German International University

Computer Science Faculty

Generation of Gamified Web and Mobile Learning Modules

Bachelor Thesis

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This is to certify that:

(i) the thesis comprises only my original work toward the Bachelor Degree

(ii) due acknowledgement has been made in the text to all other material used

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18 January, 2024

Abstract

Game design and programming are two different skills that are needed to be able to develop a game. Gamification is the processes of turning a non-gamified task into a task with game elements, and in order to achieve that the developer needs to have learned the required skills, and in the field of education gamification has proven to enhance the learning experience for the student, however the instructor would need a tool to be able to create the gamified content without the need to learn about programming or game design, and only needs the content that would be used within the game itself. This paper presents a tool that allows the instructor to generate a game without the need of learning programming or game design and easily share the game with the students. The tool is designed to be educational and ensures gamified elements are present within the game.

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Chapter 1

Introduction

Gamification and the incorporation of game-design elements in non-game contexts has gained considerable momentum in educational settings. The potential it has to raise student motivation, engagement, and improve academic performance has positioned it as one of the most well-known strategies among educators. By incorporating elements of points, badges, leaderboards, and challenges, gamification converts the monotony of learning into an enjoyable process that ultimately renders students proactive in learning.

The issue arises when an instructor needs to create a gamified learning experience for the students, and lacks the skills to create a game on the subject that is being taught. The instructor would need to learn game design and programming to be able to create such game, and even assuming that the instructor in specialized within the field of game design and programming, the time and effort needed to generate a game would be massive and impractical. This is where the tool presented in this paper comes in to play, the tool allows the instructor to generate a game without the need of learning programming or game design, and only needs the content that would be used within the game itself. The tool is designed to be educational and ensures gamified elements are present within the game.

A number studies have underlined the effectiveness of gamification in educational fields. For instance, the work by Lara-Cabrera et al. (2023) has shown that gamified techniques developed with 3D-printed badges had positive influences on performance but also reduced the rate of STEM programs dropouts [10]. Jack et al. (2024) assessed the efficiency of using gamification within flipped classroom learning environments and reported significant increases in students' engagement and motivation based on active learning efforts [8]. Gameification and game-based learning follow game design approaches and frameworks to create a more engaging and interactive learning experience. Fernando et al. 2024 have accentuated the role of GBL for fostering student motivation through immediate feedback, clear objectives, and a sense of accomplishment. Thus, these findings have come to demonstrate the ever-changing potential of gamification in education; they provide proof that gamification can create meaningful and engaging learning experiences beyond those possible through conventional pedagogies. Personalized gamification has

also emerged as an exciting area of study, in which a procedurally generated system can create tailored goals and challenges for players based on their performance. The instructors have been also a great focus of gamification studies, as they could control what is being offered to the students, however, the tools available for them are still limited. For instance, The study by Gordillo et al. (2020) introduced a game-based learning platform that allows educators to create and share educational games with their students. The platform features a library of pre-built games and educational content covering various subjects and grade levels, making it easy for teachers to implement engaging learning activities in their classrooms [5].

Reza et al. presented an automated system that automatically generated customized challenges in accordance with the preference, progress, and performance of the learners to overcome some limitations found in already developed gamified systems citekhoshkangini2021. Setting off these remarkable benefits, on the other hand, gamification is still an evolving area of study that boasts a number of challenges yet to be overcome. Probably one important limitation is that easy-to-use tools for educators who want to create gamified learning experiences without technical training in programming or game design are still in their infancy. Most of these systems are based on expert knowledge, making it hard for instructors who can't afford the resources or expertise necessary to implement gamified strategies themselves. User-centered tools in this respect could realistically let more educators take advantage of gamification, with further potentials to address a wide range from personalized and active learning settings.

Chapter 2

Background

The generation of games started as game developers created games for entertainment purposes. However, the idea of using games for educational purposes has been around for a long time. Educational games are designed to teach players about specific subjects, reinforce concepts, facilitate skill development, or help them understand historical events or cultures through gameplay [3]. Educational games can be used in various educational settings, such as schools, universities, and training programs, to engage students and enhance their learning experience. By combining educational content with game mechanics, educators can create interactive and engaging learning activities that motivate students to learn and retain information effectively. Developing a game is a process that requires many skills and resources, including programming knowledge, game design expertise, and multimedia content creation. This can be a significant barrier for educators who lack the technical skills or resources to create their own educational games. To address this challenge, game-based learning platforms have been developed to provide educators with the tools and resources they need to design and implement educational games in their classrooms. Gamification is a proven means of education that has been show to improve the morale of the user through challenges, rewards, and competition.

2.1 Game-Based Learning

Game-based learning (GBL) is an educational approach that uses games to teach students about specific subjects, concepts, or skills. GBL combines educational content with game mechanics to create interactive and engaging learning experiences that motivate students to learn and retain information effectively. By incorporating elements such as challenges, rewards, competition, and feedback, GBL can enhance student engagement, motivation, and learning outcomes. GBL can be used in various educational settings, such as schools, universities, and training programs, to facilitate skill development, reinforce concepts, and promote active learning. For example, a literature review conducted by Fernando et al. (2024) found that GBL can enhance student motivation through immediate feedback, clear objectives, and a sense of achievement [4]. These studies highlight the potential of

GBL to transform the learning experience and create meaningful and enjoyable learning activities that extend beyond traditional teaching methods.

2.2 Gamification

Gamification is the practice of integrating game-like elements into non-game settings to motivate and engage users. By incorporating features such as points, badges, leaderboards, challenges, and rewards, gamification transforms the user experience into an interactive and rewarding process that encourages participation and achievement. Gamification has been widely used in various domains, such as marketing, health, fitness, and education, to motivate users, drive behavior change, and enhance engagement. In education, gamification has gained popularity as a means of boosting student motivation, fostering engagement, and improving learning outcomes. Research has shown that gamification can enhance student performance, increase motivation, and reduce dropout rates across different educational levels and subjects [10]. For example, a study conducted by Lara-Cabrera et al. (2023) found that gamified techniques, such as awarding 3D-printed badges, can enhance academic performance and reduce dropout rates, especially in STEM programs at the higher education level [10]. Another study published in the Journal of Educational Technology (2022) demonstrated that gamification can increase student engagement and motivation in flipped classrooms by promoting active learning and collaboration [8]. These studies highlight the potential of gamification to transform the learning experience and create personalized and engaging learning activities that motivate students to take an active role in their education.

Chapter 3

Related Work

The fundamental ideas of gamification, its uses in educational contexts, and its prior research in the area of game-based learning are covered in this chapter. It also talks about the possible advantages and difficulties of gamification in the classroom, emphasizing the necessity for easily accessible resources that let teachers design customized gamified lessons.

Gamification can be categorized into three primary types: content-based gamification, structural gamification, and game-based learning (GBL). Content-based gamification involves embedding game-like elements into existing educational content, such as quizzes, assignments, or lectures, to make learning more interactive and engaging. In contrast, structural gamification focuses on redesigning the overall learning environment by incorporating game-like mechanics, such as progress tracking, rewards, or challenges, to enhance student motivation and engagement [4].

Game-based learning (GBL) has been proven as an effecetive means of education and is equally as effecetive as traditional learning methods, as Gordillo et al. (2020) have shown [5]. Another reaserch introduced a 3D game authoring tool for users with little to no programming knowledge using OpenAi's GPT-4, however the toolkit has not been tested by instructors or students [6]. The use of structural gamification was also used to make visualization of data more engaging and interactive, as shown by the work of Karuna et al. (2022), as The study explores using gamification elements to enhance user engagement in data collection, focusing on game design and behavioral data visualization, the study later concluded that using gamification in data collection, especially through visual and interactive methods, can significantly enhance user engagement and data quality. [12]. these studies, however, have not focused on the generation of games and were not tested on instructors.

As outlined by Fernando and Premadasa (2024), these approaches are central to understanding how gamification and GBL can be effectively employed in educating Generation Alpha. Their systematic literature review highlights how these methods influence learning outcomes by promoting active participation and fostering deeper engagement in educational settings [4]. The procedural generation of challenges and content in GBL has

also been explored by Khoshkangini et al. (2021), who developed an automated system that generates personalized challenges based on player preferences, progress, and performance. This system addresses existing limitations in gamified learning environments by providing tailored experiences that cater to individual needs and learning styles [9]. Another personalized gamification system was proposed by Noor et al. (2010), which explores the automatic generation of personalized levels for platform games, which uses procedural content generation to create unique game levels based on player preferences and performance [11]. None of these systems, however, provide educators with the tools to design their own gamified learning experiences, limiting their potential impact on classroom instruction.

In *The Art of Computer Game Design*, Chris Crawford describes a game as an interactive medium where players make choices and experience the consequences of those choices. This definition is intentionally broad, encompassing various forms of games, such as board games, card games, sports, video games, and even educational games. Educational games, in particular, are designed to teach players about specific subjects, reinforce concepts, facilitate skill development, or help them understand historical events or cultures through gameplay [3].

One of the closest works related to the work presented is the study by Gordillo et al. (2020) [5], which introduces a game-based learning platform designed for educators to create and share educational games with their students. The platform features a user-friendly interface that allows educators to design games, integrate multimedia content, and monitor student progress. Additionally, it includes a library of pre-built games covering various subjects and grade levels, making it easy for teachers to implement engaging learning activities in their classrooms. However, while Gordillo et al.'s work primarily focuses on game-based learning with preset game templates and pre-defined educational content, this thesis takes a different approach. It seeks to offer a more flexible and customizable platform, enabling educators to design gamified learning experiences tailored specifically to their unique needs and teaching preferences.

Chapter 4

InstaGame

InstaGame is an innovative platform designed to empower educators by enabling the creation of customizable educational games. Building on existing research, InstaGame addresses key limitations found in similar tools, such as SGAME [5]. While SGAME integrates SCORM-compliant learning objects into preexisting games, it restricts game creation to predefined templates and educational fields, limiting flexibility and broader applicability. Additionally, SGAME's language support is limited to Spanish, narrowing its accessibility for global users. InstaGame overcomes these challenges by offering a more versatile and inclusive solution that accommodates diverse educational needs, linguistic preferences, and content areas.

The work presented enables instructors to tailor games to diverse educational contexts by adapting templates to align with various curricula. Each game template excels in specific fields due to its unique mechanics and design, allowing educators to select the most suitable option for their goals. InstaGame further emphasizes user-friendly tools, and a tutorial with hint to show how to create a game, making it accessible to educators with varying technical expertise, thereby fostering an engaging and inclusive learning environment. InstaGame also alllows the instructor to create games from any device with an internet browser, ensuring that educators can easily integrate the platform into their teaching practices without the need to install additional software or learn complex programming languages and game design. Once the instructor generates a game, they can share it with students through multiple channels, including unique links, QR codes, and game codes, ensuring broad accessibility and seamless distribution.

4.1 Design and Architecture

The architecture of InstaGame is designed to provide seamless accessibility and scalability. Leveraging a web-based framework, the platform ensures that instructors and students can access the tool from any device with an internet browser. Figure 4.1 illustrates the system's architecture, which integrates a robust cloud-based backend to manage and store game data.

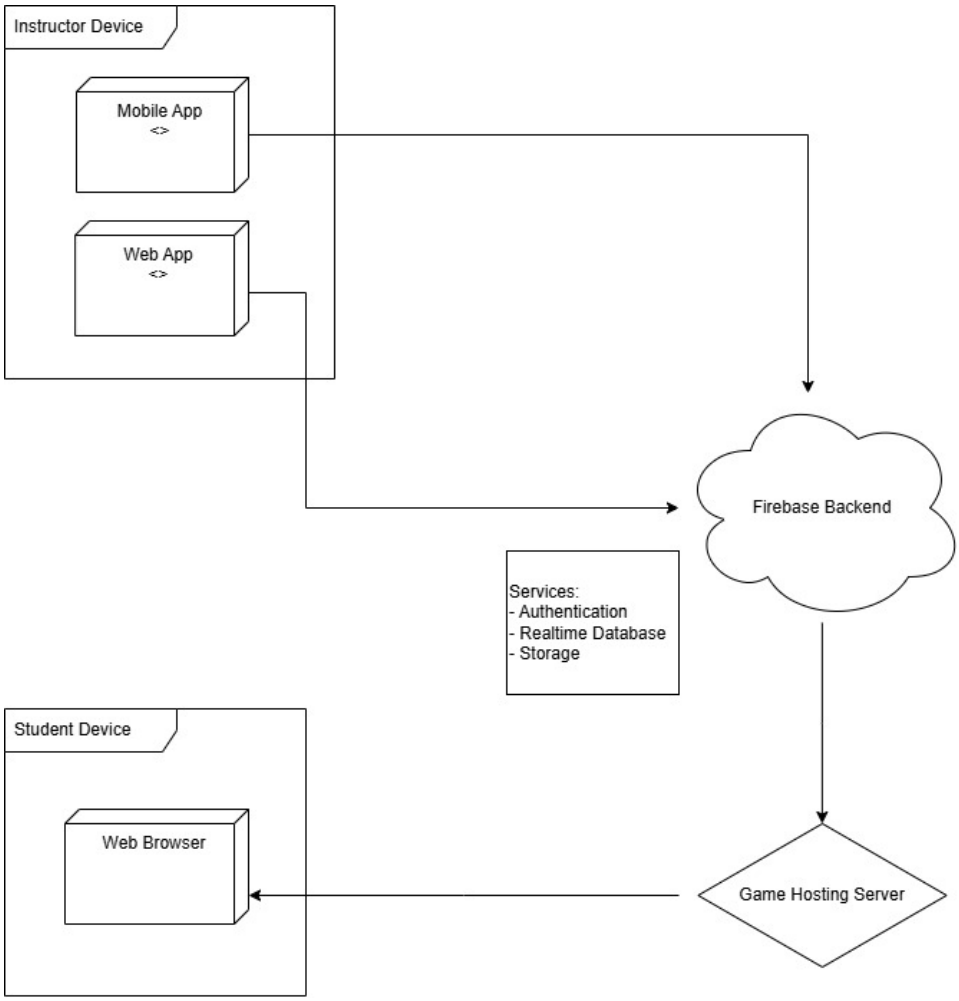

Figure 4.1: System Architecture

The instructor portal is built using Next.js, a React framework known for its server-side rendering capabilities and efficient performance. Firebase, a Backend as a Service (BaaS) platform, is employed for real-time database management, ensuring that game data is stored and can be accessed from anywhere. A cloud storage is also used to store game assets, such as images, and Appwrite, open-source service, was adopted for storage solutions. The architecture prioritizes reliability and accessibility to support educators in generating and sharing educational games. The UI is designed to be intuitive and user-friendly, enabling instructors to navigate the platform with ease and create games that align with their teaching objectives, the use of minimalistic design and color schemes ensures that the instructor can easily navigate the platform and focus on creating a game, the use of a tutorial and hint system also ensures that the instructor can easily create a game, even if they are not familiar with game design or educational games, the tutorial and hint system guides the instructor through the process of creating a game, ensuring that they can create a game that is engaging and educational.

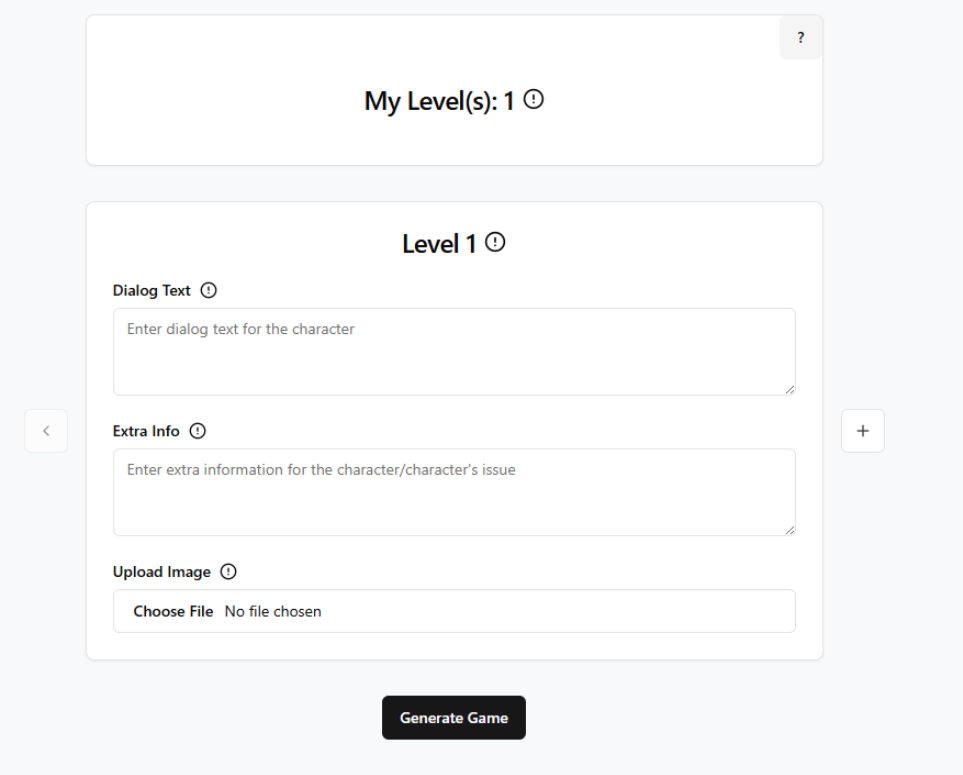

Figure 4.2: Game Customization System for Click-based Puzzle Game

4.2 Game Customization System

InstaGame's customization system is designed to provide instructors with the tools they need to tailor educational content to their specific requirements. The platform supports the creation of games that encompass a wide range of educational fields and contexts, enabling instructors to design experiences that align with their teaching objectives.

For instance, the click-based puzzle game template allows instructors to upload images, define clickable regions, and input corresponding educational content such as dialogues, questions, and explanations, as shown in figure 4.2. The system's user-friendly interface ensures that instructors can easily navigate and input data. Additionally, the platform supports the creation of multiple levels, each with distinct content and objectives, enabling instructors to design comprehensive games that cater to diverse learning needs. This versatility accommodates study fields ranging from anatomy and geography to engineering and history. The instructor can also always refer back to the tutorial and hint to guide them through the process of creating a game, ensuring that they can create a game that is engaging and educational, this is particularly useful for instructors who are new to the platform or are not familiar with what makes a game engaging and educational, and example of the hint system is being used in figure 4.3.

Another game template, the Space Invaders-like game, enables instructors to input questions and choices, which are displayed as enemies. Players must answer questions cor-

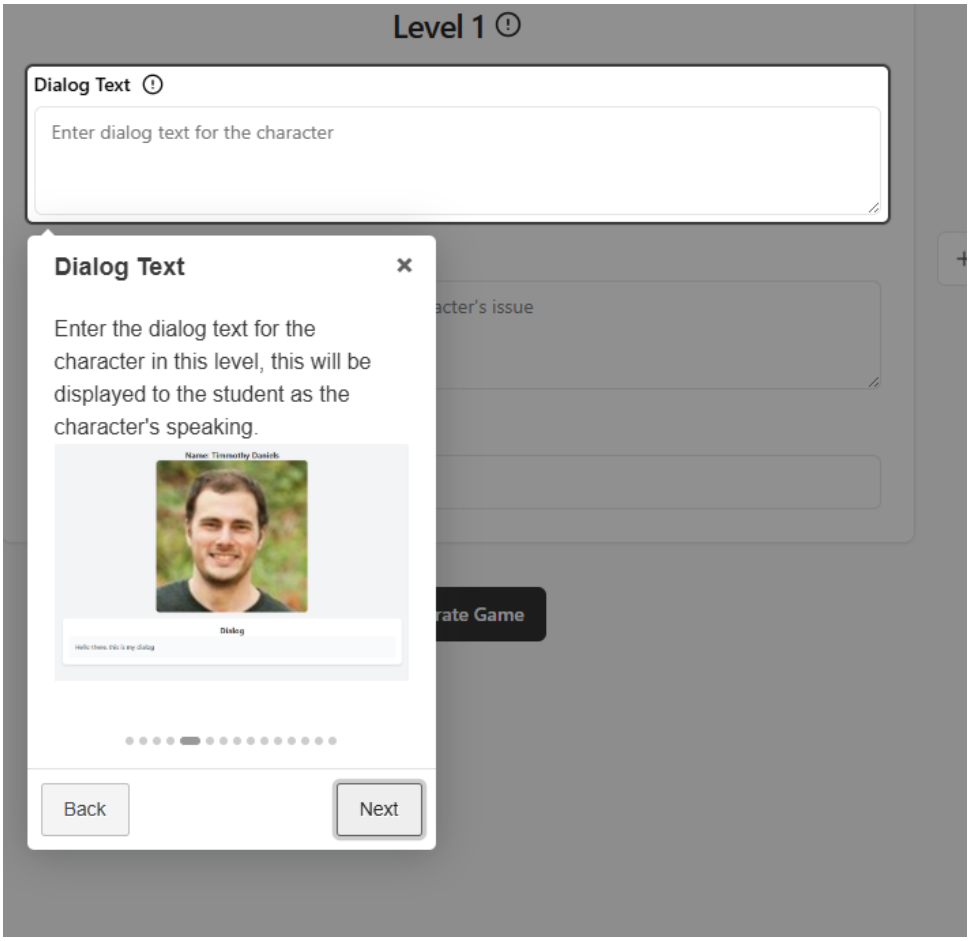

Figure 4.3: Game Customization System for Click-based Puzzle Game with Hint

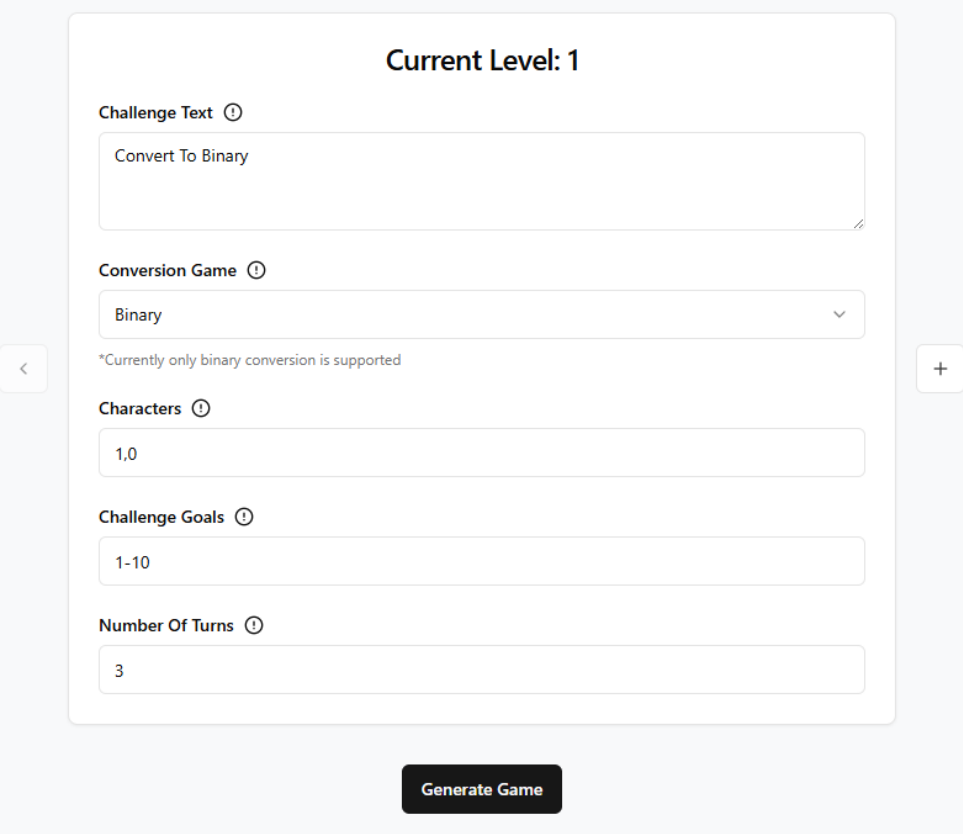

Figure 4.4: Game Customization System for Space Invaders-like Game

rectly by eliminating the enemies holding the correct answers. Instructors can customize various elements, including the title text displayed at the top of the screen, whether the game requires players to convert a goal into an answer (conversion game), the characters displayed on enemies (representing the choices), the possible goals that the system can choose from, and the number of turns within the level. Notably, the number of turns must be odd to determine if the player has won or lost the level, this is calculated by the system based on the majority of correect turns that have been won, for example, if the level has 5 turns, the player must win 3 turns to win the level, or if the level has 7 turns, the player must win 4 turns to win the level.

Both templates adhere to the MDA [7] game design framework, which consists of mechanics, dynamics, and aesthetics. The mechanics are the rules and procedures that guide the player's actions, such as answering questions or clicking on images. The dynamics refer to the interactions between the player and the game, such as the feedback provided after answering a question. The aesthetics are the emotional responses elicited by the game, such as the sense of accomplishment when completing a level.

In addition to the MDA framework, the templates also align with the elemental pentad framework, which is a more comprehensive approach directed toward game-based learning (GBL). The elemental pentad, which is another framework derived from the more famous elemental tetrad [2], consists of five elements: mechanics, story, aesthetics, technology,

and pedagogy [1]. The mechanics refer to the rules and procedures that guide the player's actions, such as answering questions or clicking on images, as mentioned earlier. The story represents the narrative that contextualizes the game, such as the dialogue present in the click-based puzzle game. The aesthetics refer to the emotional responses evoked by the game [7], such as the sense of accomplishment upon completing a level, as previously noted. The technology refers to the platform used to deliver the game, such as a web browser or mobile device. The pedagogy pertains to the educational theories that inform the game design, such as constructivism or behaviorism. The tempaltes also include content-based gamification elements, such as characters in the puzzle game and enemies in the Space Invaders-like game, which are designed to enhance player engagement and motivation, there is also structural gamification elements, such as levels and challenges, which are designed to provide a sense of progression and achievement.

By incorporating these elements, the templates provide a comprehensive learning experience that engages students while supporting educational goals. Notably, these elements are always present but are slightly altered based on the instructor's input. For example, the mechanics are determined by the instructor's questions and choices, the story is influenced by the instructor's dialogue and explanations, the aesthetics are shaped by the instructor's feedback and rewards, the technology is determined by the platform used to access the game, and the pedagogy is informed by the instructor's educational objectives.

4.3 Game Sharing System

InstaGame features a streamlined game sharing system designed to facilitate easy distribution of educational games to students. Once a game is generated, the platform generates a unique link (the view game button in figure 4.5), a QR code, and a game code, as shown in figure 4.5. These sharing options provide instructors with multiple ways to distribute the game, catering to various classroom setups and technological capabilities.

The generated link can be shared directly via email or messaging platforms, while the QR code allows students to access the game instantly using their devices. The game code serves as an additional access method, particularly useful in scenarios where students are using a shared portal or platform to enter their assigned activities. This multi-faceted sharing system ensures flexibility and convenience, enabling broad accessibility for both instructors and students. This ensures that the instructor can share the game with the students in a way that is most convenient for them, saving time and effort in the process, and incase the instructor wants save the game for future use, the game code can be used to access the game at a later time, by saving the game link or qr code, the instructor can easily access the game at a later time, without the need to generate a new game, this is particularly useful for games that are used frequently or for multiple classes.

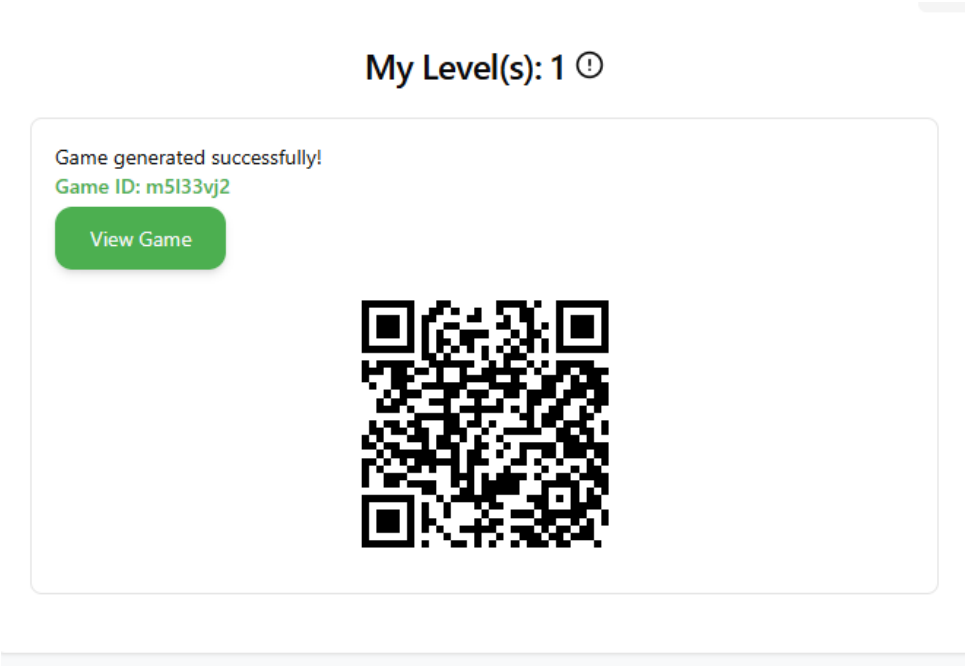

Figure 4.5: Game Sharing System

4.4 Gameplay

InstaGame supports two game templates, a Space Invaders-like game and a click-based puzzle game, each offering unique gameplay mechanics tailored to different learning objectives.

In the Space Invaders-like game, players engage in fast-paced gameplay where they must eliminate enemies before they reach the bottom of the screen or hit the player with a projectile, as shown in figure 4.6. This template is well-suited for reinforcing quick decision-making and recall in subjects like mathematics or vocabulary. The click-based puzzle game, on the other hand, offers a more relaxed experience, requiring players to solve puzzles by identifying correct answers within an image. For example, an anatomy-based game could task players with diagnosing a condition by selecting the appropriate organ, as show in figure 4.7. This template is ideal for fostering critical thinking and visual recognition skills in subjects like biology.

4.5 Goal Checking System

The goal checking system ensures that player actions are evaluated against predefined criteria set by the instructor. This allows for accurate assessment of student performance and ensures that gameplay aligns with educational objectives. By integrating these systems, InstaGame fosters a balance between engaging gameplay and meaningful learning

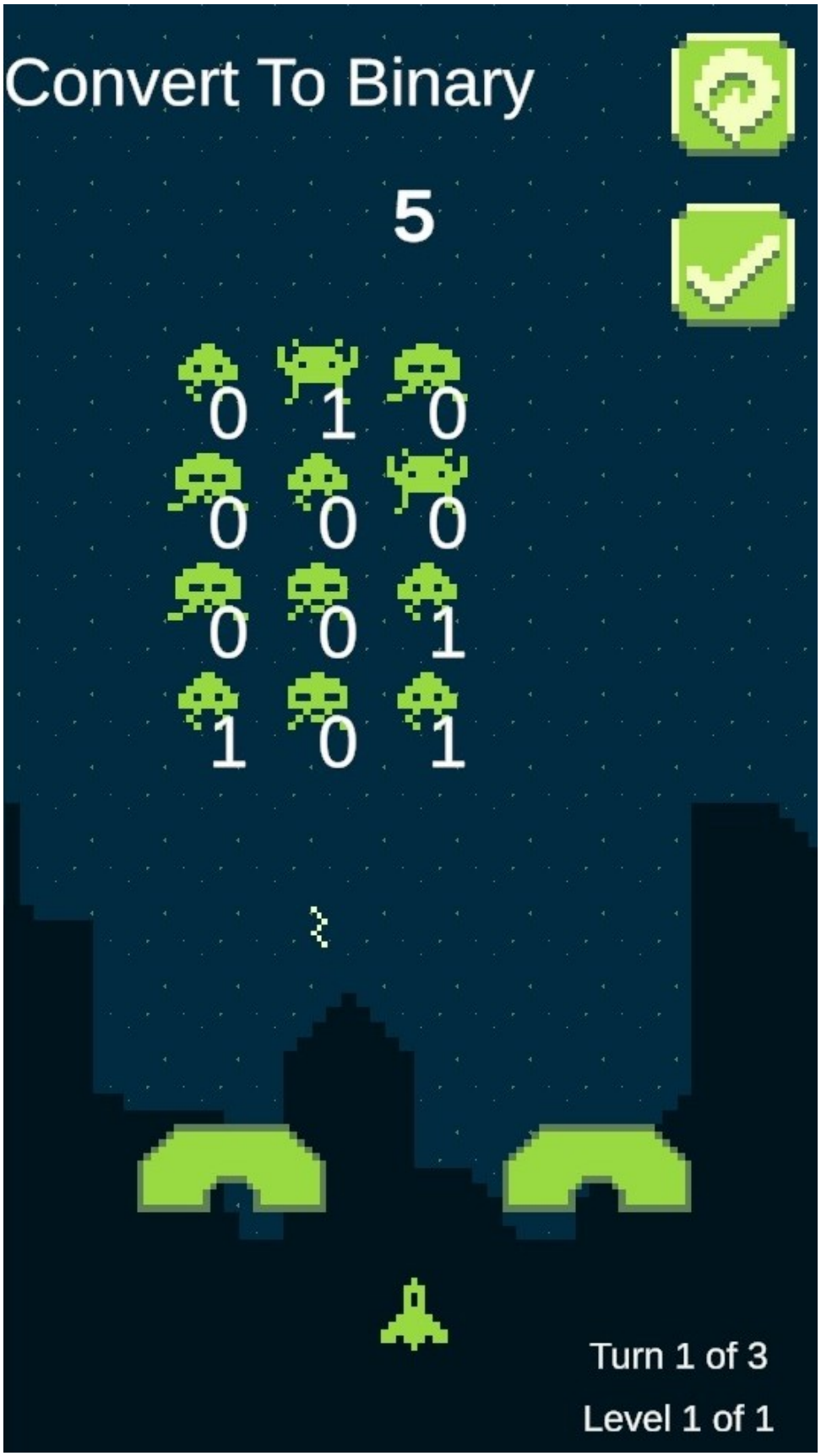

Figure 4.6: Space Invaders-like Game

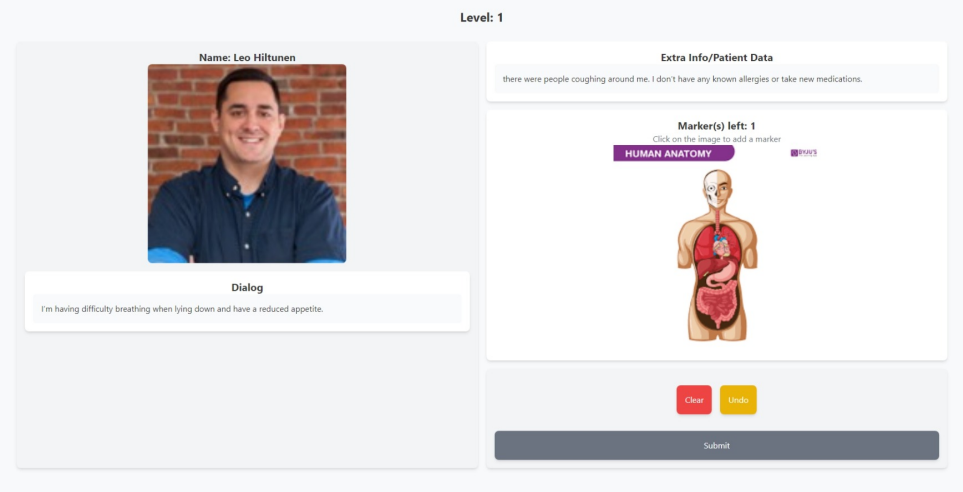

Figure 4.7: Click-based Puzzle Game

outcomes. This ensures that the instructor has full control over what is considered a correct answer, and the student has control over their answer, and as a foundational concept of the platfrom, the students input is compared to the instructors input to determine if the answer is correct or not. In pseudocode, the goal checking system would look like the following:

```
1. Initialize Goal Checking System:
   - Define ‘correctAnswer‘ as the input provided by the instructor.
   - Define ‘studentInput‘ as the answer submitted by the student.

2. Receive Student Input:
   - Prompt the student to submit their input.
   - Store the submitted input in ‘studentInput‘.

3. Compare Student Input with Correct Answer:
   - If ‘studentInput‘ exactly matches ‘correctAnswer‘:
    - Trigger Winning Condition:
     - Set ‘isCorrect‘ to ‘True‘.
     - Execute ‘winningAction‘ (e.g., display success message,
     proceed to next level, etc.).
   - Else:
    - Trigger Losing Condition:
     - Set ‘isCorrect‘ to ‘False‘.
     - Execute ‘losingAction‘ (e.g., display failure message, allow retry, etc.).

4. End Goal Checking System.

Example Code Implementation:
```

```
---------------------------
correctAnswer = instructorInput  # Input provided by the instructor
studentInput = getStudentInput()  # Function to receive student's input

# Compare inputs
if studentInput == correctAnswer:
 isCorrect = True
 print("Correct! You win!")
 winningAction()  # Execute winning action
else:
 isCorrect = False
 print("Incorrect. You lose!")
 losingAction()  # Execute losing action
```

The pseudocode outlines the core functionality and concept of the goal checking system, which is essential for evaluating student responses and providing meaningful feedback, in figure 4.8 the users is met with a modal informing that the answer is correct and all the markers have been found to give the user a sense of accomplishment over the level. By implementing this system, InstaGame ensures that gameplay is aligned with educational objectives and that students receive accurate assessments of their performance. The goal checking system is a fundamental component of the platform, since the instructor needs to always add input to the game to deteermine a correct answer that the student needs to match, this ensures that the game is always aligned with the instructors educational objectives, this also gives the instructor a sense of control over the game.

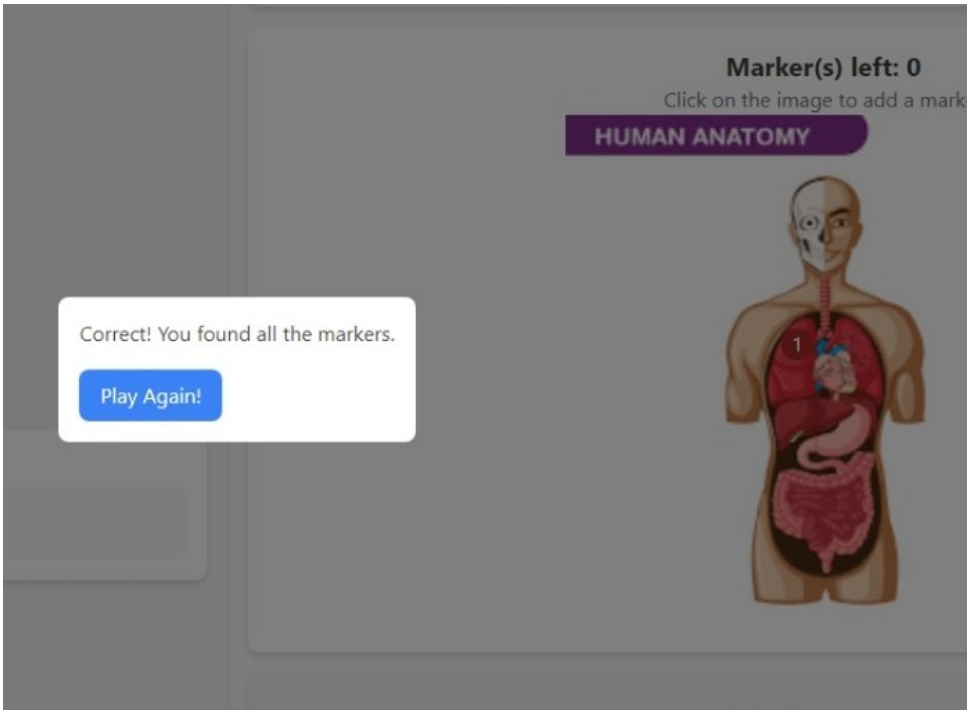

Figure 4.8: Correct Answer in Click-based Puzzle Game

Chapter 5

Experiments & Results

5.1 Experimental Setup

Experiments with educators were carried out to comprehend and assess the suggested tool's usefulness and efficacy. The experimental setting is described in depth in the parts that follow, along with subject recruitment, data collection techniques, assessment measures, and experiment results. The tests were divided into two stages: a usability study and a focus group session. In contrast to the usability study, which involved individual educators interacting with the platform to complete specific tasks and providing feedback via a questionnaire, the focus group session involved a group of educators who volunteered to provide feedback on the platform's features, interface, and overall usability after testing the platform.

5.2 Focus Group Session

Five teaching assistants from the German International University (GIU) with bachelor's degrees or above participated in the focus group. Volunteers from various academic departments and specialties participated, including two instructors from the Computer Science department, one from the Business department, and two from the Business Informatics department. Following a presentation and explanation of the InstaGame, attendees were asked to test out the platform and offer input on its features, usability, and possible applications in their classes. Thirty minutes were spent in the focus group. Prior to the usability assessment, the platform's functionality and design were improved based on input gathered from the focus group. Suggestions for enhancing the user interface for easier navigation and a better user experience overall were included in the feedback. The platform's potential uses in their courses and ways to improve student motivation and engagement were also discussed by the participants. One teacher assistant from the business department proposed using the tool to create a case study game in a talent acquisition setting so that students could put what they had learned in lectures into practice.

5.3 Usability Study

Chapter 6

Conclusion

6.1 Limitations

6.2 Future work

Appendix

List of Figures

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