German International University

Computer Science Faculty

Generation of Gamified Web and Mobile Learning Modules

Bachelor Thesis

Author:	Eyad Tamer Hassan
Supervisors:	Dr. Nada Sharaf
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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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Eyad Tamer Hassan
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Chapter 1

Introduction

Gamification, the practice of integrating game-like elements into non-game settings, has become increasingly influential in education over the past decade. Its potential to boost student motivation, foster engagement, and improve academic performance has made it a go-to strategy for educators worldwide. By incorporating features such as points, badges, leaderboards, and challenges, gamification transforms the learning experience into an interactive and rewarding process, inspiring students to take an active role in their education.

Research consistently highlights the benefits of gamification in educational contexts. For instance, Lara-Cabrera et al. (2023) found that gamified techniques, such as awarding 3D-printed badges, not only enhanced academic performance but also reduced dropout rates, especially in STEM programs at the higher education level [9]. Similarly, Jack et al. (2024) examined gamification within flipped classrooms, demonstrating its ability to significantly increase student engagement and motivation by promoting active learning [7]. Other studies, such as one published in Sustainability (2022), revealed that gamified learning environments can alleviate stress and anxiety, allowing students to concentrate better and perform more effectively [10]. Game-Based Learning (GBL) has also proven effective in improving student outcomes. For example, Fernández-Alemán et al. (2024) showed that GBL enhances motivation through immediate feedback, clear objectives, and a sense of achievement [4]. These studies collectively underscore gamification's transformative potential in education, highlighting its ability to create meaningful and enjoyable learning experiences that extend beyond conventional teaching methods. Moreover, advancements in personalized gamification have been explored. Reza et al. (2021) proposed an automated system for generating customized challenges based on players' preferences, game progress, and performance, addressing existing limitations in gamified systems [8].

Despite its advantages, gamification is still a developing field with notable challenges. While its effectiveness has been widely documented, one critical limitation is the lack of accessible tools that enable educators to design gamified learning experiences without requiring technical expertise in programming or game design. Many current systems necessitate specialized knowledge, creating barriers for instructors who may lack the

resources or skills to implement gamified strategies independently. Bridging this gap by developing user-friendly tools could empower a broader range of educators to leverage gamification, ultimately fostering more personalized and engaging learning environments.

Chapter 2

Background

This chapter outlines the core concepts of gamification, its applications in educational settings, and its past work in the field of game-based learning. It also discusses the potential benefits and challenges associated with gamification in education, highlighting the need for accessible tools that enable educators to create personalized gamified learning experiences.

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].

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 [8]. 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 this thesis 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 3

Related Work

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.

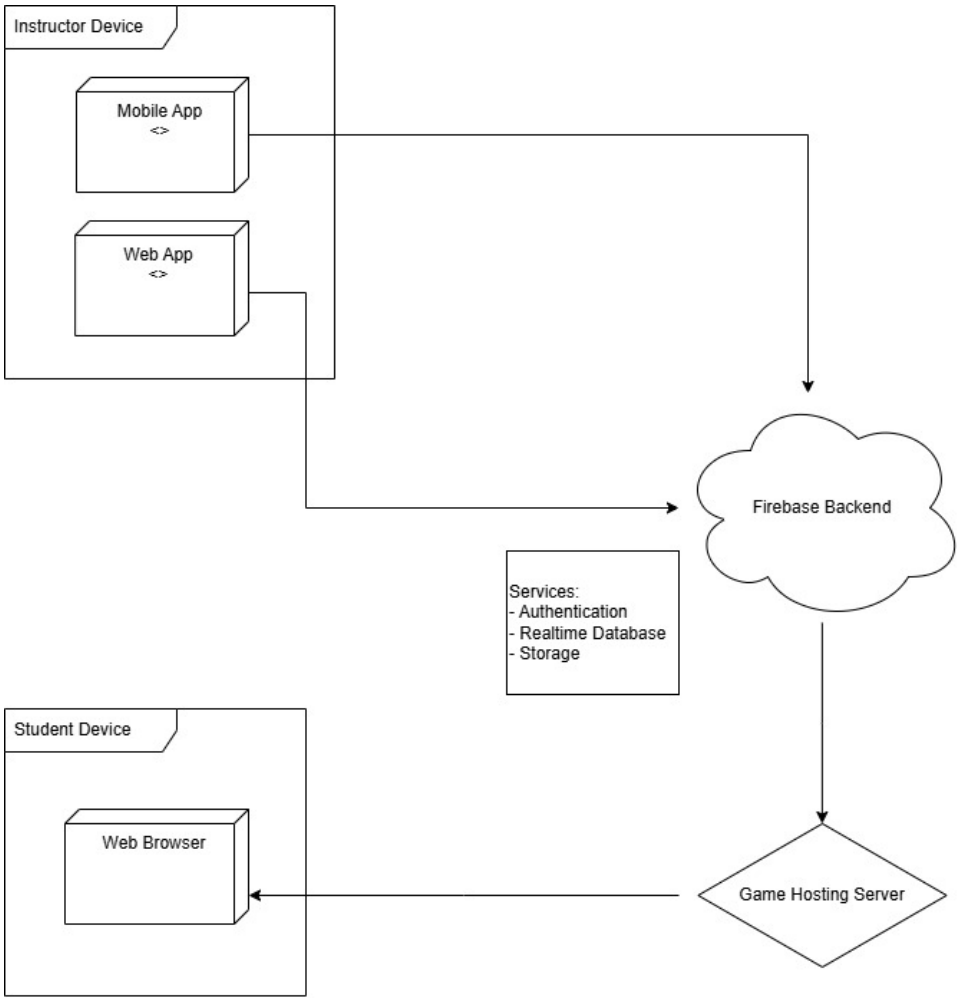

Figure 4.1: System Architecture

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.

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.

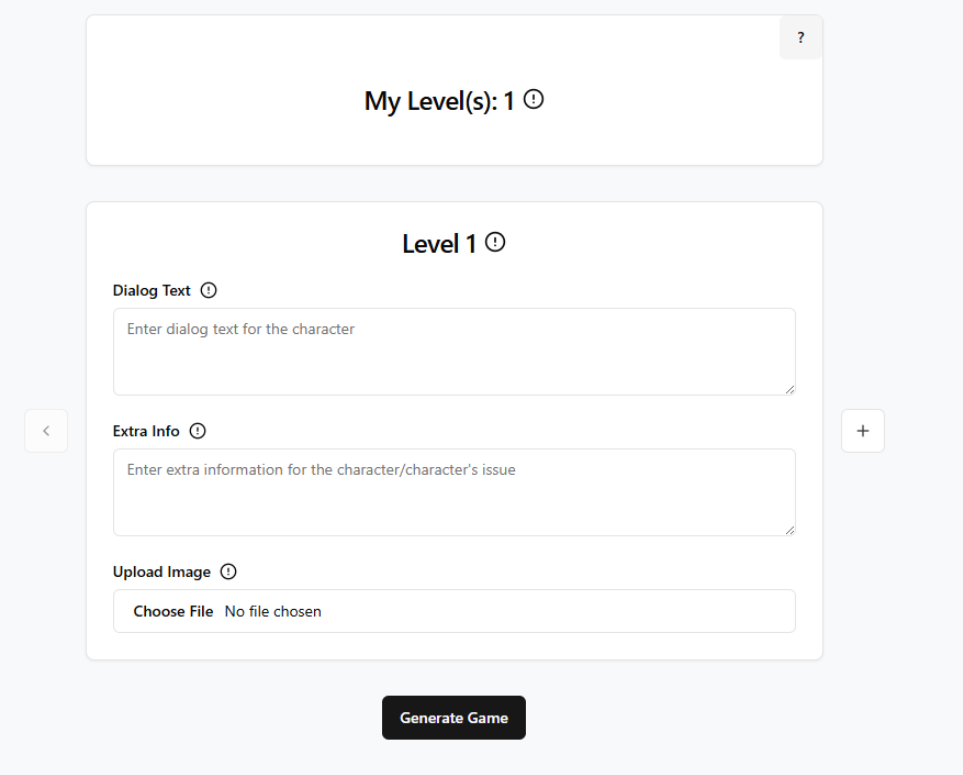

Figure 4.2: Game Customization System for Click-based Puzzle Game

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 .

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

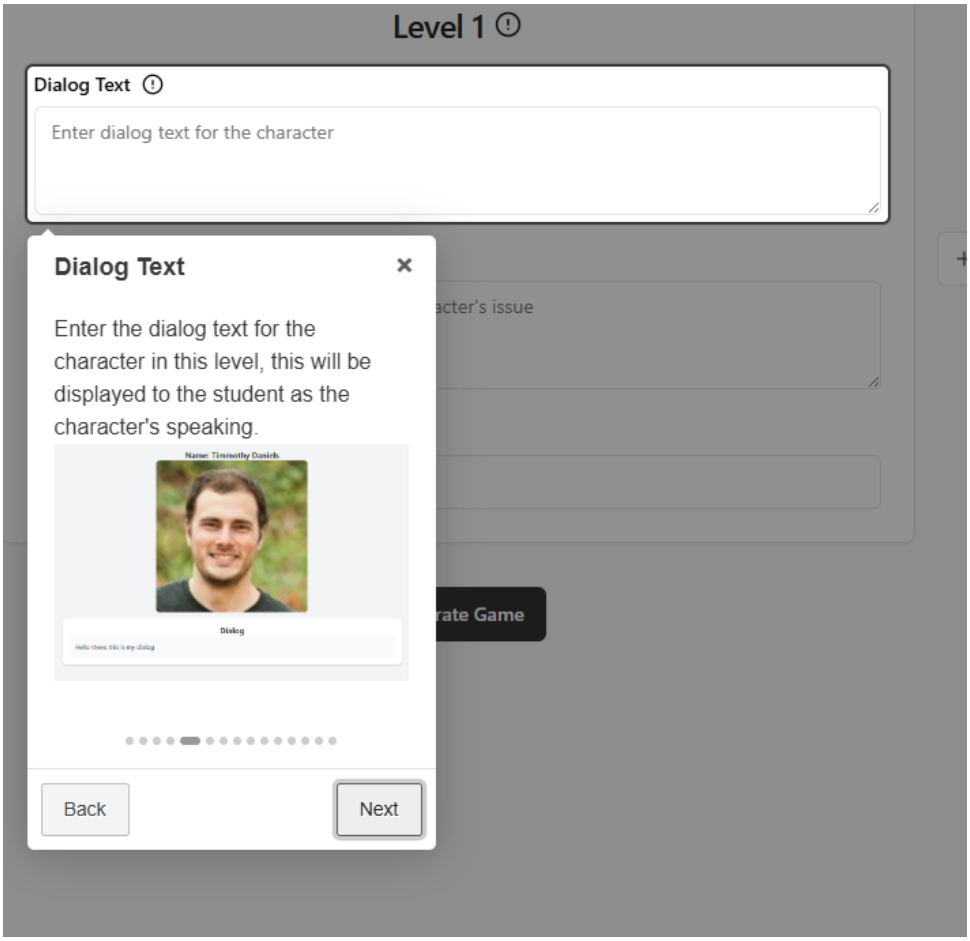

Figure 4.3: Game Customization System for Space Invaders-like Game

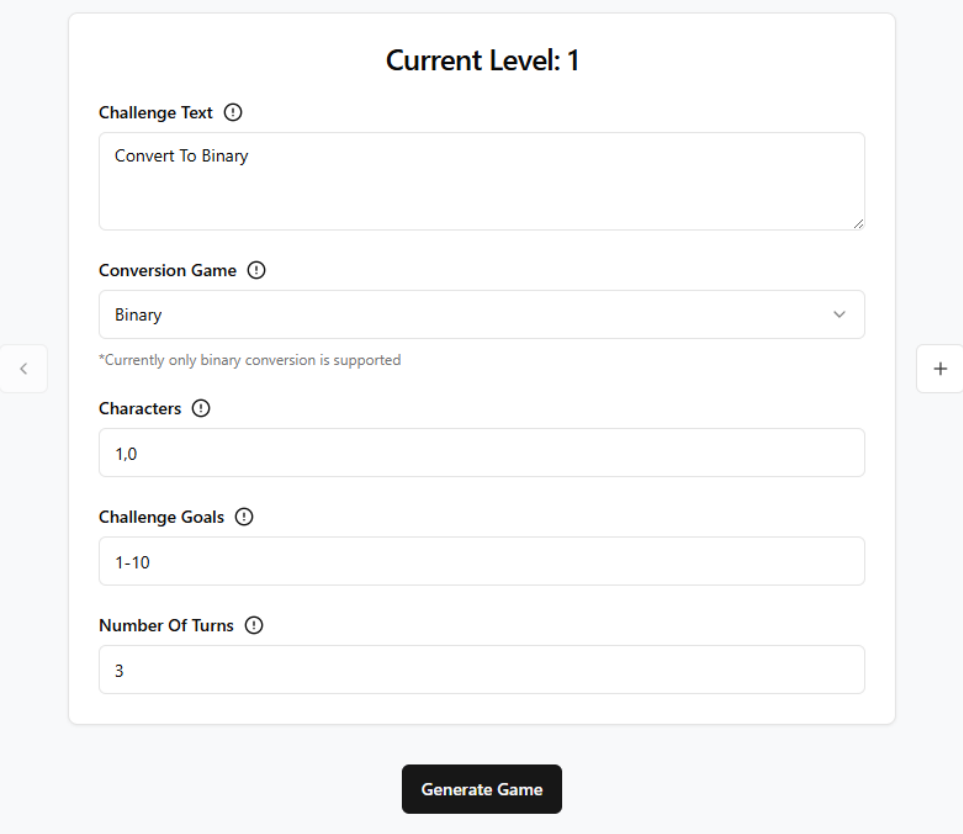

Figure 4.4: Game Customization System for Space Invaders-like Game

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 [6] 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 [6], 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

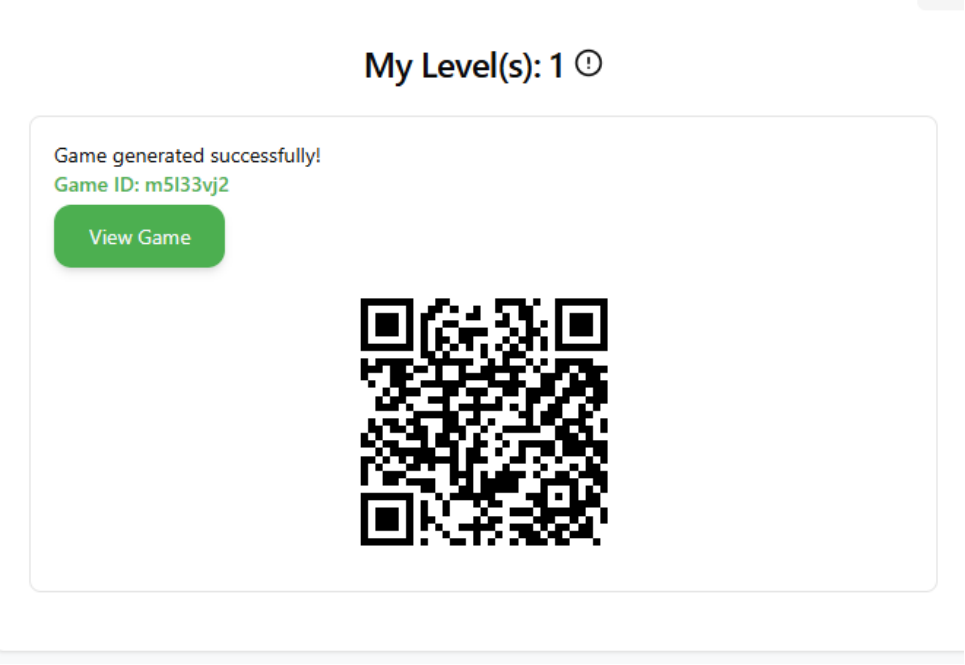

Figure 4.5: Game Sharing System

browser or mobile device. The pedagogy pertains to the educational theories that inform the game design, such as constructivism or behaviorism.

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 (view game button in 4.5), a QR code, and a game code, as shown in 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.

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 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 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 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.
```

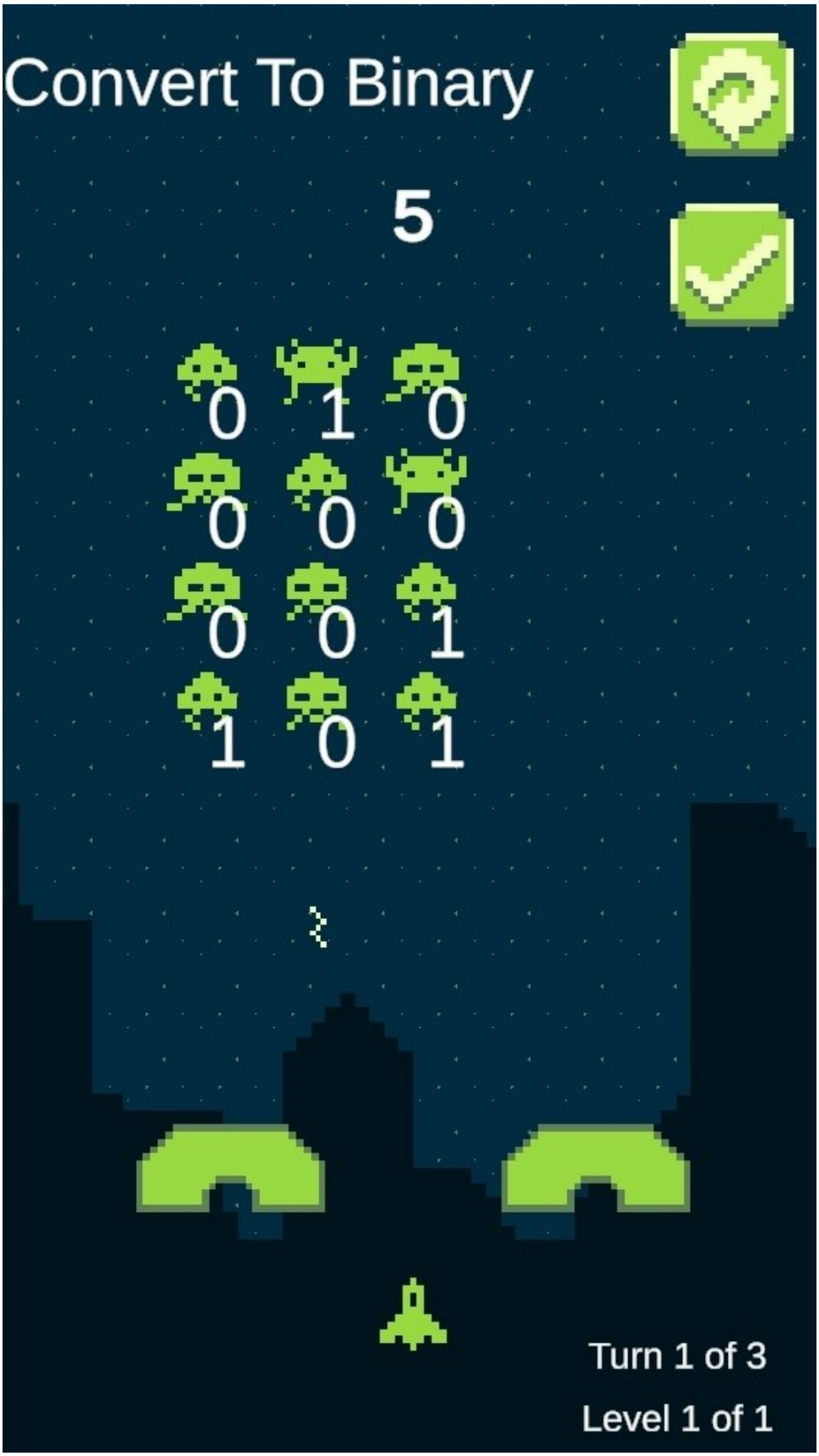

Figure 4.6: Space Invaders-like Game

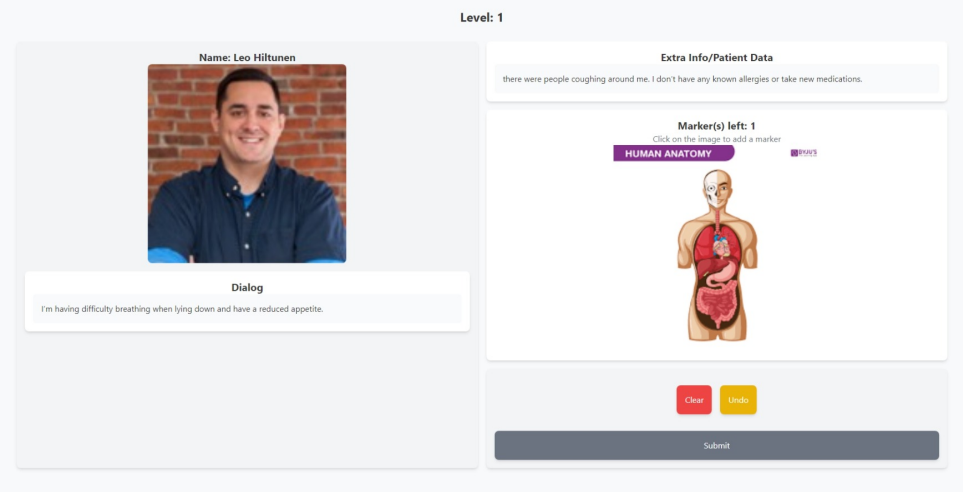

Figure 4.7: Click-based Puzzle Game

```
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. By implementing this system, InstaGame ensures that gameplay is aligned with educational objectives and that students receive accurate assessments of their performance.

Chapter 5

Experiments & Results

5.1 Experimental Setup

To evaluate the effectiveness of the proposed system, a series of experiments with educators was conducted. The experiments aimed to assess the usability, functionality, and impact of the platform on learning outcomes. The following sections detail the experimental setup, including participant recruitment, data collection methods, and evaluation metrics.

the experiments were conducted in two phases: a focus group session and a usability study. The focus group session involved a group of educators who provided feedback on the platform's features, interface, and overall usability, the usability study, on the other hand, involved individual educators who interacted with the platform to complete specific tasks and provide feedback on their experience.

The focus group session was conducted with a group of 5 educators from the German International University (GIU). The participants were volunteers from various faculties, 2 instructors from the Computer Science department, 1 from the Business department, and 2 from the Business Informatics department. The InstaGame was presented and explained to the participants, then they were asked to try out the platform and provide feedback on its features, usability, and potential use cases in their courses. The focus group session lasted for 30 minutes. The feedback collected from the focus group session was used to refine the platform's design and functionality before the usability study. The feedback included suggestions for improving the user interface for better navigation and an overall better user experience. The participants also provided insights into the platform's potential applications in their courses and how it could enhance student engagement and motivation.

Chapter 6

Conclusion

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