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Graduation Project Proposal

Rakkiz

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1 Introduction

Brain-Computer Interface (BCI) technology has, in recent years, rendered groundbreaking advancements in the domain of human-computer interaction. By facilitating direct communication between the brain and external digital systems through brainwave signals [1], BCI opens up new opportunities in the realms of healthcare, education, and cognitive training. One notable application is the use of BCI in serious games to enhance focus and attention. These games monitor and evaluate brain activity using non-invasive BCI devices and offer real-time feedback to help users improve and enhance their cognitive skills.

This project investigates methods to support attentional control for individuals with attention-related deficits, as well as for the general population seeking cognitive focus enhancement [2]. Conventional treatments, such as medication and creating a distraction-free environment, often fall short in terms of long-term effectiveness and user engagement [1]. Additionally, the growing global dependence on digital technologies has created a need for innovative tools that foster mental focus and cognitive health in both children and adults.

Creating a technological solution in this field is incredibly pertinent both locally and globally. Locally, many educational institutions and healthcare providers are in search of interactive and accessible solutions to assist students with learning challenges. On a global level, the increase of consumer-grade BCI devices has made applications more accessible [3], paving the way for inclusive digital tools that enhance mental well-being and productivity for all age groups.

In this document, we propose the design and development of a serious BCI-based game focused on improving users' attention and concentration. We define the background, the project's goals, the proposed solution and methodology, and the anticipated outcomes. The solution will combine real-time signal processing with an engaging and customizable gaming environment to achieve measurable enhancements in sustained attention.

1.1 The Problem

In our increasingly digital and fast paced world, many individuals face difficulties in maintaining focus and mental concentration during tasks that require sustained attention. This challenge becomes harder by the constant presence of digital distractions such as social media, notifications, and multitasking habits. An example of this issue is seen in individuals attempting to complete work or creative tasks but repeatedly losing focus within minutes, leading to reduced productivity and mental fatigue. Despite using timers, focus apps, or external blockers, these methods often fail to address the internal cognitive state of the user [4]. This project focuses on solving the core of the problem, which is improving the user’s ability to maintain attention through direct interaction with their brain activity in real time.

1.2 The Solution

To address this, we propose the development of an interactive brain training game powered by BCI technology. The system will use non-invasive EEG sensors to monitor the user's brain activity and analyze patterns related to attention. This data will be incorporated into the game environment in a way that encourages focus and engagement. This solution promotes enhanced self-awareness and focuses through attention enhancing activities, delivering a motivating experience that blends cognitive development with entertainment. By integrating brain activity monitoring into a game format, this approach offers an innovative and accessible method to support better concentration in everyday life.

1.3 Product

1.3.1 Product Vision

In this section, we will define the product vision of **“**Rakkiz**’’**, which outlines what we aim to achieve with the application.

Product Vision: **For** individuals looking for an engaging and effective way to enhance their focus and maintain their attention **Who** needs an interactive solution that goes beyond conventional methods **The** Rakkiz **is a** BCI-powered game application **That** helps users train and strengthen their cognitive focus in real time **Unlike** traditional lifestyle changes applications or generic brain-training applications. **Our product** delivers a personalized experience that adapts to each user’s brain activity and improves attention and performance.

1.3.2 Product Roadmap

In this section, we will present the roadmap for the 'Rakkiz' application, which outlines the development and delivery stages of the product over time in Figure 1.

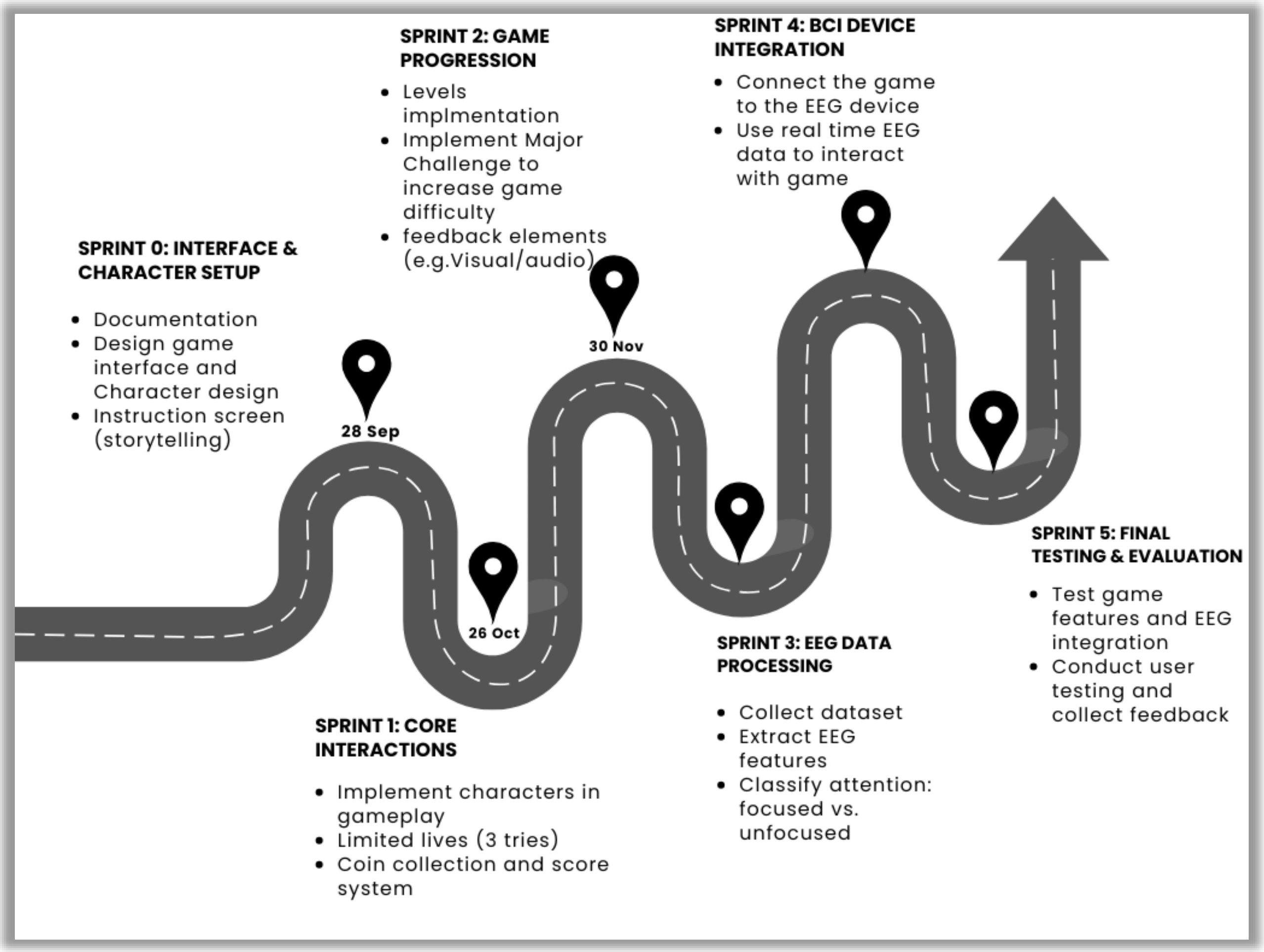

Figure 1: Project Roadmap

1.3.3 Objectives

In this section, we outline the product, project, and learning objectives for the development of “Rakkiz”, a game powered by BCI technology. These objectives define the primary goals and anticipated outcomes to be accomplished by the end of the project.

Product Objectives (customer focus-value): These objectives focus on the value and features the product delivers to end users. “Rakkiz” aims to:

- Address the challenge of maintaining focus and attention in today’s distraction-filled environments.
- Provide an interactive solution that improves users’ ability to sustain concentration.
- Benefit users by offering real-time monitoring of brain activity with continuous feedback.
- Deliver an engaging game experience that combines training with entertainment.
- Include key features such as EEG-based signal detection, scoring, levels, and challenges to support motivation and progress.

Project Objectives (solution focus-plan): These objectives describe the major phases and technical activities required to build and deliver ‘Rakkiz’:

- Design and implement the game interface, characters, and interaction mechanics.
- Collect and review the offline dataset.
- Preprocess and extract features from EEG data to distinguish between focused and unfocused states.
- Integrate EEG signal processing into the game for adaptive feedback and interaction.
- Connect and evaluate with a real EEG device to replace offline data with online signals.
- Conduct system testing, including usability evaluation and user feedback collection.

Learning Objectives (student focus): These objectives focus on what the team will learn from this project, including new tools, concepts, and techniques:

- Learn how to interface with EEG devices and interpret brainwave signals.
- Understand principles of EEG signals and how they can be applied in real-time systems.
- Apply knowledge of signal processing and data analysis to a practical project.
- Gain experience in game development using frameworks and libraries suitable for interactive applications with a focus on Unity integrated with BCI technology.
- Strengthen skills in Agile development, team collaboration, and iterative prototyping using Scrum methodology.

1.3.4 Scope

In this section, we outline the limitations of our application and identify what falls beyond the scope of this project, which may be considered for future development.

With captivating gameplay, "Rakkiz" aims to develop a game powered by BCI technology that enhances users' focus and attention. The game connects to an Emotiv Epoc EEG headset (approx. $999, available through university resources) [5] to monitor brain activity and reflect the user's attention levels through interactive gameplay. Core features include real-time EEG signal fetching, basic signal processing, and a single-player experience developed as a desktop application in English using Unity. The game will be built using the Unity IDE and the Emotiv software suite.

However, the "Rakkiz" system will not include advanced gameplay elements such as multiplayer modes, complex storytelling, or detailed graphics. It also does not provide medical diagnosis or serve as a certified therapeutic tool. These aspects, along with features like long-term evaluation or integration with additional sensors, are considered beyond the scope and may be explored in future iterations.

1.3.5 Hardware/Software Tools and Cost

Table 1: Hardware and Software Tools and Cost

Hardware Tools	
Name and Description	**Cost**
Emotiv EpocX: EEG headset used to collect brainwave signals for BCI integration	$999 Available by university resources
Laptop: Development machine, supports Unity & Python	Personal devices available
Software Tools	
Name and Description	**Cost**
C#: Programming language for Unity scripting	Free (open source)
Unity IDE: Game engine & development environment	Free (Personal plan)
Python: Used for signal processing, preprocessing, and data handling	Free (open source)
Jira: Agile project management, backlog & sprint tracking	Free (open source)
GitHub: Version control and code repository	Free (open source)
Canva: Used for design assets, UI/UX sketches, posters	Free (basic plan)
Emotiv Launcher: Main software hub to access Emotiv applications and SDK	Free with the device
Emotiv BCI: Real-time EEG visualization and performance metrics	Free with the Launcher
Emotiv SDK: Development kit for integrating EEG data with Unity/Python	Free with the Launcher
EmotivPRO: Professional tool for recording, analyzing, and exporting EEG data	$149 per month or $89 per month (annual plan)
Figma: Collaborative tool for UI/UX design and prototyping	Free (Starter Plan)

1.4 Scrum Team

1.4.1 Skill Set Requirements

To successfully design the " Rakkiz " BCI-powered game, the Scrum Team needs the following skills:

Table 2: Technical Skills and Team Levels

Technical Skill Required	What is the current level of the team (*beginner-intermediate- advanced*) for each skill? How will the gap be bridged? *(if necessary*) Learning plan
C# and Unity Development,	**Beginner** – The team is new to Unity and C# and will practice by building simple game elements to gain hands-on experience.
Python	**Intermediate** – Team has prior experience; will further develop skills related to EEG integration.
EEG Device Integration (Emotiv Epoc)	**Beginner** – Will rely on Emotiv official documentation, YouTube tutorials, and sample projects to learn real-time signal streaming.
Signal Processing	**Beginner**– Team will explore fundamental signal preprocessing methods to improve EEG data quality for use in the game.
Game Design & UX	**Intermediate** – Members have background in UI/UX; game specific design elements will be refined through focused development efforts
Agile/Scrum Practices	**Intermediate** – Team has prior experience with Scrum methodologies and will apply this knowledge using tools like Jira to organize workflow and track project progress.

1.4.2 Roles and Responsibilities

Table 3: Scrum Team Roles and Responsibilities

Scrum Team	
Product Owner:	Dr. Mashael Aldayel
Developers:	Layan Alamri Lana Albogami Arwa Almutairi Hatoun Almogherah
Scrum Master (SM):	Dr. Mashael Aldayel
Stakeholders:	Examiners' Committee End Users

2 Background

BCIs offer a method for the brain to communicate with digital systems without the need for physical controls. BCIs detect brain activity and translate its activity into signals that can be used to control applications. BCIs are typically categorized as invasive, partially invasive, and non-invasive. Invasive procedures require surgical implants, which can be used in medical research. Non-invasive methods, such as EEG, are the most common because they are safe, practical, and suitable for everyday applications. EEG measures brain activity through electrodes placed on the scalp and can detect patterns linked to different states.

EEG signals are commonly grouped into several frequency bands, each linked to different mental and physiological states. Delta waves (0.5–4 Hz) are strongest during deep sleep or unconscious states, such as anesthesia. Theta waves (4–7 Hz) often appear when a person is drowsy or drifting between consciousness and sleep, and they are connected to reduced awareness and subconscious processing. Alpha waves (8–12 Hz) occur when a person is calm and relaxed, and they help bridge memory with visual processing, reflecting a balance between conscious and subconscious activity. Beta waves (12–30 Hz) are associated with active focus, problem solving, and rational thinking, making them especially important for applications that monitor or train attention. Some researchers also include gamma waves (30–100 Hz), which are tied to higher level processes like motor coordination, recognition, and complex thinking[6].

Attentional control emerges from an integrated network of brain regions. The frontal lobe, particularly the frontal eye field, helps direct voluntary attention and guides eye movements toward what matters most in a given moment. The parietal lobe, including areas such as the superior parietal lobule and intraparietal sulcus, plays a role in shifting attention and keeping it steady across different tasks or spaces. These areas act as the main sources of attentional control signals. On the other hand, regions like the ventral temporal cortex and visual processing areas serve as the targets of these signals, handling incoming sensory information and filtering out distractions. By coordinating between these control centers in the front and parietal parts of the brain and the sensory regions in the back, the brain manages to maintain focus, redirect attention when needed, and regulate concentration effectively.

Many studies have explored different approaches to classifying attention levels using EEG data. For example, Chang et al. used the Emotiv headset's built-in focus measure to distinguish between different levels of attention for children [7]. Li et al. developed the MindGomoku game, applying a Bayesian deep learning model to EEG signals to improve the detection of user intentions during gameplay [8]. These studies demonstrate the practical potential of EEG-based classification techniques for attention monitoring in real-time or interactive settings.

The exponential rise in digital device usage has precipitated a corresponding decline in the capacity for sustained attention, creating unnecessary barriers to performance in critical domains. Addressing this issue requires innovative approaches that move beyond conventional methods. The integration of real-time neurofeedback with interactive gaming platforms represents a promising solution. Such a cooperation provides a dynamic tool to support focus, translating abstract concentration training into a tangible and engaging activity. This direction not only bridges neuroscience and application but also opens new avenues for enhancing cognitive performance and user engagement in fields ranging from education to healthcare.

This bridge between neuroscience and interactive application creates a powerful tool to enhance learning and performance. It offers a practical method for converting concentration training into a compelling, playable activity.

3 Literature Review

3.1 Games in Research

In this section, we review studies that have applied BCIs in games to see how these systems worked for training attention and improving thinking skills.

For example, MindNinja by Joselli et al. [9] was a simple mobile game where players cut objects on the screen, similar to Fruit Ninja, but it also connected to the NeuroSky MindWave headset. The game reacted to the player's focus: if attention went down, the screen turned foggy. This idea made the game more immersive and fun. But it was still just a prototype. There was no real story, no levels, and nothing that kept players coming back. It proved that EEG signals can be used in games, but it did not feel like a complete product.

Muñoz et al. [1] worked on Harvest Challenge, a game for children with Attention-deficit/hyperactivity disorder (ADHD). It used the theta/beta ratio from EEG signals to measure attention and gave feedback during small mini games. Children practiced waiting, planning, and following instructions. The results were good, and the children improved in their ability to focus. But the game was made in a Colombian context and did not easily transfer to other places. It also lacked variety, so children might lose interest after a short time. This shows that games need to be both fun and flexible for different users.

Liu et al. [10] proposed a neurofeedback training system that included several protocols and a shooting game to enhance attention and working memory. In their study, three subjects completed six training sessions, where EEG-based feedback was used to modulate either individual alpha peak frequency or the beta/theta ratio. Results showed consistent increases in alpha peak frequency after training, indicating improved cognitive abilities such as multitasking and attention. However, the prototype still resembled a research tool rather than a fully developed game, lacking the engaging features needed for long-term use.

Another study by Lee et al. [11] explored playful treatments for children with ADHD. The games they tested helped children engage more compared to normal therapy, which is often strict and not enjoyable. But the games themselves were very simple and lacked adaptive challenges. This means that after some time, children might get bored. The study is useful because it shows the value of game-based therapy but also that games need depth and personalization.

Li et al. [6] took a different path and studied how EEG signals could be used to classify game genres. Their system looked at brain activity while players tried different types of games, and they managed to reach over 96% accuracy. This was impressive because it showed that EEG can also be applied in mainstream gaming, not just therapy. Still, the study focused on proving the technical part and did not create a system that players could use.

3.2 Competitive Product Analysis

Before advancing the development of Rakkiz, it is essential to examine existing market solutions and evaluate their strengths and limitations. Table 4 presents a comparative overview of major competitors alongside our proposed project. The following paragraphs describe each product to provide context for the comparison:

Neuro Tower Defense [12] demonstrates a direct connection between EEG input and gameplay by linking players' focus levels to the strength and pace of towers in a tower-defense format. Its strengths lie in its simplicity, making it accessible to beginners and useful for educational or demonstration purposes. However, its weaknesses are also evident: the graphics and gameplay are very basic, replay value is limited, and it lacks adaptive mechanics or cultural features that would make it more engaging in the long term.

Vīrya EEG [13] is designed for adults and wellness-focused users, offering neurofeedback-based meditation training with guided sessions and performance tracking. It provides real-time EEG feedback, helps manage stress, and comes with a modern, appealing design. Despite these strengths, it is not truly a game since it lacks scoring systems, levels, or a storyline. It also requires a compatible EEG device, which can be costly, and its focus is more on meditation than on interactive gameplay.

EEG Attention App [14] targets general users and provides real-time attention monitoring with both visual and audio feedback. Its primary strengths are its simplicity, ease of use, low barrier to entry, and ability to give users instant awareness of their focus levels. Nonetheless, it has clear weaknesses: minimal interactivity beyond simple feedback, the absence of a storyline or challenges, and its overall feel is more like a utility tool than a true game.

BrainBit EEG Waves [15] is oriented toward researchers and clinicians, providing real-time visualization of Alpha, Beta, and Theta brainwaves, along with session recording and analytical dashboards. The strengths of this product are its professional-grade accuracy and value in structured neurofeedback training. However, it is not designed as a game and thus offers no entertainment value. It requires the use of a BrainBit headset and comes with a steep learning curve, making it unsuitable for casual users.

Mindball Game [16] is a unique tabletop game in which players use EEG headbands to move a ball across a track through concentration and relaxation, making it engaging for families, science centers, and public demonstrations. Its strengths include its novelty, multiplayer competitive format, and availability as a commercial product. Still, it has notable weaknesses: it requires a large physical setup, focuses more on relaxation than progression, and offers limited depth compared to digital games.

Rakkiz is designed for students and individuals with attention needs, using the Emotiv EpocX as its EEG device. Its strengths include combining cognitive training with fun gameplay, adaptive difficulty for sustained engagement, and culturally relevant design appealing to local users. However, current limitations are that it is restricted to single-player mode, it is not a certified medical tool, and it requires relatively costly EEG hardware.

Table 4: Competitive Product Analysis of BCI Based Games

Product	**Domain**	**Target Users**	**BCI Device**	**Core Features**
Neuro Tower Defense [12]	Attention	Casual gamers, students	NeuroSky	Tower defense mechanics where focus levels power towers. EEG input affects game pace and tower strength
Vīrya EEG [13]	Meditation	Adults, wellness/ meditation users	Compatible EEG (e.g., Muse)	Neurofeedback-based meditation training. Guided sessions, mental/emotional performance tracking
EEG Attention App [14]	Attention	General users	NeuroSky	- Real-time attention meter. - Visual/audio feedback. - Simple focus tracking tool.
BrainBit EEG Waves [15]	Neurofeedback	Researchers, Clinicians.	BrainBit	Real-time visualization of Alpha, Beta, Theta brainwaves. Session recording and analysis. Graphical dashboards.
Mindball Game [16]	Attention and Relaxation	Families, science centers, casual players	EEG headbands	-Physical tabletop game where concentration and relaxation move a ball across a track. -Multiplayer competitive format.
Rakkiz	Attention	Students & individuals with attention needs	Emotiv EpocX	- Real-time EEG monitoring. - Adaptive difficulty and feedback. - Scoring, levels, and challenges. - Culturally localized gameplay. - Developed in Unity for scalability.

Looking at the current BCI-based products, it is clear that each has contributed but also carries obvious limits. Neuro Tower Defense, for example, demonstrates in a simple way how EEG signals can directly drive gameplay. Yet its basic design and visuals make it feel more like a demo for students rather than a product people would keep playing. Vīrya EEG provides neurofeedback support for meditation and wellness. While it is modern and accessible, the lack of scoring, levels, or storyline makes it function more like a wellness tracker than a true game. The EEG Attention App follows a similar pattern: it gives users quick awareness of their focus levels, but the absence of interaction or challenges makes it closer to a utility than an entertainment tool. BrainBit EEG Waves is very different, offering accurate, professional-grade neurofeedback and brainwave visualization, but its steep learning curve and lack of fun elements limit it mainly to research and clinical settings. Finally, the Mindball Game adds a unique physical twist by letting players move a ball across a track using their mental states. Families and science centers may find it engaging, but the large setup and limited progression mechanics mean it functions more as a novelty experience than a long-term training solution.

3.3 Discussion

The studies (discussed in section 3.1) show the promise of BCI games in training attention and improving memory, but they also reveal clear gaps: most are prototypes, many are limited to short-term use, and few are designed to keep players engaged in the long run.For this reason, Rakkiz seeks to build on these foundations by integrating EEG signals with adaptive and culturally relevant gameplay, aiming to provide both real cognitive benefits and enjoyable experiences.

Rakkiz is designed to address the limitations identified in previous work while carrying forward their valuable insights. By using a consumer-friendly EEG device such as the Emotiv EpocX, it ensures accessibility without the need for specialized laboratory setups. The game further incorporates real-time monitoring, adaptive difficulty, structured progression with scoring systems and levels, and culturally localized design elements that make it relevant to local users. Unlike most current tools, Rakkiz maintains engagement over time through progression and personalization. In this way, it positions itself between research prototypes, wellness applications, and novelty products, but advances further by offering both measurable cognitive value and a genuinely meaningful gaming experience.

4 System Description

The “Rakkiz” system is an EEG-based attention training game that integrates BCI technology with gamified interaction to enhance focus and concentration. It is designed to be accessible for a wide range of adult users with minimal technical background, ensuring usability without requiring prior knowledge of neuroscience or EEG tools. The system is grounded in user-centered design, informed by survey data and expert interviews that highlight both the demand for focus-enhancing solutions and the challenges of existing methods. Architecturally, it follows a layered structure that combines hardware, software, and data storage: EEG signals are captured by the Emotiv headset, processed by the Emotiv Launcher, and then consumed by a Unity-based game application, while a NoSQL database ensures persistent tracking of player progress. Through this integration, Rakkiz creates a real-time feedback loop between brain activity and gameplay, offering an immersive, evidence-based, and scalable platform for cognitive performance enhancement.

4.1 Users

"Rakkiz" is intended for individuals aged 18 years or above who want to enhance their attention and concentration through a gamified experience facilitated by BCI. These users may include university students, employees, or curious individuals interested in exploring EEG based products for cognitive performance enhancement. Most users are expected to have at least a high school education, with many likely possessing a college-level background. Users will most likely have no experience in neuroscience or EEG based tools, but "Rakkiz" is designed to be straightforward and accessible for everyone regardless of their background. Only a minimal amount of experience using a computer will be required. Overall, "Rakkiz" is intended for adults who are open to using technology for self-improvement, regardless of their technical expertise.

4.2 Requirements Elicitation

We used a short bilingual questionnaire (Arabic and English) to gather the requirements for the proposed EEG-based attention training game. A total of 227 people answered. Their feedback gave us a clearer view of who might play the game, what problems they face with focus, and how they see the idea of using a BCI. The full set of graphs is shown in appendix A.

When looking at age, most of the responses came from people in the 18–25 group (44.9%). A large number were also 36 years or older (37.4%), while 16.3% were between 26–35. Only a very small share, around 1.3%, were under eighteen. This shows that the audience is not only young students but also includes many older adults. The gender split leaned strongly toward female participants (74%), compared with 26% male, which means the game should use a style that is neutral and inviting for everyone.

When asked about staying focused on tasks, answers varied. Around one-third said it was easy for them, another third said it was difficult, and the rest gave neutral answers. A follow-up question about being "in the zone" or fully absorbed in an activity revealed that more than half (52.9%) said this happened rarely, and about a third (33.9%) said sometimes. Very few said it happened often (7.9%) or almost always (5.3%). This makes it clear that many people struggle with concentration in daily life.

We also asked about previous methods for improving focus. Just over half (54.6%) had tried apps, exercises, or certain habits, while the rest had not. Among those who had, most described the results as somewhat effective (56.6%) or neutral (26.3%). Only a small portion (11.2%) said they were very effective, and 5.9% said they were not effective at all. This shows that people are open to trying solutions, but current options don't always meet their needs.

The idea of a focus-training game was welcomed by many. About 66.1% said yes, they would like to play such a game, while 22.9% were unsure, and only 11% said no. Interest became even stronger when we explained that the game could use EEG signals in real time: 54.6% were very interested, and 27.9% were somewhat interested. Only a small number showed little or no interest. In addition, 52.9% felt that seeing their brain activity reflected inside the game would help them focus, while 34.6% thought it might help.

When ranking features, three stood out almost equally: clear feedback and progress indicators (56.4%), real-time interaction with brain signals (54.6%), and motivating challenges or levels (54.6%). Storytelling (43.2%) was valued by some but not all, while coins and rewards (27.3%) were least important. This tells us that players mainly want a system that reacts quickly to their brain activity, shows clear signs of progress, and keeps them engaged with meaningful challenges.

In short, the survey results confirm there is strong interest in a BCI-based game. People want transparency, interactivity, and motivating challenges, with inclusivity in design so that it appeals to different age groups and both genders.

In addition to the questionnaire, we also conducted three structured interviews with experts to gain deeper insights for the proposed EEG-based attention training game. The full details of these interviews are presented in appendix B.

Fahad Alqisy, a Chief Technology Officer and game programmer, provided insights on the use of EEG in gaming applications. He pointed out that EEG signals are not always reliable since they come with noise and vary between players. Because of this, any game that uses EEG needs strong filtering and calibration before the signals can be useful. From his experience, players stay motivated when games show progress clearly, build difficulty step by step, and feel immersive. He believed slower-paced genres, like puzzles or meditation games, work better with EEG because they reduce the effect of unstable signals. He also stressed that difficulty should adapt to the player's ability. If the challenge is balanced well, players will continue to engage without feeling overwhelmed.

Doctor Teif Albogami at the Security Forces Hospital in Riyadh explained that the brain's parietal and prefrontal cortices are strongly linked with attention, while the visual cortex becomes more active when people are concentrating. She also described how brainwaves reflect attention: alpha waves are common when someone is relaxed but decline when focus increases, while beta waves become stronger. She emphasized that attention should be measured with both behavior and brain activity. In her view, EEG can be helpful as a supportive tool, but it has limits when used outside medical or controlled environments.

Assistant Professor Nouf Alromaih shared strategies for improving sustained attention, starting with reducing distractions and breaking large tasks into smaller ones. She also mentioned mindfulness and short, structured reinforcement as effective tools. In more serious cases, she noted that medication may be useful, but it works best when combined with behavioral methods. For measuring attention, she highlighted a mix of objective tools such as performance tests, eye tracking, or EEG ratios and subjective ratings like self-reports. She warned that quick improvements in lab tasks might not always transfer to real life, so long-term tracking is important. On feedback, she recommended mainly visual indicators, such as progress bars, and short but regular training sessions. According to her, consistency matters more than length; for example, 10–20 minutes for children and 20–30 minutes for adults with breaks are most effective.

Together, these interviews give a broad view, Fahad focused on technical and design aspects, Dr. Teif explained the medical and neurological side, and Dr. Nouf provided research-based strategies and evaluation methods. Their combined input helps shape a clear direction for developing a practical and effective BCI attention-training game.

4.3 Architecture

The system architecture follows a layered design that integrates hardware, software, and data storage to work together to create the EEG based gaming immersive experience. There are four main components making up the architecture: the EEG headset, the Emotiv Launcher, the Unity game application, and a NoSQL database. The system user (the player) interacts with the game by wearing the EEG headset, which capture brain signals that are processed and translated into meaningfull game responses, while the database ensures persistent player progress.

The first component of the architecture is the Emotiv EpocX headset, which captures the EEG signal in real-time from the player. The EEG signal describes the user's neural activity, which is the primary input to the system. The brain signal is transmitted to the Emotiv Laucher, where EEG data is stored and archived, analyzed, and prepared for the game environment. The Unity game application receives the real-time signal from Emotiv Launcher and then consumes EEG signals to drive gameplay elements and manage player interactions. This enables the system to adapt gameplay elements based on the player's attention levels and provide the user with feedback, linking real-time EEG changes in brain activity with corresponding game responses.

In order to ensure continuity between gameplay sessions, the Unity application connects to a NoSQL database, which stores essential player information such as usernames and current level. This database enables data retrieval and storage in a flexible manner. The system separates responsibilities across hardware, software, and data storage. This separation enhances modularity, scalability, and maintainability, while also clarifying the flow of information within the system. At the highest level, EEG signals serve as the system input, the Unity game provides real-time feedback as the system output, and the NoSQL database ensures persistent storage of player progress.

Our project's architecture takes inspiration from earlier BCI research. Past studies showed how EEG signals can be collected, sent in real time, and connected to Unity games to create a feedback loop between brain activity and gameplay [7]. In our design, shown in Figure 2, the Emotiv headset records the EEG signals, which pass through the Emotiv Launcher before being processed in Unity. This process lets the game respond directly to changes in the player's attention.

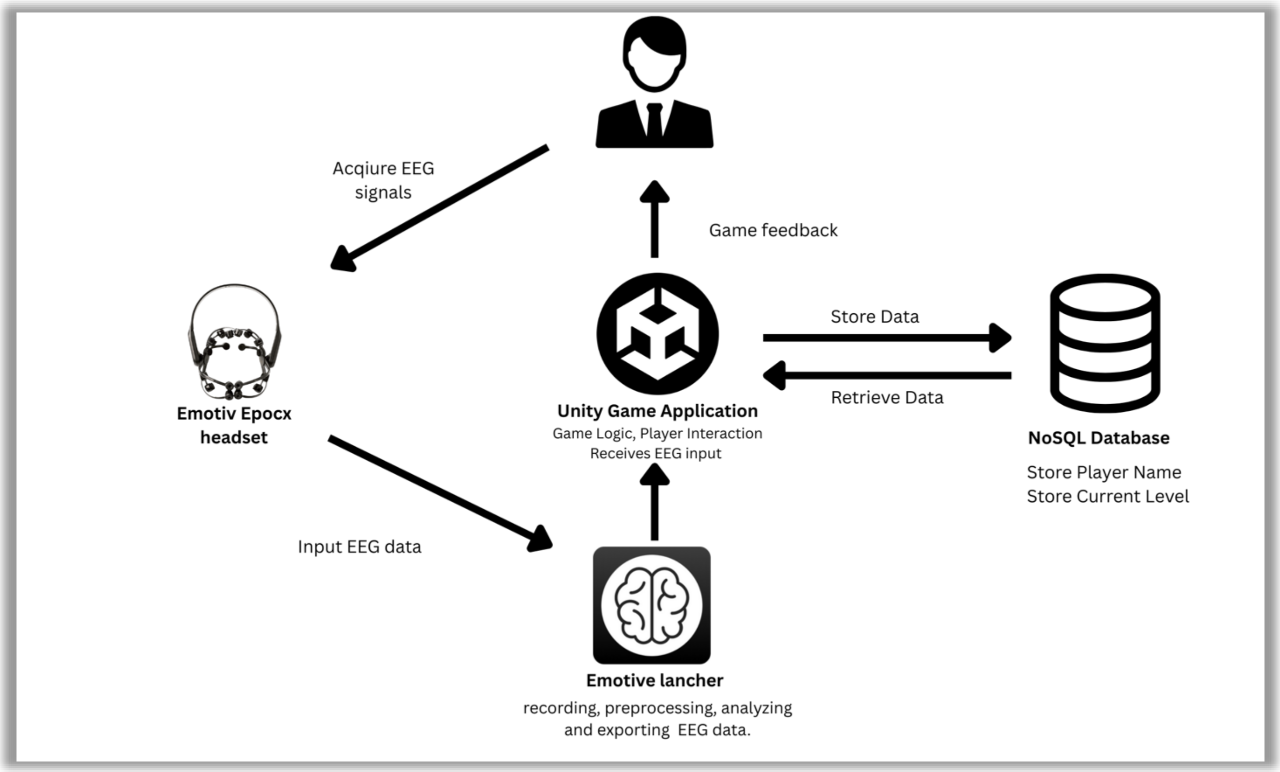

Figure 2: Architectural Diagram of RAKKIZ

4.4 Use Case Diagram

The use case diagram represents the core functional requirements of the "Rakkiz". It captures the interaction between the player and the system, illustrating essential actions such as entering a name, selecting a character, starting or resuming the game, and receiving attention-based feedback. This diagram provides a high-level overview of the system's features, which guarantees that user interactions are clearly defined.

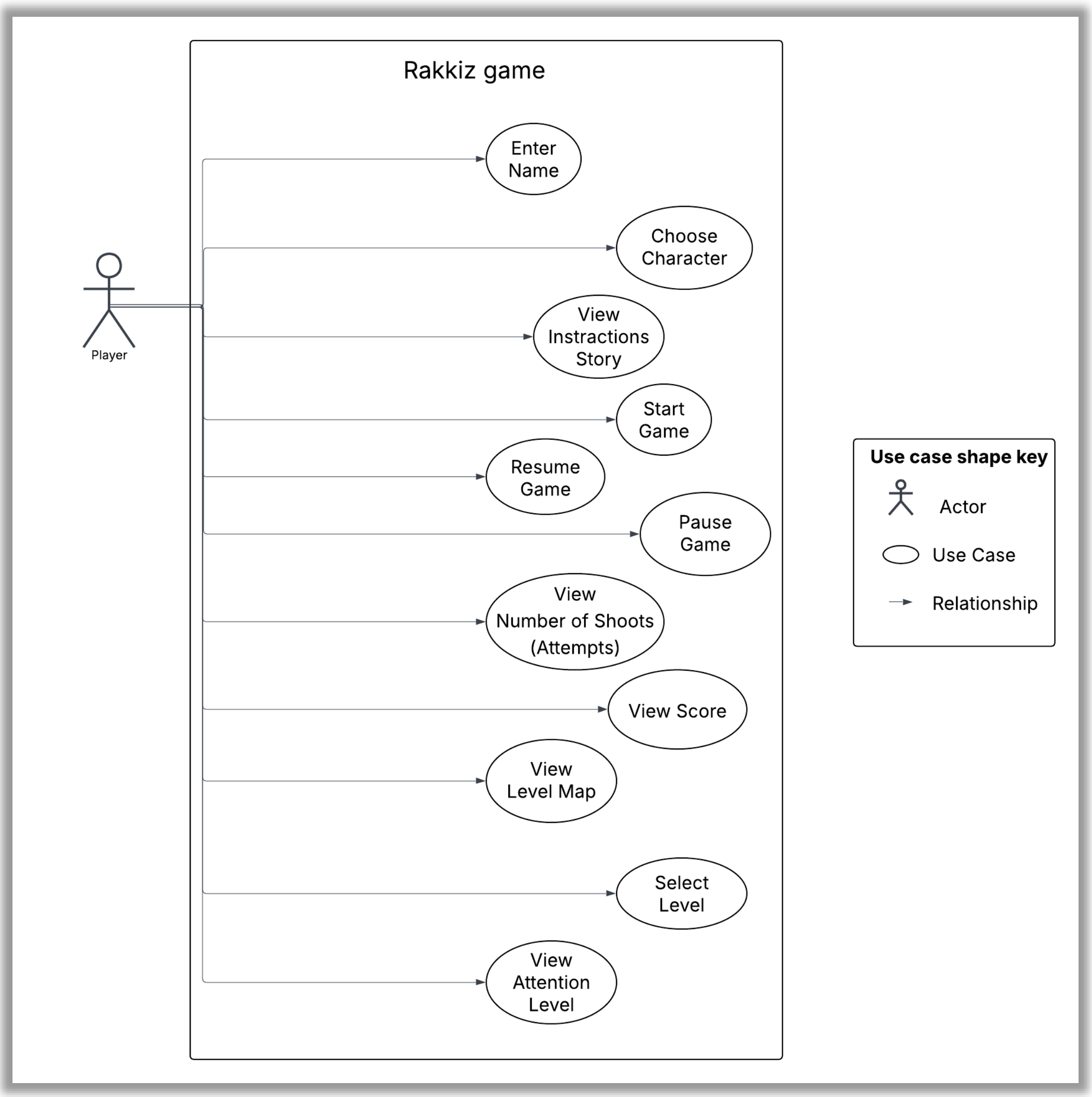

Figure 3: Use Case Diagram of RAKKIZ

5 Product Backlog

5.1 Product Backlog Table

ID	PBI (User Story)	Size (Story Points)	Type	Acceptance Criteria
1	As a player, I want to enter my name when I open the game so that my name is saved and used in the gameplay.	3	Feature	• If I open the game for the first time, then I should see a field to enter my name. • If I type my name, then the name is saved locally. • If I restart the game, then the previously saved name is loaded and shown automatically.
2	As a player, I want the Start button to always be visible and become active only when my name is entered or already saved, so that I can proceed to the next screen.	3	Feature	• If I enter my name, then the Start button becomes active. • If my name is already saved locally, then the Start button is active immediately without re-entering my name. • If I press the Start button, then the next screen should open. • If I do not enter a name, then the Start button should remain inactive.
3	As a player, I want to select and view my characters so that I feel engaged with the game.	3	Feature	• If I open the character screen, then I can view available characters with a clear preview. • If I select a character, then that character appears in gameplay. • If I do not select a character, then the default character is applied in gameplay.

4	As a player, I want to be able to press the play button so that I can play the game.	3	Feature	• If I press the Play button after selecting a character, then the game starts. • If I try to press the Play button without selecting a character, then a default character is chosen and the game starts.
5	As a player, I want to see a storytelling screen so that I can understand the game story before playing.	5	Feature	• If I press the Play button, then a storytelling screen should appear automatically. • If the storytelling screen is displayed, then it should remain visible for 30 seconds. • If the 30 seconds end, then the gameplay should start automatically. • If 5 seconds have passed, then I should be able to skip the storytelling screen.
6	As a player, I want to be able to press the buttons so that I can interact with the game world.	3	Feature	• If the game is running and I press an action button, then the character performs the intended action.
7	As a player, I want to have limited tries in each round so that the game feels challenging.	4	Feature	• If gameplay starts, then the tries counter should always initialize to 3 tries. • If I fail an attempt, then one try is consumed, and the remaining number is updated. • If all three tries are consumed the next round will start.

8	As a player, I want each level to have multiple rounds so that the gameplay feels structured, and progressively challenging.	4	Feature	• If a level starts, then the player should begin at Round 1. • Each level should contain exactly 5 rounds. • If a round ends either by using all 3 tries or by completing it, then the player should automatically advance to the next round. • If all 5 rounds of the level are completed, then the player should move to either the Congrats or Game Over screen.
9	As a player, I want to view my score during the game so that I feel rewarded.	2	Feature	• If I shoot at the target and hit it correctly, then my score increases by 500 points. • If I hit a target, then the updated score appears immediately.
10	As a player, I want levels of difficulty so that the game becomes progressively challenging.	5	Feature	• If I start the game, then I begin at Level 1, Round 1. The game consists of 3 levels, and each level contains a total of 5 rounds. • If I win a level, then the next level becomes unlocked and available to play. • If I progress to a higher level, then the difficulty increases compared to the previous one. • If I want to access the levels, then I can navigate to them from the Levels page.

11	As a player, I want the game to provide visual feedback through color changes so that I can easily know when I gain or lose focus.	3	Feature	• If my focus increases, then the game shows a positive color change. • If my focus decreases, then the game shows a negative color change. • If my focus state changes, then the color feedback is updated.
12	As a player, I want audio feedback so that I stay motivated and engaged.	3	Feature	• If my score increases, then a positive sound plays. • If I lose focus, then a warning sound plays.
13	As a player, I want to see a clear end screen based on my performance so that I know whether I succeeded or failed and can choose my next action.	4	Feature	• If the player's total score is ≥ 1500 (meaning they won at least 3 rounds), then a "Congratulations" screen is shown. • If the player's total score is < 1500, then a "Game Over" screen is shown. • The Congratulations screen must include two options Home page and Levels page. • The Game Over screen must include Home page option.
14	As a developer, I want to collect EEG signal samples so that I have enough data for training and testing the focus classification.	5	Knowledge Acquisition	• If recording is started, then the EEG signals are captured. • If recording ends, then the data file is saved and can be opened for later processing.
15	As a developer, I want to build a basic classification model that distinguishes between focused and unfocused states so that the game can	8	Technical Work	• If I provide labeled EEG input, then the model outputs either "focused" or "unfocused".

	later respond in real time.			
16	As a player, I want my brain signals to be integrated to influence the game so that I can play using my focus level.	8	Feature	• If I am focused, then the game shoots automatically. • If I am not focused, then no shooting happens.
17	As a player, I want to use the BCI device (Emotiv EpocX) so that I can see the connection status in the game.	8	Feature	• If the device is connected, then EEG signals stream in real time. • If the EEG device is not connected, the game does not attempt to process brain signals.

5.2 Non-functional requirements

ID	PBI (User Story)	Size (Story Points)	Type	Acceptance Criteria
1	As a player, I want the game to process my EEG signals and respond within 2 second so that the interaction is immediate. (Performance)	5	Feature	• If EEG input changes, then the game responds within ≤ 2 second. • If feedback is triggered, then it updates without noticeable delay.
2	As a player, I want a clear and simple game interface so that I can easily navigate through the game. (Usability)	3	Feature	• If I open the game, buttons are labeled clearly. • If I am inside gameplay, then Pause, Resume, and

				Home are visible and easy to use.
3	As a player, I want screens to load quickly so that I can start or resume playing without waiting. (Efficiency)	5	Feature	• If I move between screens, then the change happens in ≤1 second. • If I pause or resume gameplay, then the action happens instantly.
4	As a player, I want Rakkiz to be available 95% of the time I try to open it, so that I can practice my attention training without interruptions. (Availability)	3	Feature	• If I open the game 20 times, then at least 19 attempts should launch successfully. • If the game is already installed, then it should open within ≤ 10 seconds.
5	As a player, I want the game to run on both Windows and macOS laptops so that I can play on my own device. (Portability)	3	Feature	• If the game is installed on Windows, then it launches successfully. • If the game is installed on macOS, then it launches successfully

6 References

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7 Appendix A: Survey Questionnaire:

- **Questionnaires Questions:**

Section 1: General Information

1. Age

☐ Under 18
☐ 18–25
☐ 26–35
☐ 36+

2. Gender

☐ Male
☐ Female

Section 2: Focus & Attention Experience

3. How difficult is it for you to stay focused on a task?

☐ Very easy
☐ Easy
☐ Neutral
☐ Difficult
☐ Very difficult

4. How often do you feel "in the zone" or fully focused during daily activities?

☐ Rarely
☐ Sometimes
☐ Often
☐ Almost always

5. Have you tried any methods to improve your focus before (apps, exercises, habits)?
☐ Yes
☐ No

If yes, how effective were they?
☐ Very effective
☐ Somewhat effective
☐ Neutral
☐ Not effective

Section 3: Game Perception & Preferences

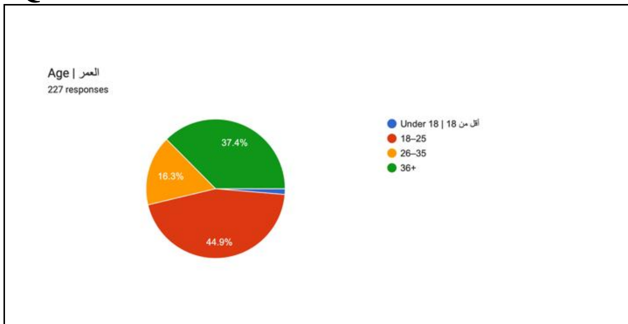
6. Would you be interested in playing a game designed to help you train or improve your attention?
☐ Yes
☐ Maybe
☐ No

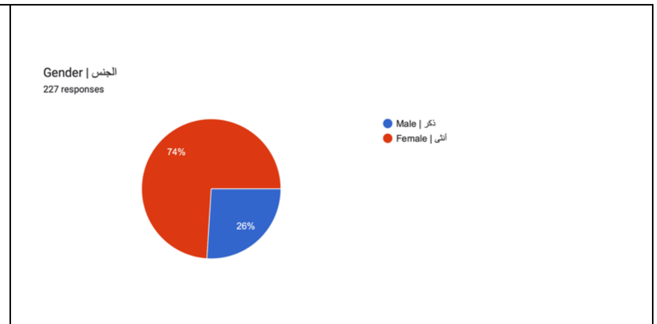
7. What feature do you consider most important in the game?
☐ Real-time interaction with brain signals
☐ Clear feedback and progress tracking
☐ Motivating challenges and levels
☐ Storytelling
☐ Collecting coins or rewards

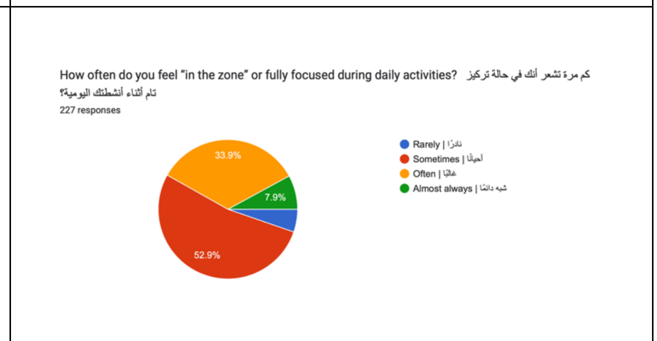
8. If a game could monitor your focus in real-time using a brainwave headset, how interesting would this be to you?
☐ Very interesting
☐ Somewhat interesting
☐ Neutral
☐ Not very interesting
☐ Not interesting at all

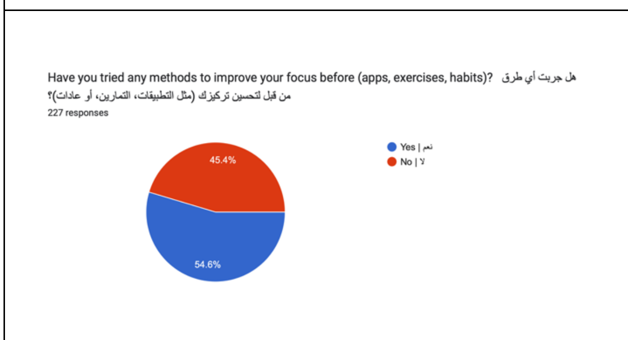
9. Would seeing your brain activity reflected in the game help you stay more focused?
☐ Yes, definitely
☐ Maybe
☐ Not sure
☐ Probably not
☐ No

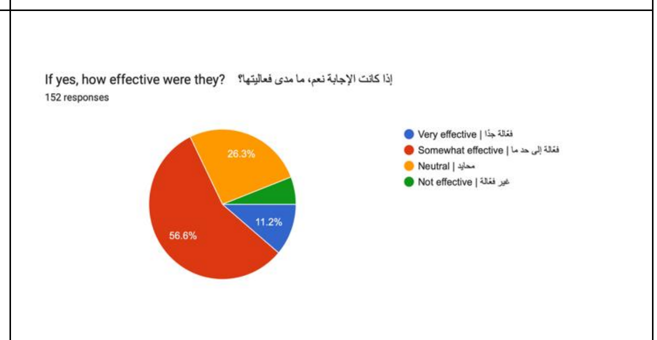
- Questionnaires Answers:

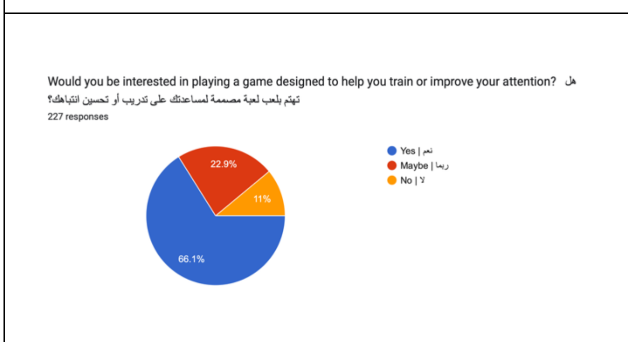


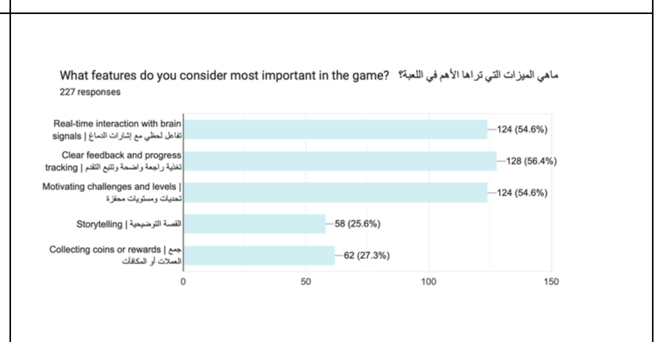


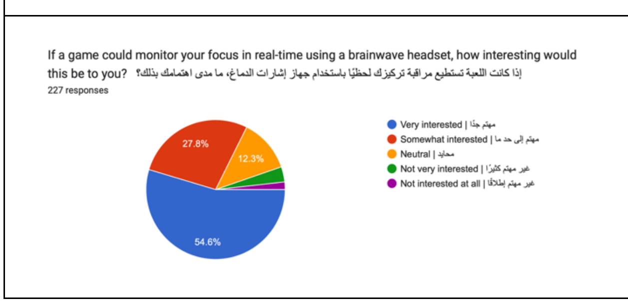


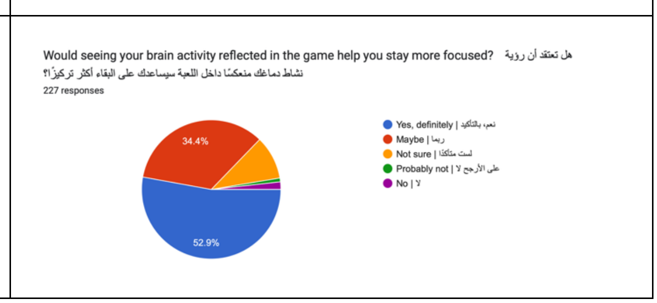












8 Appendix B: Interview Results and Analysis

<table>
<tr><th colspan="2">Interview (1)</th></tr>
<tr><td>Interviewee: Fahad Alqisy
Age: 25
Job Title: CTO & Game Programmer at Floaty
Nationality: Saudi
Gender: Male</td><td>Interviewer: Lana Albogami</td></tr>
<tr><td>Location/Medium: Zoom Meeting
Phone Number: -</td><td>Appointment Date: 17-09-2025
Start Time: 3:00PM
End Time: 3:25PM</td></tr>
<tr><td>Objectives:
Understand the challenges of integrating EEG signals into game environments.
Identify the main design elements that make BCI-based games engaging and enjoyable.
Explore suitable game genres for experimenting with BCI technologies.
Gather insights on how adaptive difficulty can improve player motivation.</td><td>Reminders: The interviewee has previous experience with digital games and expressed interest in focus based and adaptive gameplay.</td></tr>
<tr><td>Agenda:
Introduction
Background of project
Overview of interview
Topics to be covered
Permission to record
Question 1
Question 2
Question 3
Question 4
Summary of major points
Questions from interviewee</td><td>Approximate Time:
1 minute
2 minutes
1 minute
1 minute
1 minute
3 minutes
3 minutes
3 minutes
3 minutes
2 minutes
2 minutes</td></tr>
</table>

Closing	1 minute
General Observation: Overall, the interviewee showed strong interest in games that provide clarity, gradual progression, and real-time feedback. He expressed concern about the reliability of EEG signals, but also saw potential for focus based games if the system is designed to be simple and adaptive. His responses highlight the need for technical stability, user friendly design, and adaptive difficulty to maintain engagement.	
Topic not covered: All planned topics were successfully addressed during the interview.	

Interview (1)	
Interviewee: Fahad Alqisy	**Date:** 17-09-2025
Questions:	**Answers:**
Q1: What challenges should we expect when integrating EEG signals into Unity-based games?	**Answer:** The hardest part is the signals themselves they're noisy, not always consistent, and every player's brain is different. You need good filtering and calibration to make it usable in real time. On top of that, keeping Unity responsive while handling all that data is a big challenge **Observation:** The interviewee highlighted the unreliability of EEG signals, emphasizing the need for effective filtering and calibration. This shows a concern for technical stability and data quality before focusing on gameplay design.
Q2: In your opinion, what are the key elements that make a game engaging and enjoyable for players?	**Answer:** For me it's simple: clear feedback, real progression, and immersion. Players need to feel their actions matter, see themselves growing, and get pulled into the world. When those three click together, the game becomes fun **Observation:** The interviewee stressed the importance of clarity, feedback, and progression. This indicates that players value simple interfaces and visible rewards that sustain motivation.
Q3: Which types or genres of games do you think are most suitable for experimenting with Brain–	**Answer:** I see BCIs working best with slower or more focused genres puzzle, strategy, meditation, or narrative games. These don't rely on fast reactions, so brain signals can be part of the gameplay without frustrating the player

Computer Interfaces (BCIs)? Why?	**Observation:** The interviewee leaned toward slower-paced games like focus, puzzle, or meditation genres. This suggests that BCI games are more effective in calm environments where signal instability is less disruptive.
Q4: How should game difficulty and challenges be adjusted during gameplay to maintain player motivation and interest?	**Answer:** I think games should read the player and adapt. If someone's struggling, ease it a bit. If they're cruising, push them with more challenge. The goal is to keep them in that flow state not bored, not overwhelmed, just engaged **Observation:** The interviewee emphasized maintaining a balance between challenge and encouragement. This reflects support for adaptive difficulty systems that prevent frustration and keep players engaged.

Interview (2)	
Interviewee: Teif Albogami **Age:** 28 **Job Title:** doctor **Nationality:** Saudi **Gender:** Female	**Interviewer:** Layan Alamri
Location/Medium: Zoom Meeting **Phone Number: -**	**Appointment Date:** 20-09-2025 **Start Time:** 5:00PM **End Time:** 5:22 PM
Objectives: Understand the brain regions and brainwaves most linked with attention. • Explore how EEG neurofeedback can improve attention over time. • Compare EEG reliability with behavioral performance indicators. • Identify risks and limitations of using BCI devices outside clinical environments.	**Reminders:** The interviewee demonstrated a clear understanding of EEG basics, especially brain regions linked to attention and the role of brainwave patterns.
Agenda: • Introduction	**Approximate Time:** • 2 minutes

• Background of project • Overview of interview • Permission to record • Question 1 • Question 2 • Question 3 • Question 4 • Question 5 • Summary and Closing	• 3 minutes • 2 minutes • 1 minute • 4 minutes • 4 minutes • 1 minute • 1 minute • 1 minute • 3 minutes
General Observation: The interviewee emphasized the role of the fronto-parietal networks and the prefrontal cortex (PFC) in regulating attention, highlighting how brain activity in these regions is closely linked to focus. She also explained the connection between brainwave patterns and attention, noting that beta waves are strongly associated with concentration, while increases in theta waves may indicate distraction or lapses of focus. For the remaining topics—such as the long-term impact of neurofeedback training, the reliability of EEG compared to behavioral indicators, and the medical risks of using BCI devices outside clinics—the interviewee did not provide answers. These areas require additional sources or future interviews to be fully addressed.	
Topic not covered: The interviewee did not provide answers to questions 3–5 which are: • Q3: How can neurofeedback training with EEG measure the long-term effects on attention? • Q4: How reliable is EEG compared to behavioral indicators of attention? • Q5: What medical limitations or risks exist when using BCI devices outside clinics?	

Interview (2)	
Interviewee: Teif Albogami	**Date:** 20-09-2025
Questions:	**Answers:**
Q1: What brain regions are most indicative of attention levels?	**Answer:** Key Brain Regions Indicative of Attention Levels: 1. Posterior Parietal Cortex (PPC): integrates sensory and visual information; crucial for spatial attention and guiding eye/hand movements.

<table>
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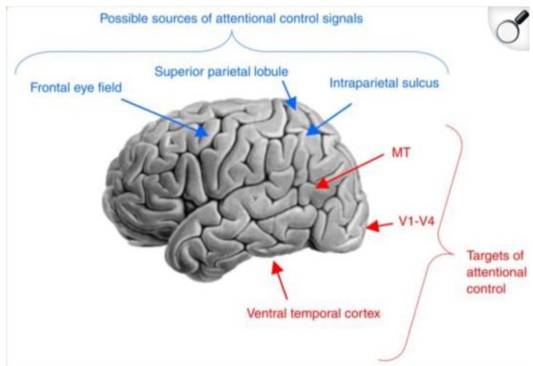
2. Frontal Eye Fields (FEF): controls voluntary eye movements and directs visual attention; strongly connected with PPC.
3. Prefrontal Cortex (PFC): regulates attention based on goals and planning; provides top-down control to modulate sensory processing.
4. Visual Cortex (V1–V4): shows amplified activity for attended locations or features; influenced by frontal and parietal signals.
5. Fronto-Parietal Networks: the main system for directing attention, combining FEF and PPC for voluntary attention, plus ventral parietal regions for involuntary shifts.


Figure 1. Adapted from PubMed [source].
Observation: The interviewee emphasized the role of the fronto-parietal network in attention control and highlighted how visual cortex activity increases for attended stimuli.
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<tr>
<td>Q2:
Which brainwave patterns are most strongly associated with attention?</td>
<td>
Answer:
• With eyes closed: synchronous alpha waves dominate due to coordinated neuronal activity.
• When attention shifts to a mental task: alpha waves disappear and are replaced by asynchronous, higher-frequency, lower-voltage beta waves.
• Visual input immediately suppresses alpha activity, again replaced by beta rhythms.
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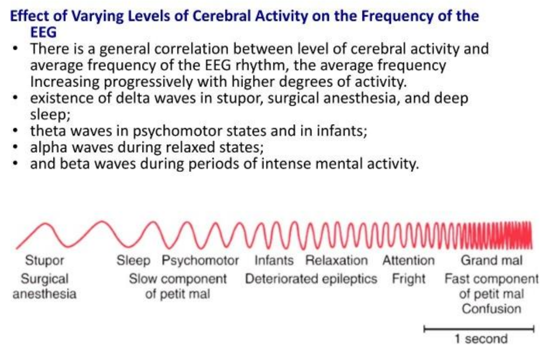
<tr><td></td><td>

Figure 2. Adapted from Dr. Amal Dawood’s EEG lecture.
Observation: The interviewee explained that beta waves are strongly linked to active focus, while alpha waves signal relaxation, and excessive theta waves may indicate distraction or lapses in attention.</td></tr>
<tr><td colspan="2">Sources:
PubMed (2025), Lecture by Dr. Amal Dawood (Physiology Department).</td></tr>
</table>

<table>
<tr><th colspan="2">Interview (3)</th></tr>
<tr><td>Interviewee: Nouf Alromaih
job Title: University Lecturer & Researcher in Attention
Nationality: Saudi
Gender: Female</td><td>Interviewer: Hatoun Almogherah and Arwa Almutairi</td></tr>
<tr><td>Location/Medium: Zoom Meeting
Phone Number: -</td><td>Appointment Date: 24-09-2025
Start Time: 12:00PM
End Time: 12:30PM</td></tr>
<tr><td>Objectives:
• Identify effective strategies to improve sustained attention.
• Explore methods used to measure and evaluate attention in research and practice.
• Understand how to test if training tools lead to real-life attention improvements.</td><td>Reminders: The interviewee has academic and research expertise in ADHD, sustained attention, and training interventions. Her insights highlight both practical applications and scientific evaluation methods.</td></tr>
</table>

• Examine which feedback types best support sustained focus. • Determine the optimal duration for attention training sessions without causing fatigue.	
Agenda: • Introduction • Background of project • Overview of interview • Permission to record • Question 1 • Question 2 • Question 3 • Question 4 • Question 5 • Summary and Closing	**Approximate Time:** • 2 minutes • 2 minute • 1 minute • 1 minute • 5 minutes • 5 minutes • 5 minutes • 4 minutes • 4 minutes • 1 minutes
General Observation: The interviewee emphasized a multi-layered approach to attention training, combining behavioral adjustments, cognitive strategies, and where appropriate, medical support. She stressed the importance of objective and subjective evaluations, the value of real world validation beyond lab tasks, and the effectiveness of visual feedback paired with subtle cues. She concluded that short, consistent, and frequent sessions are the most effective for long term improvement.	
Topic not covered: All planned topics were successfully addressed during the interview.	

Interview (3)	
Interviewee: Nouf Alromaih	**Date:** 24-09-2025
Questions:	**Answers:**
Q1: Based on your expertise, what are the most effective strategies to improve sustained attention?	**Answer:** Minimize distractions, break tasks into smaller steps, use working memory and inhibitory control exercises, practice mindfulness, apply structured reinforcement, and consider prescribed medication if necessary.

	Observation: Attention is best supported when behavioral, cognitive, and medical strategies are combined.
Q2: How is attention typically measured or evaluated in research or practice? Are there known signs that indicate someone is truly focused?	**Answer:** Objective: CPT tests (errors, reaction times), eye-tracking (fixations), EEG (theta/beta ratio). Subjective: standardized rating scales, self/teacher reports. **Observation:** A reliable evaluation of attention requires combining objective measures with observed behavior.
Q3: From your perspective, what is the best way to test whether a training tool really improves attention in real life?	**Answer:** Short-term: lab tasks (CPT, n-back, Stroop), immediate teacher/parent ratings, and homework completion. Long-term: academic/work outcomes, participation, and randomized controlled trials. **Observation:** Short-term lab improvements are not enough; real-world outcomes must also be tested.
Q4: What kind of feedback (visual, audio, real-time performance indicators) helps users stay focused the most?	**Answer:** Visual feedback (progress bars, scores, color changes) works best; subtle audio cues may help if used sparingly. Overly flashy or loud feedback can distract. **Observation:** Visual feedback should be primary, with simple predictable audio for reinforcement.
Q5: How long do you think a typical session of attention training should last to be effective without causing fatigue?	**Answer:** Children: 10–20 minutes. Adolescents/adults: 20–30 minutes with short breaks. Short, frequent sessions are most effective. **Observation:** Consistency is more important than long sessions; fatigue must be avoided for lasting progress.

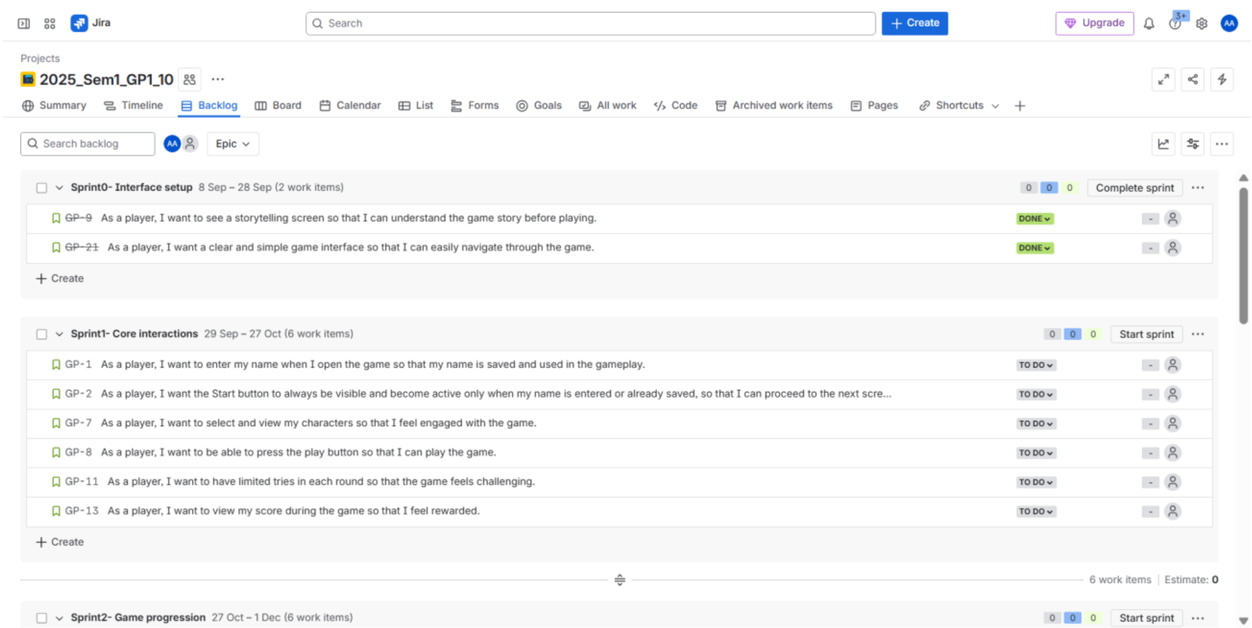
9 Appendix C: Project Related Links

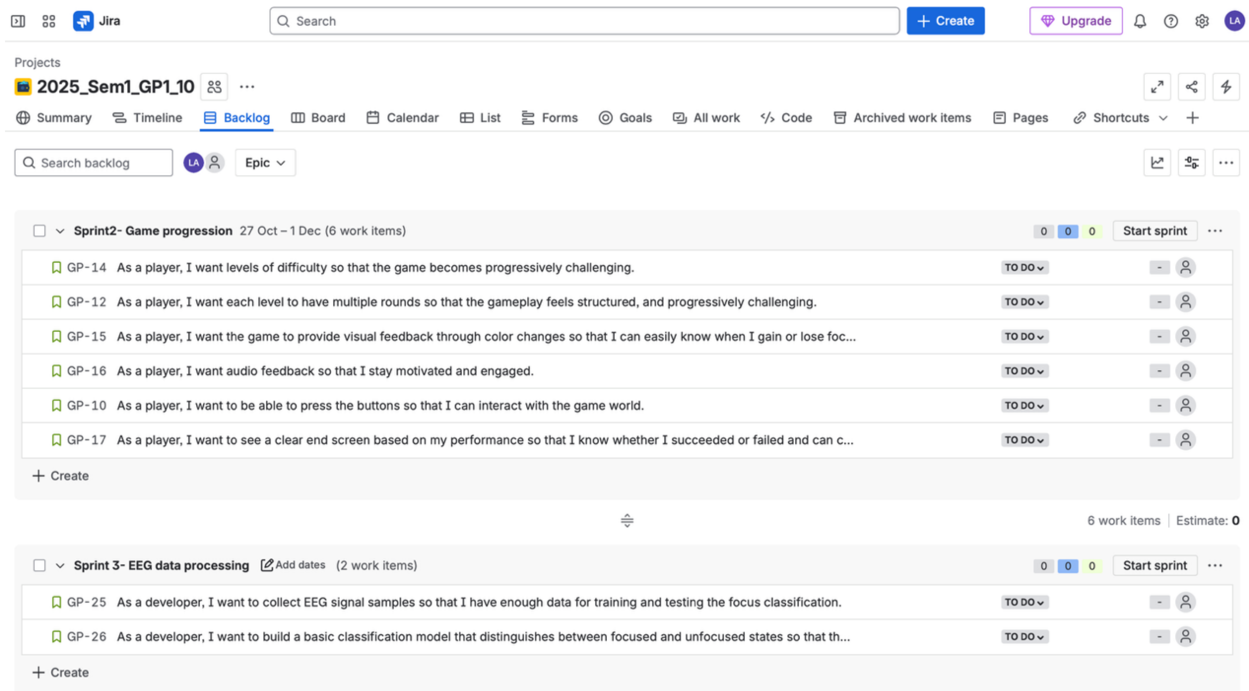
GitHub:

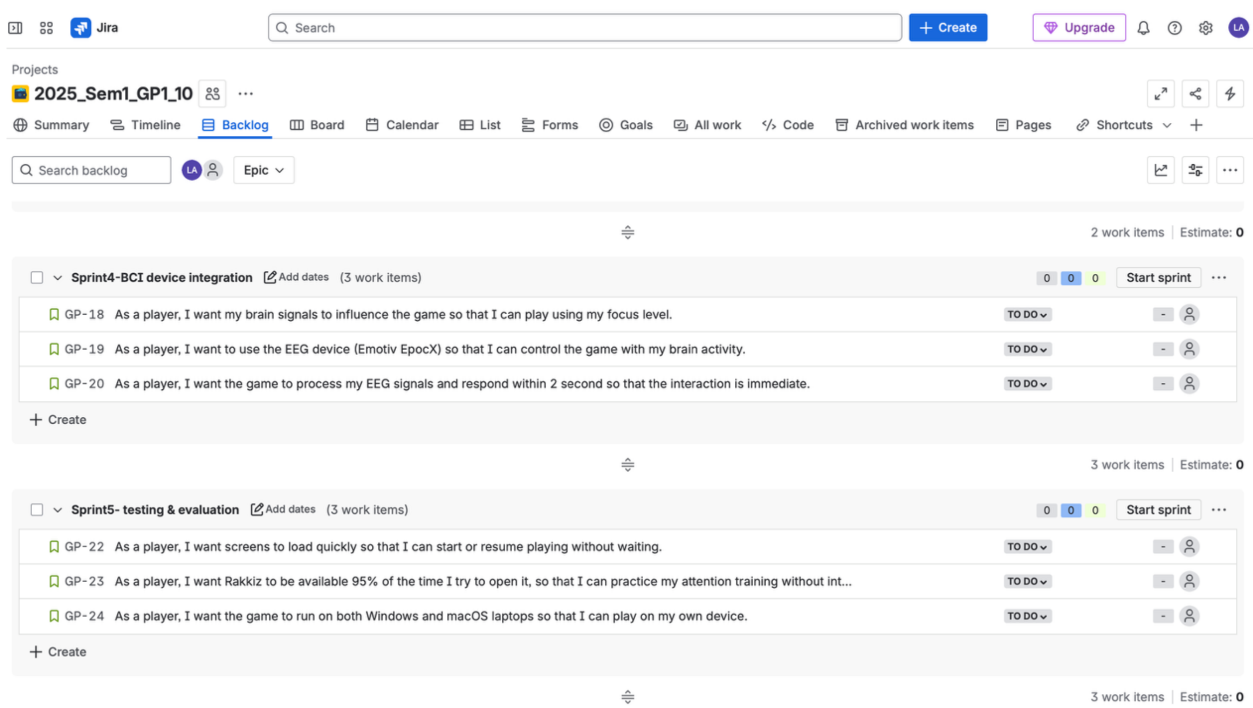
https://github.com/Layan34/2025_GP_10

Jira:

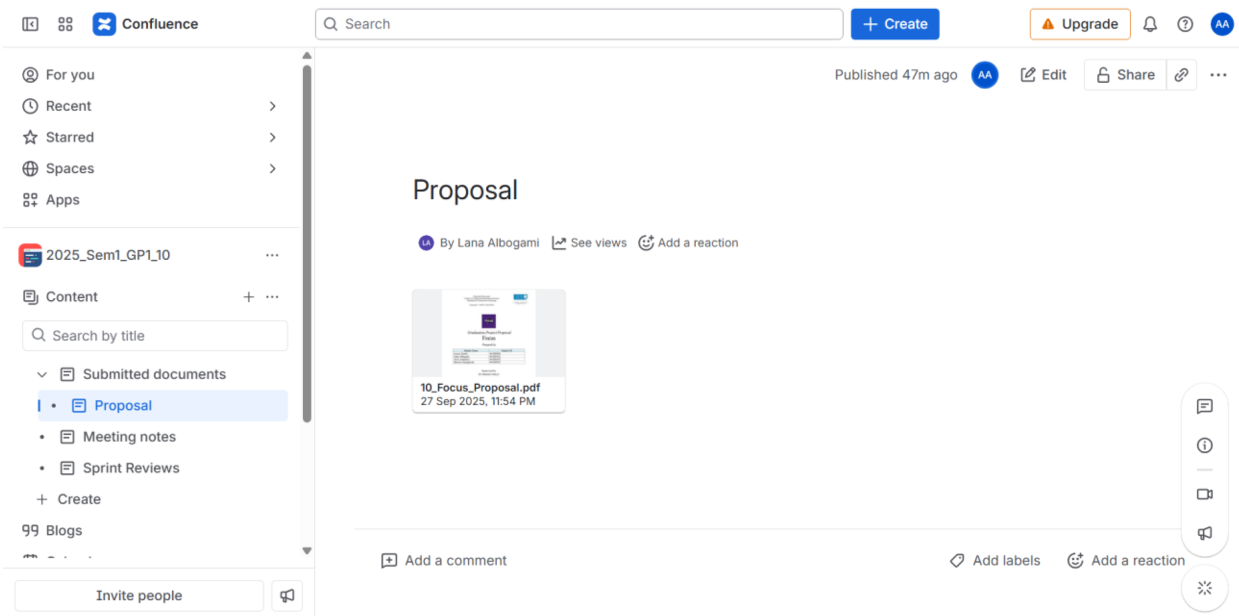
https://2025-sem1-gp10.atlassian.net/jira/software/projects/GP/boards/1/backlog







Confluence:
https://2025-sem1-gp10.atlassian.net/wiki/spaces/GP/pages/98311/Submitted+documents


Confluence
Search
+ Create
Upgrade
AA
For you
Recent
Starred
Spaces
Apps
2025_Sem1_GP1_10
Content
Search by title
Submitted documents
Proposal
Meeting notes
Sprint Reviews
+ Create
Blogs
Invite people
Published 47m ago
Edit
Share
Proposal
By Lana Albogami
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