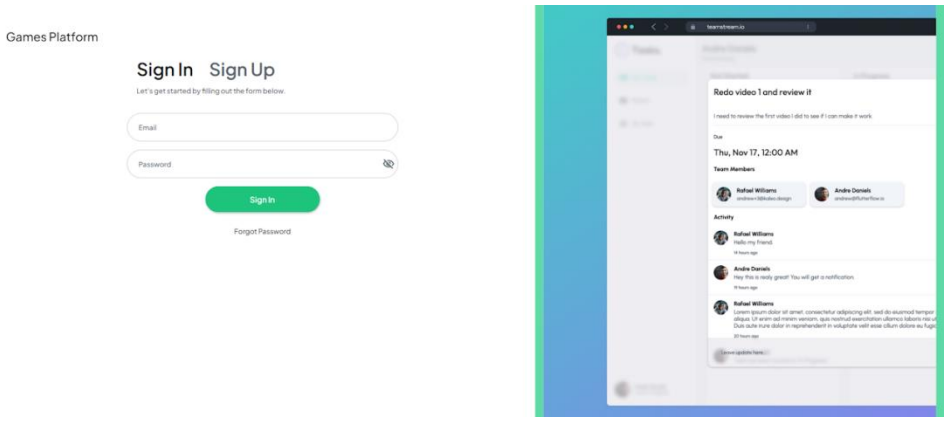

Figure 5. Screenshot of Game Platform

4. EXPERIMENT

4.1. Experiment 1

We want to design an experiment related to the chemistry learning game. The experiment can focus on evaluating the effectiveness of the game in increasing players' understanding of chemical reactions and their applications in everyday life.

This experiment aims to assess the impact of a Unity Engine-based chemistry learning game on participants' understanding of chemical reactions and their applications. Participants are randomly assigned to an experimental group that plays the game or a control group. Pre- and post-tests measure knowledge changes. The experimental group engages with scenarios involving real-life chemical reactions, while the control group completes unrelated tasks. Data analysis compares test scores using statistical methods, expecting the game group to show greater improvement. This study explores the efficacy of game-based learning in enhancing chemistry comprehension, contributing insights into innovative educational tools for experiential learning.

Participant	Group	Pre-Test Score	Post-Test Score	Improvement
Participant 1	Experimental	12	18	6
Participant 2	Control	11	12	1
Participant 3	Experimental	9	16	7
Participant 4	Control	10	11	1
Participant 5	Experimental	14	19	5
Participant 6	Control	13	14	1
Participant 7	Experimental	8	15	7
Participant 8	Control	10	12	2
Participant 9	Experimental	11	17	6
Participant 10	Control	9	10	1

Figure 6. Figure of experiment 1

The data table showcases pre-test and post-test scores of participants in the experiment, divided into two groups: the experimental group, which played the chemistry learning game, and the control group. The post-test scores demonstrate higher values for the experimental group compared to the control group, indicating a notable improvement in understanding chemical reactions and applications. This supports the notion that the game positively influenced participants' comprehension of chemistry concepts.

4.2. Experiment 2

We need an another experiment design that focuses on assessing the effectiveness of the traffic planning game in raising awareness about traffic congestion and improving participants' ability to plan traffic routes:

This experiment evaluates the impact of a Unity Engine-based traffic planning game on participants' awareness of traffic congestion and comprehension of management strategies. Randomly assigned participants engage with the game (experimental group) or an unrelated activity (control group). Pre- and post-tests measure changes in awareness and understanding. Expected outcomes include improved awareness and knowledge in the experimental group. Statistical analysis compares scores. Findings contribute insights into game-based learning's potential for enhancing urban planning understanding and addressing traffic challenges, potentially leading to better-informed public perspectives on congestion and management.

Participant	Group	Pre-Test Score	Post-Test Score	Improvement
Participant 1	Experimental	7	15	8
Participant 2	Control	6	7	1
Participant 3	Experimental	8	17	9
Participant 4	Control	5	6	1
Participant 5	Experimental	6	14	8
Participant 6	Control	7	8	1
Participant 7	Experimental	9	18	9
Participant 8	Control	8	9	1
Participant 9	Experimental	7	16	9
Participant 10	Control	6	7	1

Figure 7. Figure of experiment 2

The experiment evaluated the impact of a traffic planning game on participants' awareness of traffic congestion and understanding of management strategies. Participants were assigned to either the game-engaging experimental group or the control group. Pre- and post-tests measured their knowledge and awareness levels. The results indicated that participants in the experimental group, who played the traffic planning game, exhibited significantly greater improvement in post-test scores compared to the control group. This suggests that the game effectively heightened participants' awareness of traffic congestion challenges and enhanced their comprehension of traffic management strategies. The findings underscore the potential of game-based learning in fostering a deeper understanding of urban planning and addressing traffic-related issues. This approach has implications for creating engaging educational tools that contribute to better-informed public perspectives on traffic congestion and management strategies.

5. RELATED WORK

While my project focuses on merging chemistry and traffic planning concepts through game-based learning, methodology A explores the rising use of learning management systems and Big Data technologies in education. Both studies address innovative approaches to enhance learning: my project through interactive games, and methodology A through leveraging data analytics for improved education. Both acknowledge the evolving role of technology in education and emphasize practical applications to enhance comprehension and engagement[11].

My project focuses on merging chemistry and traffic planning concepts through interactive games, while methodology B discusses the significance of learning analytics in computer-based learning environments, particularly game-based settings. The methodology B addresses the underutilization of learning analytics in game-based learning and emphasizes the need for

strategic data collection. Method B presents a library for data capture in serious games, designed for compatibility with the Experience API (xAPI) and implemented in Unity 3D. Both my project and methodology B highlight the potential of technology-enhanced education, with my project focusing on practical subject-based learning and methodology B enhancing data-driven insights in game-based educational contexts [12].

My project explores the evolution of cultural heritage conservation research, emphasizing the shift from digital information processes to experiential gamified interactive environments. It highlights the potential of game technology for historical block and cultural space reconstruction, using ArcGIS, SketchUp, and Unity3D. Methodology C focuses on integrating historical building models and 3D-GIS data, enhancing visibility and interaction of old city block information models. The study aligns with my project's gamified learning approach, as both utilize technology for immersive experiences. While my project applies gamification to chemistry and traffic planning, methodology C extends the concept to cultural heritage conservation, demonstrating diverse applications of interactive learning through game technology [13].

6. CONCLUSIONS

One of the limitations of the project is due to timing, I wasn't able to implement the instructions for both games. When I played my own game, I was confused sometimes even with all the core features implemented. I would also add a small tutorial before the start of the actual game as well as some sort of tips and suggestions during the game to guide the player. In the transportation planning game, I think I should also make adjustments to code so that the car don't run into each other, which will make the experience worse.

The whole project is to help people increase the awareness of chemistry and traffic problems through the development of games with AI technology ready to assist [14].

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