INSTITUTO SUPERIOR DE ENGENHARIA DO PORTO
MESTRADO EM ENGENHARIA INFORMÁTICA




Technological Interventions in Mental Health: A VR and Mobile-Based Gamification Approach for Anxiety Management

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Junho de 2025

POLITÉCNICO
DO PORTO

ISEP INSTITUTO SUPERIOR DE ENGENHARIA DO PORTO

Technological Interventions in Mental Health: A VR and Mobile-Based Gamification Approach for Anxiety Management

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A dissertation submitted in partial fulfillment of the requirements for the degree of Master of Science, Specialisation Area of Games, Graphics, and Interactive Systems

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Porto, June 29, 2025

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Dedicatory

To my parents and Guida, for your constant support and love.

To my supervisor, Professor Carlos Vaz de Carvalho, thank you for your guidance and availability.

Abstract

Anxiety and panic attacks are among the most prevalent mental health challenges today, significantly impacting individuals' daily lives, emotional stability, and overall well-being. Despite the availability of effective therapeutic techniques, such as guided meditation and breathing exercises, many individuals struggle to access and apply these tools consistently, particularly during acute episodes. This gap reveals the need for accessible, personalized, and engaging digital interventions that support both prevention and crisis management.

This thesis presents the design, development, and evaluation of a digital solution that leverages Virtual Reality (VR) and mobile applications to assist individuals in managing anxiety. The system integrates evidence-based techniques into two primary modules: a **Daily Work Module**, promoting regular emotional regulation, and an **SOS Module**, for immediate intervention during crises.

To maximize user engagement, the solution incorporates gamification elements grounded in psychological principles. Specifically, it maps the **5-4-3-2-1 grounding technique** to a sequence of interactive, sensory-focused mini-games. The development follows a lifecycle-based Work Breakdown Structure (WBS) and a Design-Based Research (DBR) methodology.

The prototype was evaluated with two major approaches, involving usability testing (SUS) and qualitative feedback from both mental health experts and end-users. The results confirmed the high usability and therapeutic potential of the application. Participants reported significant feelings of calmness and immersion, highlighting the effectiveness of the breathing and interactive grounding phases. The SOS mode was consistently validated as a valuable and reassuring feature for crisis management. Ethical considerations, such as data privacy and informed consent under GDPR, were paramount throughout the design.

The outcome is a validated, user-centered framework for a gamified mental health tool that combines therapeutic efficacy with technological innovation, demonstrating a promising direction for accessible and engaging digital interventions.

Keywords: Virtual Reality (VR), Anxiety Management, Mental Health Technology, Mobile Applications, Gamification, Immersive Therapy

Resumo

A ansiedade e os ataques de pânico são desafios prevalentes para a saúde mental que afetam significativamente o bem-estar de milhões de pessoas. Embora existam técnicas terapêuticas eficazes, a sua aplicação consistente, especialmente em momentos de crise, permanece um obstáculo. Esta lacuna evidencia a necessidade de intervenções digitais que sejam acessíveis, personalizadas e envolventes, apoiando tanto a prevenção como a gestão de crises.

Esta tese apresenta o desenho, desenvolvimento e avaliação de uma solução digital híbrida que utiliza Realidade Virtual (VR) e aplicações móveis para auxiliar na gestão da ansiedade. A solução integra técnicas baseadas em evidências em dois módulos: o **Módulo de Trabalho Diário**, para a regulação emocional contínua, e o **Módulo SOS**, para intervenção imediata em episódios agudos. Para maximizar a adesão e o envolvimento do utilizador, a solução implementa uma estratégia de gamificação fundamentada na técnica de *grounding* **5-4-3-2-1**, que foi mapeada para uma sequência de minijogos interativos e focados nos sentidos.

O desenvolvimento do projeto foi estruturado através de metodologias robustas, incluindo a *Work Breakdown Structure* (WBS) e o *Design-Based Research* (DBR), que garantiram uma abordagem iterativa e centrada no utilizador, com integração contínua de feedback. Adicionalmente, uma revisão sistemática de literatura (PRISMA) foi conduzida para identificar as lacunas nas tecnologias existentes, que confirmou a falta de soluções integradas (VR e mobile) e com personalização dinâmica.

A validação do protótipo foi realizada através de uma abordagem de métodos mistos, com testes de usabilidade (SUS) e entrevistas qualitativas a especialistas em saúde mental (psicólogos) e a utilizadores finais. Os resultados demonstraram a elevada usabilidade e o potencial terapêutico da aplicação. Os participantes reportaram uma notável redução do stress e uma forte sensação de imersão, destacando a eficácia das fases de respiração guiada e das interações de *grounding*. O Módulo SOS foi unanimemente validado como uma funcionalidade valiosa e segura para a gestão de crises.

Os aspetos éticos, como a privacidade de dados (em conformidade com o GDPR) e o consentimento informado, foram rigorosamente considerados em todas as fases do projeto para garantir uma implementação responsável.

Em conclusão, este trabalho não só entrega uma ferramenta funcional, mas também um *framework* validado para o desenvolvimento de intervenções de saúde mental gamificadas. A solução demonstra como a fusão de VR, tecnologia móvel e design terapêutico pode criar experiências eficazes e acessíveis, oferecendo um contributo significativo para o avanço da saúde mental digital.

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Chapter 1

Introduction

Mental health challenges, particularly anxiety and panic attacks, represent a growing concern in contemporary society, impacting millions worldwide and significantly affecting quality of life. This chapter introduces the problem domain and highlights the urgent need for innovative and accessible solutions. It outlines the technical complexities associated with designing personalized digital interventions and clearly states the objectives and research questions guiding this thesis. Furthermore, it details the stakeholders involved, the multidisciplinary scope of the project, and the research methodologies adopted, setting the stage for the subsequent chapters of the thesis.

1.1 Problem Statement

Anxiety and panic attacks are prevalent mental health challenges that significantly impact individuals' daily lives and overall well-being. According to the World Health Organization, anxiety disorders affect approximately 4% of the global population, corresponding to around 301 million people worldwide Organization 2023. In Portugal, the situation is particularly concerning, with one of the highest rates of anxiety disorders globally, estimated at 8,671 cases per 100,000 inhabitants World Health Organization 2022b. Moreover, the COVID-19 pandemic has intensified this crisis, triggering a global increase of about 25% in anxiety and depression cases during its initial year World Health Organization 2022a.

Individuals affected by anxiety disorders frequently experience difficulties in consistently managing their symptoms, both in everyday situations and during acute episodes. Although therapeutic methods such as guided meditation and controlled breathing are well-established, their application remains inconsistent. This inconsistency typically results from limited immediate accessibility to these resources and challenges in tailoring interventions to individual needs and contexts.

The unpredictable nature of anxiety and panic attacks further compounds the problem, underscoring the necessity for rapid, reliable, and continuous access to emotional management tools. Additionally, anxiety manifests uniquely in each individual, complicating the identification of universally effective strategies. Consequently, there is an urgent demand for adaptable solutions that integrate seamlessly into individuals' lives, providing immediate crisis support while simultaneously fostering long-term emotional resilience and prevention.

1.2 Objectives

The main objective of this thesis is to explore how digital technologies can support individuals in managing anxiety and panic attacks, both in everyday contexts and during moments of acute emotional distress.

More specifically, this project aims to:

- Investigate the potential of immersive (VR) and mobile applications to promote emotional self-regulation and relaxation.
- Design an accessible and engaging experience that encourages regular use as part of preventive mental health routines.
- Provide immediate support tools to help users cope with intense anxiety or panic symptoms.
- Address ethical and regulatory concerns associated with the use of digital tools in mental health interventions.

1.2.1 Research Questions

To guide the development and evaluation of the proposed solution, the following research questions have been formulated:

- How can immersive and mobile technologies be used to promote emotional well-being in users with anxiety?
- What design strategies best support intuitive, calming, and emotionally safe user experiences in this context?
- How can digital tools provide effective, accessible support during moments of high emotional distress?
- What ethical and regulatory measures are necessary to ensure safe and responsible use of such technologies in mental health?

1.3 Stakeholders and Multidisciplinary Scope

The proposed solution involves multiple stakeholders, including: - **Individuals experiencing anxiety and panic attacks**, who are the primary users and beneficiaries of the tool. - **Mental health professionals** (psychologists, therapists, psychiatrists), who validate and guide the incorporation of therapeutic techniques. - **Technologists and game designers**, responsible for developing VR and mobile platforms while ensuring accessibility and user-friendliness.

The project is inherently multidisciplinary, encompassing psychology for therapeutic content, technology for implementation, and ethics to address privacy and safety concerns.

1.4 Thesis Timeline

The development of this thesis and the associated project has been organized into a structured timeline to ensure systematic completion of key objectives. Figure 1.1 presents the Gantt chart, which outlines the planned phases of work:

- **October to December 2024:** Literature review and development of the Introduction and State of the Art chapters.
- **January to May 2025:** Development of VR and mobile components, including prototyping, development, and testing.
- **January to June 2025:** Writing of subsequent thesis chapters and finalizing the conclusions.
- **June 2025:** Final thesis revision and submission.

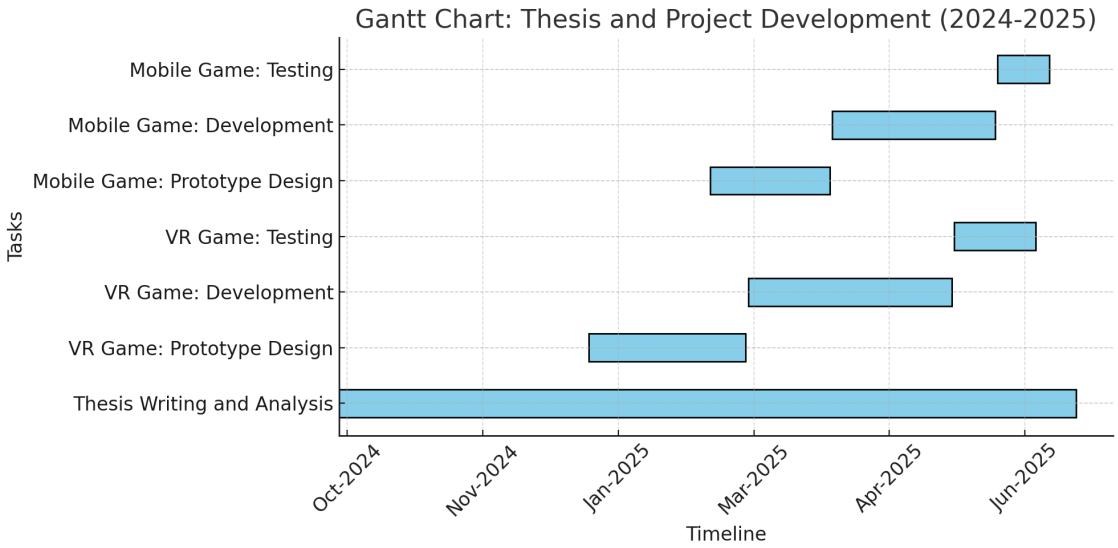

Figure 1.1: Gantt Chart of Thesis and Project Development Timeline

1.5 Research Methodologies

This section explores the research methodologies applied throughout the development of this thesis, focusing on the use of the **Work Breakdown Structure (WBS)** and **Design-Based Research (DBR)**. Both approaches were chosen for their relevance in structuring complex projects and integrating theory with practice, ensuring the creation of an effective anxiety management solution.

1.5.1 Work Breakdown Structure by Lifecycle

The **Work Breakdown Structure (WBS)** was chosen as the primary methodology to organize the development of this project, adapted to a lifecycle-based model. This type of WBS divides the project into five main phases: research and planning, solution design, implementation, testing and validation, and documentation. Each phase has clearly defined deliverables, detailed descriptions, and progress criteria, as summarized in Table 1.1.

Advantages of Using a Lifecycle-Based WBS

The lifecycle-based WBS was selected for the following reasons:

- **Structured Progression:** Dividing the project into phases ensures logical and systematic progress tracking (Terry Anderson and Shattuck 2005).

- **Deliverable-Oriented:** Each phase is clearly associated with specific deliverables, ensuring accountability and alignment with project objectives (Collins, Joseph, and Bielaczyc 2004).
- **Flexibility:** Allows for dynamic adjustments in response to new challenges or discoveries (F. Wang and Hannafin 2005).
- **Role Clarity:** Provides stakeholders with a clear understanding of their responsibilities and expected outcomes (A. L. Brown 1992).

Lifecycle Phases and Deliverables

Table 1.1 outlines the lifecycle phases, their deliverables, descriptions, and progress criteria.

Table 1.1: Lifecycle Phases and Deliverables

Phase	Deliverables	Description and Additional Notes	Progress Criteria
1. Research and Planning	- Literature review - Stakeholder analysis	Comprehensive understanding of the problem domain and alignment with ethical and regulatory guidelines.	- Completion of literature review
2. Solution Design	- Conceptual designs for modules - Prototypes (VR and mobile)	High-level design of the Daily Work and SOS modules, including interactive prototypes.	- Approval of design specifications - Validation of prototypes by stakeholders
3. Implementation	- Functional VR and mobile applications	Development of VR and mobile components with core features implemented.	- Successful internal testing of core features - Functionality demonstration
4. Testing and Validation	- Usability test reports - Feedback summary	Validation of the solution through user testing and iterative improvements.	- Collection of user feedback - Resolution of at least 80% of reported issues
5. Documentation and Finalization	- User guide - Technical documentation - Completed thesis	Comprehensive documentation of the project and submission of the final thesis.	- Approval of all documentation by advisors - Submission of thesis

Visualization of the WBS

The WBS is visually represented in Figure 1.2, illustrating the hierarchical structure of the project's phases and deliverables.

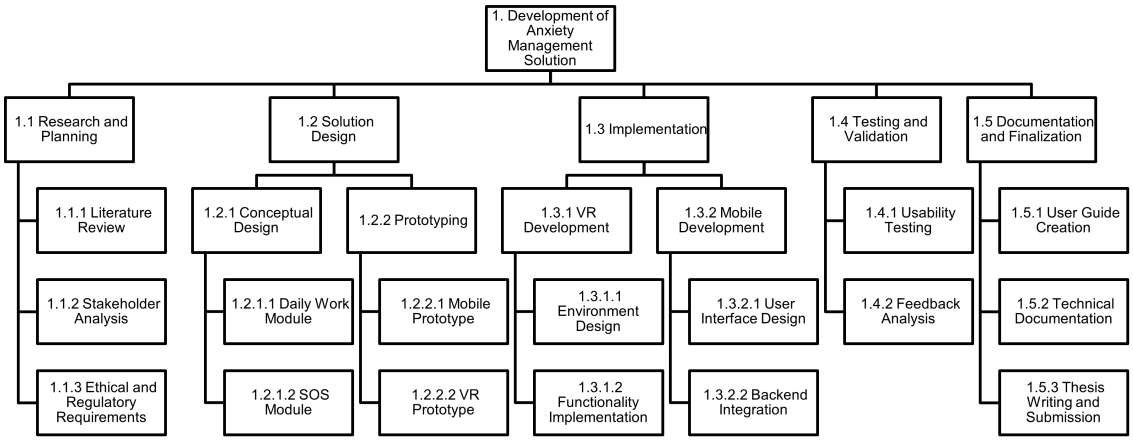

Figure 1.2: Lifecycle-Based WBS for Anxiety Management Solution Development

Benefits of WBS in This Project

Using a lifecycle-based WBS ensures that:

- Deliverables are aligned with the project's goals at each stage.
- Progress can be systematically monitored and evaluated.
- Resources are efficiently allocated to manage the complexity of integrating therapeutic content with advanced technologies (Reimann 2011).

1.5.2 Design-Based Research in This Thesis

Design-Based Research (DBR) is an iterative methodology that bridges theory and practice, making it highly suitable for projects addressing complex challenges and leveraging emerging technologies (Terry Anderson and Shattuck 2005; Reimann 2011). Its application in this thesis is particularly relevant, given the dual focus on addressing anxiety management and utilizing VR and mobile applications.

Reasons for Using DBR

The choice of DBR is justified by several factors:

- **Iterative Development:** DBR emphasizes cycles of design, implementation, evaluation, and refinement, aligning well with the development of VR and mobile components (A. L. Brown 1992).
- **Contextual Relevance:** Focuses on creating solutions applicable to real-world scenarios, such as providing tools for anxiety management (Collins, Joseph, and Bielaczyc 2004).
- **Stakeholder Involvement:** Integrates feedback from stakeholders, ensuring the solution meets their needs and expectations (F. Wang and Hannafin 2005).
- **Theory-Practice Integration:** Combines theoretical insights with practical development to produce scientifically grounded and functional tools (Reimann 2011).

Application of DBR in This Thesis

The application of DBR in this thesis involves:

- **Exploration:** Identifying user needs and reviewing literature to inform the design.
- **Design and Prototyping:** Developing prototypes of VR and mobile modules.
- **Implementation:** Testing the solution with real users to assess effectiveness.
- **Evaluation and Refinement:** Using feedback to iteratively improve the modules (Terry Anderson and Shattuck 2005).

Benefits of DBR for This Project

Adopting DBR allows this project to:

- Adapt dynamically to challenges and user feedback.
- Ensure a user-centered approach, enhancing accessibility and engagement.
- Bridge theoretical insights with practical applications, contributing to both research and real-world impact (Reimann 2011).

By combining the structured approach of WBS with the iterative and stakeholder-focused nature of DBR, this thesis aims to deliver a robust, user-centered solution for anxiety management.

1.6 Thesis Structure

This thesis is organized into five chapters:

- **Chapter 1: Introduction** Introduces the problem domain, the project's objectives and guiding research questions, the stakeholders involved, and the methodologies used for project management and development.
- **Chapter 2: State of the Art** Reviews existing literature and technologies related to mental health, anxiety management, and digital solutions such as VR and mobile applications. It also includes a systematic literature review to identify gaps and opportunities for innovation.
- **Chapter 3: Design and Development** Details the core of the practical work. This chapter outlines the application's design, functional requirements derived from expert interviews with psychologists, and the gamification strategies employed. It further presents the system's architecture, user flow, and the detailed technical implementation of the proposed VR and mobile solution.
- **Chapter 4: Testing, Validation and Discussion** Describes the comprehensive evaluation process of the prototype. This chapter presents the results from both expert validation and end-user testing, using instruments like the System Usability Scale (SUS). It analyzes these findings, discusses their implications in light of the project's objectives, and addresses the ethical and regulatory considerations.
- **Chapter 5: Conclusion and Future Work** Summarizes the main contributions and conclusions of the thesis. It provides direct answers to the initial research questions,

discusses the project's limitations, and proposes concrete directions for future research and development.

Chapter 2

State of the Art

2.1 Mental Health and Anxiety

2.1.1 Overview of Anxiety Disorders

As established in the previous chapter, anxiety disorders represent a significant and widespread global health issue. This section now delves into the clinical foundations of these conditions, which are formally defined by excessive fear and worry that interfere with daily activities and encompass a range of specific disorders with distinct features.

The scale of their prevalence makes them the most common mental disorders worldwide. In 2019, an estimated 301 million people were living with an anxiety disorder, including 58 million children and adolescents (Organization 2023). While prevalence varies across regions, with higher rates often observed in high-income countries (Andrade and al. 2014), the situation in Portugal is particularly notable, with one of the highest rates globally at 8,671 cases per 100,000 people (World Health Organization 2022b). Demographically, women are more frequently affected than men, with a ratio of approximately 1.66:1 (Organization 2023).

2.1.2 Symptoms and Patterns

Anxiety disorders are characterized by excessive fear or worry, which may be specific to certain situations (e.g., social interactions or panic-inducing events) or more generalized across everyday scenarios. These symptoms typically persist over several months and often lead to avoidance of anxiety-provoking situations.

Common Symptoms

Anxiety disorders often manifest through various physical, emotional, and cognitive symptoms, including:

- Difficulty concentrating or making decisions (Mental Health 2022a).
- Irritability, tension, or restlessness (Beck 2011).
- Physical symptoms such as nausea, abdominal distress, heart palpitations, sweating, trembling, or trouble sleeping (Organization 2023).
- A pervasive sense of imminent danger, panic, or doom (Mental Health 2022a).

Anxiety disorders often co-occur with depression, substance use disorders, and an increased risk of suicidal thoughts or behaviors (Mental Health 2022a).

Types of Anxiety Disorders

Anxiety disorders encompass various subtypes, including:

- **Generalized Anxiety Disorder (GAD):** Persistent worry about daily activities or events (American Psychiatric Association 2013).
- **Panic Disorder:** Recurring panic attacks and fear of future episodes (Mental Health 2022b).
- **Social Anxiety Disorder:** Intense fear of social situations due to potential humiliation or rejection (American Psychiatric Association 2013).
- **Agoraphobia:** Fear and avoidance of places that can cause feelings of panic or helplessness (American Psychiatric Association 2013).
- **Separation Anxiety Disorder:** Excessive fear of being separated from loved ones (Organization 2023).
- **Specific Phobias:** Irrational fears of specific objects or situations, leading to avoidance (American Psychiatric Association 2013).
- **Selective Mutism:** Inability to speak in specific social settings, despite being able to speak in others (commonly seen in children) (American Psychiatric Association 2013).

Symptoms often begin in childhood or adolescence and persist into adulthood (American Psychiatric Association 2013; Organization 2023). Women are more likely to experience anxiety disorders than men (Organization 2023). It is also common for individuals to experience more than one type of anxiety disorder simultaneously (Mental Health 2022b).

Impact on Individuals' Lives

The impact of anxiety disorders extends beyond mental health, affecting various aspects of an individual's life:

- **Physical Health:** Symptoms such as increased heart rate, sweating, trembling, and gastrointestinal issues (Organization 2023).
- **Daily Functioning:** Impairment in work, school, and social relationships due to avoidance behaviors and difficulty concentrating (American Psychiatric Association 2013).
- **Quality of Life:** Reduced overall well-being and life satisfaction (Mental Health 2022b).
- **Comorbidity:** Increased risk of other mental health conditions, such as depression and substance use disorders (American Psychiatric Association 2013).

Early identification and appropriate treatment are crucial to mitigate these impacts and improve outcomes for individuals with anxiety disorders (Organization 2023).

2.1.3 Panic Attacks: Symptoms and Triggers

Panic attacks are sudden episodes of intense fear or discomfort that peak in minutes and are accompanied by a range of physical and cognitive symptoms (Mental Health 2022b). These attacks can occur unexpectedly, without an obvious trigger, or may be associated with particular situations.

Common Symptoms

During a panic attack, individuals may experience at least four of the following symptoms (Mental Health 2022b):

- Palpitations or accelerated heart rate
- Sweating
- Trembling or shaking
- Sensations of shortness of breath or smothering
- Feelings of choking
- Chest pain or discomfort
- Nausea or abdominal distress
- Dizziness, lightheadedness, or faintness
- Chills or heat sensations
- Paresthesias (numbness or tingling sensations)
- Derealization (feelings of unreality) or depersonalization (being detached from oneself)
- Fear of losing control or "going crazy"
- Fear of dying

These symptoms can be so severe that individuals often believe they are experiencing a medical emergency, such as a heart attack, which leads them to seek urgent medical attention (American Psychiatric Association 2013).

Common Triggers

Although panic attacks can occur without a clear cause, several factors can trigger or increase the likelihood of an episode (Organization 2023):

- **Stressful Life Events:** Major changes such as the death or serious illness of a loved one, significant life transitions, or traumatic experiences can precipitate panic attacks (Mental Health 2022b).
- **Medical Conditions:** Certain health issues, including thyroid problems or cardiovascular conditions, may be associated with panic attacks (American Psychiatric Association 2013).
- **Substance Use:** Consumption of caffeine, alcohol, or illicit drugs, as well as withdrawal from certain medications, can trigger attacks (Mental Health 2022b).
- **Environmental Factors:** Situations like being in crowded places, driving, or even sleeping can sometimes act as triggers (Organization 2023).

Identifying and understanding these triggers is crucial for effective management and prevention of future panic attacks (American Psychiatric Association 2013).

2.1.4 Psychological and Behavioral Therapies

Anxiety disorders are commonly treated using evidence-based psychological and behavioral therapies, which aim to reduce symptoms, improve coping mechanisms, and improve overall quality of life. The following are some of the most widely used approaches:

Cognitive-Behavioral Therapy (CBT)

CBT is considered the gold standard for treating anxiety disorders (Beck 2011). It focuses on identifying and modifying negative thought patterns and behaviors that contribute to anxiety. Key components include:

- **Cognitive Restructuring:** Identifying irrational or distorted thoughts and replacing them with more realistic and positive perspectives (Mental Health 2022a).
- **Exposure Therapy:** Gradual and controlled exposure to anxiety-provoking situations or triggers to desensitize the individual and reduce avoidance behaviors (Health and (NICE) 2011).
- **Behavioral Techniques:** Developing healthier coping strategies to manage anxiety in challenging situations.

CBT has been shown to be highly effective across various anxiety disorders, including generalized anxiety disorder (GAD), panic disorder, and social anxiety disorder.

Mindfulness-Based Therapies

Mindfulness practices involve focusing attention on the present moment and accepting thoughts and feelings without judgment. Techniques such as mindfulness-based stress reduction (MBSR) and mindfulness-based cognitive therapy (MBCT) have demonstrated benefits for anxiety reduction (Kabat-Zinn 1990). These therapies emphasize:

- **Breathing Exercises:** Controlling breath to regulate the autonomic nervous system and reduce physiological symptoms of anxiety (Beck 2011).
- **Body Scans:** Paying attention to physical sensations to ground oneself in the present moment (Kabat-Zinn 1990).
- **Meditation:** Developing a non-reactive awareness of thoughts and feelings (Beck 2011).

Mindfulness-based approaches are particularly effective for reducing stress and enhancing emotional resilience (Hofmann et al. 2010).

Relaxation Techniques

Relaxation strategies aim to alleviate physical tension and calm the mind, which can be beneficial for managing anxiety symptoms. Common methods include:

- **Progressive Muscle Relaxation (PMR):** Alternating between tensing and relaxing different muscle groups to promote relaxation (Bernstein, Borkovec, and Hazlett-Stevens 2000).
- **Guided Imagery:** Visualizing calming scenes or experiences to reduce stress and anxiety (Kabat-Zinn 1990).

- **Deep Breathing Exercises:** Practicing slow, diaphragmatic breathing to counteract hyperventilation and induce a sense of calm (Mental Health 2022a).

These techniques are often used in conjunction with other therapies to provide holistic anxiety management (Health and (NICE) 2011).

Effectiveness and Limitations

While these therapies are highly effective for many individuals, challenges remain. Some people may experience difficulty accessing trained professionals, and the effectiveness of these methods can vary depending on the severity of the disorder and individual differences (Andrade and al. 2014).

2.1.5 Challenges in Managing Anxiety

Effective management of anxiety disorders often faces several barriers, ranging from individual factors to systemic issues. These challenges can hinder the accessibility, consistency, and effectiveness of therapeutic approaches.

Access to Therapy

Access to professional therapy is one of the most significant barriers to effective anxiety management. Key issues include:

- **Limited Availability of Therapists:** A shortage of trained mental health professionals, particularly in rural or low-income areas, makes accessing therapy difficult for many individuals (Andrade and al. 2014).
- **Financial Constraints:** The high cost of therapy sessions and limited insurance coverage for mental health services often prevent individuals from seeking help (Andrade and al. 2014).
- **Stigma:** Social stigma surrounding mental health can deter individuals from acknowledging their struggles and seeking professional support (Organization 2023).

Consistency in Applying Techniques

Even when therapy is accessible, maintaining consistent use of therapeutic techniques poses challenges:

- **Lack of Motivation:** Anxiety can lead to avoidance behaviors, making it difficult for individuals to practice the strategies learned in therapy (Beck 2011).
- **Difficulty in Self-Regulation:** During high-anxiety episodes, individuals may struggle to recall or apply calming techniques effectively (Mental Health 2022a).
- **Limited Follow-Up Support:** Without continuous guidance from therapists, individuals may fail to integrate these techniques into their daily lives (Andrade and al. 2014).

Technology and Accessibility Gaps

Digital tools for managing anxiety, such as mobile applications and online therapy platforms, have potential but also face limitations:

- **Usability Issues:** Some tools are not user-friendly or require advanced digital literacy, excluding certain populations (Meta 2023).
- **Lack of Personalization:** Many digital solutions do not adequately tailor interventions to individual needs or the severity of anxiety (Meta 2023).
- **Privacy Concerns:** Fear of data breaches or misuse of personal health information may discourage users from engaging with digital solutions (Commission 2023).

Cultural and Individual Factors

Cultural norms and individual differences can also complicate anxiety management:

- **Cultural Beliefs:** In some cultures, discussing mental health openly is discouraged, limiting awareness and support (Organization 2023).
- **Varied Responses to Treatment:** Individual differences in biology, personality, and life experiences mean that not all therapeutic approaches are equally effective for everyone (Health and (NICE) 2011).

Addressing these challenges requires a holistic approach, combining accessible, affordable, and culturally sensitive solutions with innovative technologies that can support individuals in overcoming these barriers (Organization 2023).

2.1.6 Techniques for Managing Anxiety and Panic Attacks

Managing anxiety and panic attacks effectively often requires a combination of techniques that target both physiological and psychological symptoms. The following are some widely recognized methods:

Breathing Exercises

Controlled breathing helps regulate the autonomic nervous system, reducing the physical symptoms of anxiety and panic attacks. Common techniques include:

- **Diaphragmatic Breathing:** Involves deep breaths using the diaphragm to increase oxygen intake and promote relaxation (Mental Health 2022a).
- **Box Breathing:** A structured pattern of inhaling, holding the breath, exhaling, and holding again for equal counts (e.g., 4 seconds each phase) (Beck 2011).
- **Pursed-Lip Breathing:** Helps slow down breathing and reduce hyperventilation, often used during panic attacks (Mental Health 2022a).

Mindfulness and Meditation

Mindfulness practices aim to focus attention on the present moment, helping individuals manage intrusive thoughts and emotional distress. Key techniques include:

- **Mindfulness Meditation:** Involves sitting quietly, focusing on the breath, and observing thoughts without judgment (Kabat-Zinn 1990).
- **Body Scans:** Gradually paying attention to physical sensations in different parts of the body, promoting awareness and grounding (Kabat-Zinn 1990).

- **Loving-Kindness Meditation:** Focuses on cultivating feelings of compassion and self-acceptance, reducing self-criticism often associated with anxiety (Beck 2011).

Progressive Muscle Relaxation (PMR)

PMR helps alleviate tension by systematically tensing and relaxing muscle groups. This technique enhances body awareness and promotes physical relaxation (Bernstein, Borkovec, and Hazlett-Stevens 2000).

Visualization and Guided Imagery

Visualization involves mentally creating calming and peaceful scenarios to reduce stress. Guided imagery often includes audio instructions to help individuals visualize settings like beaches, forests, or other serene environments (Kabat-Zinn 1990).

Grounding Techniques

Grounding techniques are particularly useful during panic attacks to reorient attention away from fear and towards the present moment. Examples include:

- **The 5-4-3-2-1 Method:** Identifying five things you can see, four you can touch, three you can hear, two you can smell, and one you can taste (Mental Health 2022a).
- **Cold Water Technique:** Splashing cold water on the face or holding an ice cube to engage the parasympathetic nervous system (Beck 2011).

Physical Activity

Exercise is a well-established method for reducing anxiety. Activities like walking, yoga, and aerobic exercises release endorphins and improve mood regulation (Organization 2023).

Effectiveness and Integration

These techniques are often most effective when tailored to the individual's specific needs and incorporated into a regular routine. For panic attacks, having readily accessible strategies, such as grounding or breathing exercises, can provide immediate relief (Health and (NICE) 2011).

2.2 Technological Solutions

2.2.1 Serious Games and Their Integration

Serious games are designed with a primary purpose beyond entertainment, often targeting education, training, or health-related outcomes. In the context of mental health, serious games can serve as powerful tools to engage individuals in therapeutic activities, making them more approachable and enjoyable. By gamifying daily exercises for anxiety management, these games can significantly enhance motivation and adherence to therapeutic practices(Fleming et al. 2017).

Benefits of Serious Games in Anxiety Management

Integrating serious games into anxiety management interventions offers several advantages:

- **Increased Engagement:** Games provide an interactive and immersive experience, encouraging users to return regularly to complete exercises and track their progress.
- **Routine Building:** Daily gameplay fosters the development of a structured routine, making anxiety management exercises a consistent part of the user's life.
- **Positive Reinforcement:** Reward systems in games, such as achievements, levels, or in-game rewards, can motivate users to complete tasks like breathing exercises, mindfulness activities, or progressive muscle relaxation.
- **Reduction of Stigma:** Presenting anxiety management within a gaming context normalizes these practices, reducing the stigma often associated with mental health interventions.

Integration in This Project

In this project, serious games will play a central role in motivating users to perform daily anxiety-reduction exercises. The game mechanics will be designed to create a balance between therapeutic practices and engaging gameplay. Key elements include:

- **Daily Challenges:** Users will receive tasks such as completing a guided breathing exercise or a mindfulness activity, earning points or rewards upon completion.
- **Progress Tracking:** A visual representation of progress, such as a streak tracker or level system, will encourage users to maintain consistency in their practices.
- **Personalized Gameplay:** The game will adapt to the user's preferences and anxiety levels, offering exercises and tasks suited to their needs.
- **Virtual Rewards:** Gamified elements, such as unlocking new environments or customizing an avatar, will serve as positive reinforcement for regular engagement.

Motivational Impact

By incorporating game mechanics, the project aims to transform anxiety management exercises into an enjoyable daily routine rather than a burdensome task. Motivation through gameplay not only ensures regular practice of therapeutic techniques but also empowers individuals to take control of their mental health in a structured and positive way.

2.2.2 Mobile Applications for Anxiety Management

Mobile applications have gained popularity as accessible tools for managing anxiety and improving mental health. Some of the most commonly used apps include:

- **Calm:** Provides guided meditations, sleep stories, breathing programs, and relaxation techniques specifically designed to reduce anxiety and improve sleep.
- **Headspace:** Offers mindfulness and meditation exercises tailored to help users manage stress and anxiety in daily life.
- **BetterHelp:** Connects users with licensed therapists for remote counseling sessions via chat, voice, or video.

- **Sanvello:** Combines cognitive-behavioral therapy (CBT) techniques with guided meditation, journaling, and mood tracking.

While these apps are beneficial due to their portability and ease of use, they also present some limitations:

- Lack of real-time interventions during acute anxiety episodes or panic attacks.
- Minimal personalization to the user's unique anxiety triggers or therapeutic needs.
- Dependence on a stable internet connection for full functionality.

2.2.3 Virtual Reality in Mental Health Interventions

Virtual reality (VR) offers immersive experiences that are particularly effective in therapeutic settings. VR applications for mental health often focus on two primary approaches:

- **Exposure Therapy:** Simulates environments or situations that provoke anxiety, allowing individuals to confront and gradually desensitize themselves to their fears in a controlled setting. For example:
  - Simulating crowded spaces for individuals with social anxiety.
  - Replicating flight experiences for those with aviophobia (fear of flying).
- **Relaxation and Safe Spaces:** Provides calming environments, such as serene landscapes or guided relaxation scenarios, to help individuals manage acute anxiety and stress.

Studies have shown that VR interventions can enhance engagement, provide immediate feedback, and create a safe, controlled space for therapeutic activities (Freeman et al. 2017). However, challenges such as cost, motion sickness, and accessibility remain significant barriers to widespread adoption (Geraets, Stouwe, and Veling 2021).

2.2.4 Existing VR Devices

Several VR devices are commonly used in mental health interventions, each offering unique features suitable for therapeutic purposes:

- **Oculus Quest 2:** A standalone headset that provides high-quality visuals and an extensive library of VR applications, including mental health tools. (Meta 2023).
- **HTC Vive:** Known for its precision tracking and advanced hardware, making it ideal for complex VR simulations. (Vive 2023).
- **PlayStation VR:** A console-based device that offers an affordable entry point for VR applications. (VR 2023).
- **Meta Quest Pro:** Advanced features such as mixed reality capabilities and improved resolution, making it suitable for professional therapeutic applications. (Pro 2023).

These devices enable both exposure therapy and relaxation techniques, offering a range of options based on therapeutic goals and user needs.

2.2.5 Technologies for Development

The development of VR and mobile applications for mental health requires robust and versatile technologies. Among the most widely used tools are:

- **Unity:** A powerful game engine that supports VR and mobile development, offering features such as: (Technologies 2023)
  - Cross-platform compatibility, allowing developers to create applications for both VR headsets and mobile devices.
  - Integration with VR SDKs such as Oculus SDK and OpenXR for seamless VR experiences.
  - A user-friendly interface and extensive documentation, making it accessible for developers of varying experience levels.
- **Unreal Engine:** Known for its high-fidelity graphics, Unreal Engine is used in creating highly realistic VR environments.
- **VR SDKs:** Software development kits such as Oculus SDK, SteamVR, and Google VR SDK are essential for integrating VR functionalities into applications.
- **Mobile Frameworks:** Tools like Android Studio and Xcode are used for developing mobile-specific features that complement VR applications.

In this project, **Unity** will be the primary tool used for development, as it offers a balance between versatility and ease of use. Its ability to support both VR and mobile platforms ensures seamless integration across devices, making it an ideal choice for creating a comprehensive solution for anxiety management.

2.3 Systematic Literature Review

This section presents the systematic literature review conducted to identify and analyze existing works related to anxiety management, panic attacks, mental health, and the use of VR and mobile applications. A PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology was employed to ensure transparency and reproducibility.

2.3.1 Search Strategy and Criteria

The systematic search was conducted exclusively on IEEE Xplore, as it is a reputable database for technology-focused research and offers a robust collection of studies related to VR and mobile applications. The following query was used:

```
("All Metadata":anxiety management) OR ("All Metadata":panic attacks)
OR ("All Metadata":mental health) AND ("All Metadata":virtual reality)
OR ("All Metadata":VR) OR ("All Metadata":immersive technology)
AND ("All Metadata":mobile applications) OR ("All Metadata":smartphone apps)
```

This query initially returned 50,519 results. After applying filters to restrict the search to *Standards, Journals, Early Access Articles, and Books*, the results narrowed to 5,356. The final selection of articles was based on relevance and specific inclusion and exclusion criteria.

Inclusion and Exclusion Criteria

- **Inclusion Criteria:**
  - Articles focused on mental health applications, specifically anxiety and panic attack management.
  - Use of VR, immersive technologies, or mobile applications in the proposed solutions.
  - Published in peer-reviewed journals or conferences.
  - Articles that provided clear methodologies or practical implementations.
- **Exclusion Criteria:**
  - Articles not in English.
  - Studies that addressed unrelated mental health conditions without focus on anxiety.
  - Works without clinical applications, practical implementations, or robust methodologies.

To ensure rigor, the Covidence software was used for managing and screening the articles. The software helped automate the removal of duplicates and allowed for the consistent application of inclusion and exclusion criteria across all reviewers.

2.3.2 PRISMA Flowchart

Figure 2.1 outlines the PRISMA flowchart, detailing the systematic review process, from initial identification to final selection of articles.

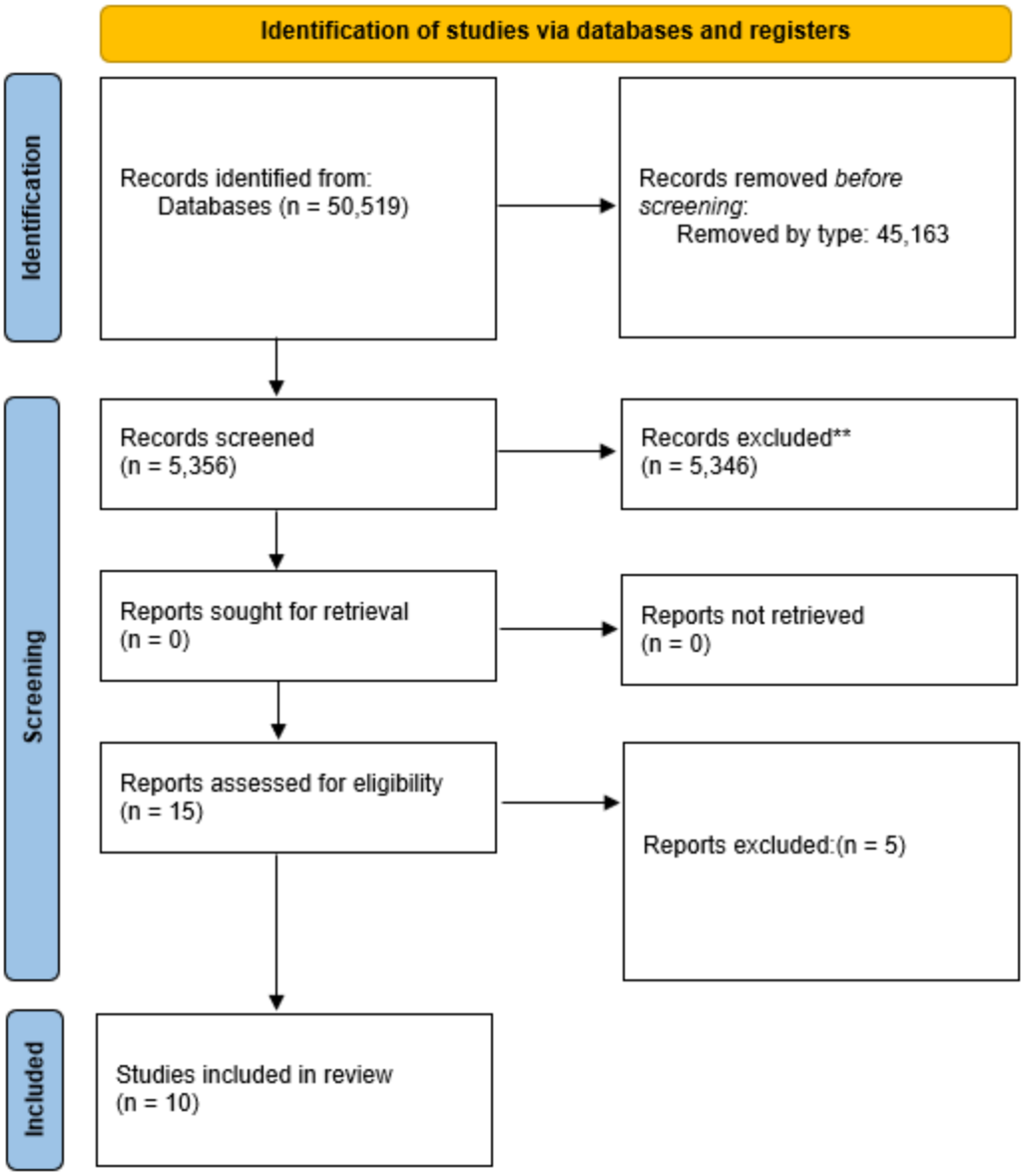

Figure 2.1: PRISMA Flowchart for Systematic Literature Review

2.3.3 Summary of Selected Articles

The following table summarizes the selected articles that informed the development of this thesis:

Article	Summary
Smith and Doe 2023	Demonstrates the efficacy of VR-based exposure therapy in reducing symptoms of generalized anxiety disorders.
Taylor and Lee 2020	Highlights the benefits of mobile applications using real-time notifications for anxiety grounding techniques.
Chen and Zhang 2023	Proposes an integrated VR and mobile solution for stress and anxiety relief.
M. Brown and Green 2021	Shows how gamified elements in therapy apps increase engagement and adherence.
Miller and White 2019	Explores the use of VR to simulate safe spaces for panic attack management.
Tom Anderson and Garcia 2023	Investigates the use of VR for immersive relaxation training to enhance mindfulness.
Kumar and Patel 2022	Provides evidence supporting the effectiveness of mobile-based CBT for anxiety reduction.
Williams and Lin 2023	Discusses ethical issues in VR mental health apps, including data privacy and informed consent.
Nguyen and Davis 2023	Reports sustained improvements in anxiety symptoms after long-term VR interventions.
Lopez and V. Wang 2023	Proposes algorithms to personalize content in mobile health apps based on user behavior.

Table 2.1: Summary of selected articles related to anxiety management using VR and mobile technologies.

2.3.4 Differentiation of This Project

While the reviewed literature offers valuable contributions, this project stands out by directly addressing several of the identified gaps and challenges:

- **Integrated Dual-Platform Solution:** Unlike most works that focus solely on VR or mobile platforms, this project merges both, enabling users to access support regardless of their environment or available hardware.
- **Real-Time and Personalized SOS Intervention:** Tackles the lack of immediate support in existing tools by introducing an SOS module that uses predefined user preferences and physiological state (e.g., via heart rate sensors) to trigger grounding and calming interventions dynamically.
- **User-Centered Personalization:** Moves beyond one-size-fits-all designs by allowing adaptive content based on individual behavior, mood patterns, and feedback – in line with personalization algorithms discussed in the literature but not widely implemented.
- **Gamified Motivation Engine:** Applies gamification not just for engagement but as a therapeutic mechanism to reinforce habit formation and emotional resilience through daily interactive challenges and rewards.
- **Ethically-Compliant Design:** Incorporates strict adherence to GDPR, transparent data usage, and ethical design principles — essential but often overlooked in existing implementations.

- **Focus on Accessibility and Inclusivity:** Prioritizes affordability and cultural relevance through the use of lightweight mobile solutions and low-cost VR experiences, expanding usability to underrepresented populations.

By tackling the critical gaps from real-time crisis response to ethical data handling and engaging design this project offers a robust and holistic approach to anxiety and panic attack management.

These differentiating features directly address the key limitations identified in the existing literature, which are further detailed in the following section.

2.4 Gaps and Challenges

Despite the advancements in technological solutions for mental health, several gaps and challenges persist, limiting the effectiveness and accessibility of current tools.

2.4.1 Lack of Personalized and Immediate Support

Existing solutions often fail to provide real-time, personalized interventions during acute anxiety episodes or panic attacks. This gap is particularly evident in:

- **Generalized Approaches:** Most mobile applications and VR tools offer one-size-fits-all solutions, which do not adapt to the unique needs, triggers, and preferences of individuals (Lattie and Mohr 2020).
- **Crisis Management:** Tools that provide immediate support during panic attacks, such as real-time grounding exercises or guided breathing, are scarce or not widely implemented in commercially available apps (Venturo-Conerly et al. 2022).

This lack of personalization and immediate accessibility highlights the need for tools that dynamically adapt to the user's emotional and physiological state.

2.4.2 Ethical and Regulatory Considerations

As highlighted earlier, the integration of technologies such as VR and mobile applications into mental health interventions raises ethical and regulatory issues:

- **Data Privacy:** Sensitive health data collected by these tools must be securely stored and used in compliance with regulations such as GDPR.
- **Informed Consent:** Ensuring users understand how their data is collected, used, and shared remains a significant challenge.
- **Lack of Specific Standards:** There is a shortage of guidelines specifically designed for the ethical use of VR and gamified tools in therapeutic settings, leading to significant concerns about data privacy and user safety (Torous et al. 2021).

Addressing these challenges requires collaboration between developers, mental health professionals, and policymakers to create clear, ethical frameworks for digital health tools.

2.4.3 Barriers to Accessibility and Engagement

While mobile devices and VR headsets are powerful tools, their accessibility and engagement present challenges:

- **Affordability:** High-quality VR headsets, such as the Oculus Quest 2, remain cost-prohibitive for many users.
- **User Experience:** Poorly designed interfaces can make therapeutic applications difficult to use, particularly for those in distress.
- **Cultural Relevance:** Many tools are not adapted for diverse cultural contexts, which can limit their effectiveness in certain populations, an issue known as the "digital divide" in mental healthcare. (Wasil, Schleider, and Weisz 2020) .

Ensuring affordability, inclusivity, and user-friendly design is critical for the broader adoption of these tools.

2.4.4 Opportunities for Innovation

These gaps create opportunities for innovation in anxiety management technologies:

- **Dynamic Personalization:** Using data-driven insights to tailor interventions to the user's specific needs and triggers.
- **Real-Time Support:** Leveraging mobile notifications, sensors, and VR simulations to provide immediate assistance during panic attacks.
- **Gamification:** Incorporating serious game mechanics to motivate users to engage with anxiety management exercises on a daily basis.
- **Improved Accessibility:** Developing affordable VR tools and simplifying mobile applications to ensure wider accessibility.

By addressing these challenges, the project can create a more impactful and user-centered tool for anxiety and panic management.

Chapter 3

Design and Development

3.1 Design and Requirements

This section outlines the conceptual and functional foundations of the proposed solution, detailing the main requirements and design principles that guide its development.

The design process is supported by psychological theory, existing technological practices, and direct input from mental health professionals. Particular attention is given to personalization, accessibility, and the integration of evidence-based therapeutic strategies into an interactive and user-friendly environment. The following subsection presents the expert feedback that helped shape and validate the initial design requirements.

3.1.1 Expert Feedback: Interview with Psychologists

To validate and refine the design of the proposed solution, an interview was conducted with two psychologists - referred to as P1 and P2 - who collaborated in a joint session to brainstorm and share professional insights. P1 holds a master's degree in educational psychology and a specialization in sports psychology, while P2 has a master's degree in clinical psychology and a postgraduate degree in clinical sexology and couples therapy. Both have approximately three years of experience working with anxiety and panic disorders.

The interview aimed to evaluate the therapeutic effectiveness of integrating relaxation and mindfulness techniques within a gamified digital environment, as well as to explore potential therapeutic methods and game mechanics suitable for the solution. The questions asked were designed based on previously identified challenges, such as personalization, accessibility, and motivational aspects detailed in Chapters 1 and 2.

Questions and Key Feedback

The following summarizes the questions presented and key insights from participants, reformulated to improve clarity and academic consistency.

- **Q1. Are breathing and mindfulness exercises effective for anxiety reduction, and does it make sense to incorporate them into a digital, gamified solution?**
  Both psychologists confirmed the effectiveness of breathing and mindfulness techniques. They emphasized that integrating these practices into a gamified environment is highly relevant, particularly for individuals with low intrinsic motivation. Gamification could serve as a motivational catalyst, increasing engagement with therapeutic content.

- **Q2. Can gamification increase adherence to these practices? What elements could enhance its effectiveness?**
  Gamification was seen as particularly useful for helping individuals remember to practice regularly. Suggestions included adding user-customizable notifications and reminders, allowing users to schedule them according to their routine. Personalizable environments and exercises were considered essential to reinforce engagement and emotional safety.

- **Q3. Given the variability of anxiety symptoms between individuals, how should the exercises be adapted?**
  The experts recommended offering the same types of exercises with adjustable parameters (e.g., intensity, duration, pace), and allowing customization of ambient noise and visual environments. This flexibility would help meet diverse user profiles and comfort levels.

- **Q4. What kind of interactive task or game mechanic could help users practice mindfulness effectively?**
  Both psychologists emphasized the importance of nature-based environments, highlighting that users should have the ability to select their preferred settings. They proposed adapting the grounding technique 5-4-3-2-1, a mindfulness practice in which individuals identify five things they can see, four they can touch, three they can hear, two they can smell, and one they can taste. Considering the VR medium, the focus should primarily be placed on the sensory modalities that can be realistically stimulated through virtual immersion—specifically visual, auditory, and tactile experiences.

  Within VR, the gameplay mechanic could guide users to visually explore and identify specific calming or intriguing visual elements in the environment, actively listen for subtle ambient sounds (such as birds, wind, or water flowing), and interact tactilely with virtual objects that provide haptic feedback (e.g., touching leaves, stones, or water surfaces). Additionally, the psychologists recommended simple interactive breathing games, such as virtually blowing out a candle in sync with guided breathing patterns, further enhancing mindfulness through coordinated sensory engagement.

- **Q5. What immediate tools would be most useful during an anxiety or panic crisis in the SOS module?**
  Key recommendations included: immediate environmental change through VR (i.e., automatic immersion in a calming space upon headset use); breathing exercises that help shift the user's attention away from the stressful situation; and sensory redirection, such as interacting with cold virtual objects. Although personalization improves effectiveness, both psychologists acknowledged that success cannot be guaranteed in all crisis situations.

- **Q6. Are there additional psychological techniques that could be adapted to the digital experience?**
  Guided meditation was suggested as a powerful technique. They recommended creating scripts and validating them with experts before integration into the platform.

- **Q7. What are the main concerns when designing a VR experience for users with anxiety?**
  The environment must not be overwhelming. It should be simple, calming, and adaptable to user preferences. One important concern raised was the risk of dependency—users becoming overly reliant on VR environments for emotional regulation.

- **Q8. What adaptations should be made to ensure that the mobile version is equally effective?**
  The solution should maintain interactivity (e.g., use of vibration feedback), disable external notifications during use, and apply gamification to ensure ongoing engagement.
- **Q9. Which elements should be customizable to ensure a personalized experience without affecting usability?**
  All elements—exercise type, duration, intensity, and audiovisual feedback—should be customizable. However, to avoid overwhelming users, a "quick start" or simplified onboarding option should also be offered.
- **Q10. What differentiating features could this solution offer compared to existing tools?**
  The integration of VR, gamification, and deep personalization was identified as a clear differentiator. Both psychologists also highlighted the importance of usability and efficacy testing, and the need to monitor potential dependency on the tool.

Key Takeaways and Design Implications

Based on the analysis of the psychologists' feedback, the following key points were identified as critical design implications for the solution:

- **Customization is key:** All modules must include adjustable parameters for audio, visual, and exercise pacing.
- **Simplicity is essential:** Especially in crisis scenarios, the user interface and navigation must be streamlined and intuitive.
- **Gamification should support, not distract:** Challenges, points, or rewards must enhance engagement without compromising therapeutic value.
- **VR is powerful but must be used with caution:** It must be calming, not overstimulating, and offer alternatives to the real world.

This collaborative validation step confirmed the relevance of the proposed concepts and provided concrete directions for content creation, system architecture, and feature prioritization in subsequent development phases.

3.1.2 Gamification Design Principles

The gamification approach is based on the following principles:

- **Relaxation over reward:** The game avoids traditional reward loops or competitive features. The focus is on intrinsic motivation and emotional relief.
- **Gentle pacing:** All interactions are designed to be slow and deliberate to support emotional regulation.
- **Sensory alignment:** Each phase targets a specific sense, reinforcing the connection between gameplay and therapeutic grounding.
- **Emotional feedback:** Visual cues (soft animations, color transitions) and audio (soothing soundscapes) are used to guide and reward actions in a calming manner.

3.1.3 Strategies for Engagement and Long-Term Use

Although the game is not based on performance metrics, minimal progression elements are used to encourage continued engagement and habit formation:

- **Breathing cycle tracking:** Each breathing session counts the number of completed cycles. If the user surpasses a previous record, a gentle "New Record" message is shown to provide a sense of accomplishment.
- **Daily engagement monitoring:** The application tracks how many times the user has launched the experience across different days.
- **Reminder notifications:** Users receive daily notifications encouraging them to return to the game and complete at least one relaxation phase. This helps reinforce consistency and long-term emotional resilience.
- **Positive reinforcement:** Upon completing all five phases, the user is shown an encouraging message, emphasizing self-care and emotional awareness.

These elements support therapeutic goals through stress-free engagement and served as the foundation for the structural design presented next.

3.2 Application Design

This section presents the conceptual and structural design of the application, covering the main components, the user interaction flow, and the strategies employed to enhance motivation and engagement through gamification.

3.2.1 System Overview

The application was structured around two primary modes: the **Normal Mode**, designed for daily relaxation and emotional regulation, and the **SOS Mode**, which serves as a rapid intervention tool during high-anxiety episodes. Each mode includes a set of carefully crafted phases focused on different senses or cognitive processes (visual, auditory, physical, emotional, and mental).

The user interface is centered on simplicity and accessibility, allowing players to navigate intuitively through menus and experiences. Customization options, such as environmental settings or preferred activities, are provided to ensure the experience adapts to different preferences and levels of anxiety.

3.2.2 User Flow and Interaction Design

To clarify the structure and behavior of the application, a series of flow diagrams was developed. These diagrams illustrate the user's journey from the moment the application is launched, including the available modes (Normal and SOS) and how users interact with the system.

Global Application Flow

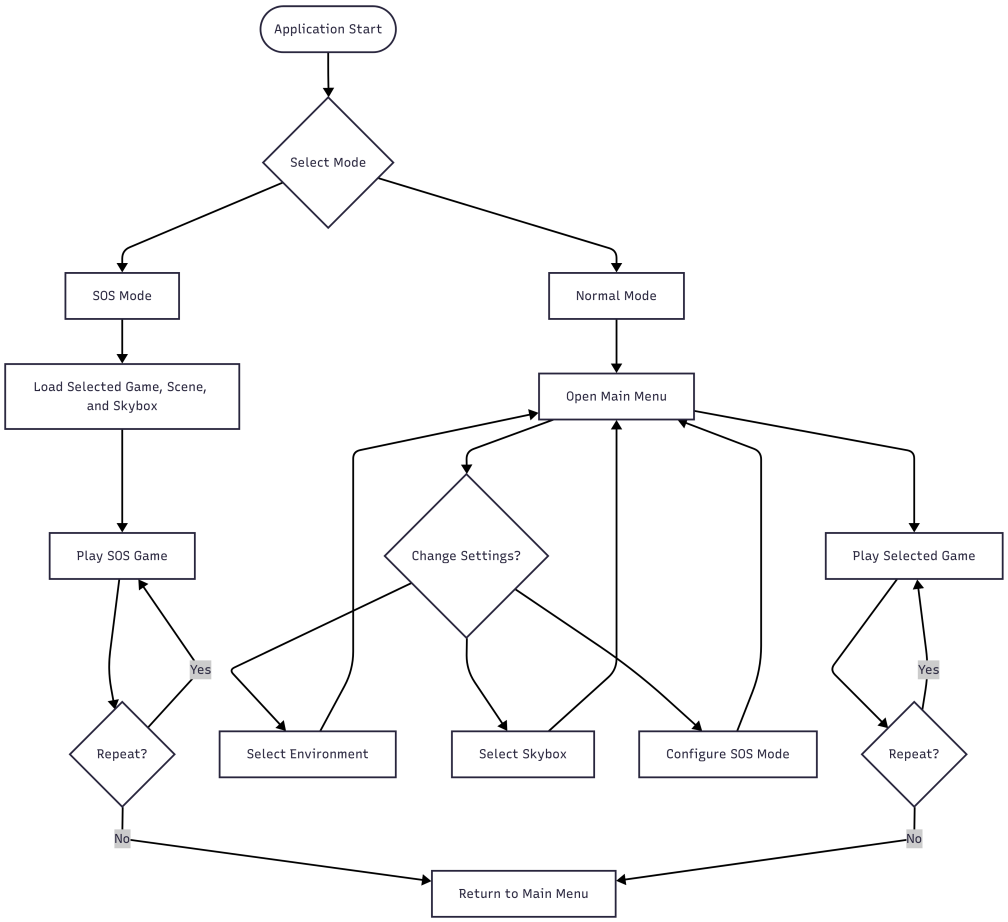

Figure 3.1: User Flow Diagram showing navigation across Normal and SOS modes.

Beyond the global application flow, individual diagrams were created to describe the internal logic of each game phase. These diagrams outline the sequence of steps, user actions (e.g., movement, interaction, decision-making), and transitions that define the progression through each activity. This modular approach not only improves clarity for both users and developers but also supports future scalability of the system.

Butterfly Phase Flow

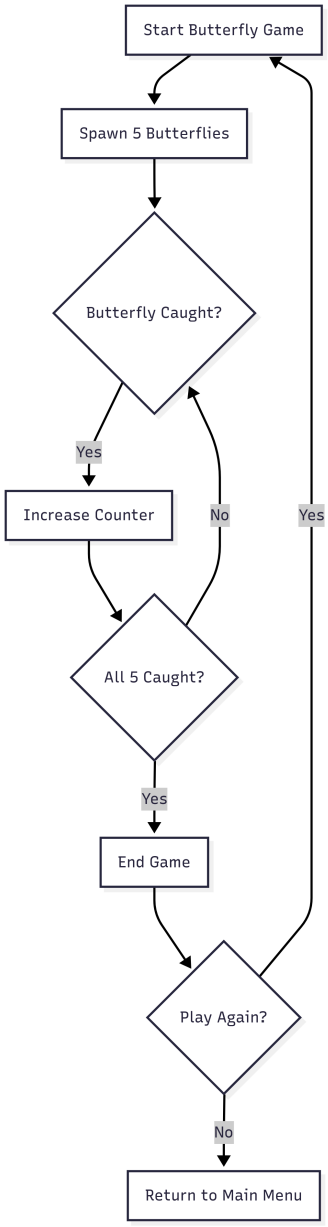

Figure 3.2: Flowchart of the Butterfly Phase.

Figure 3.2 depicts the logic of the Butterfly phase, in which the player must catch five butterflies. The game begins by spawning the butterflies around the player, who then collects them through interaction. Once all butterflies have been caught, the player can choose to replay the activity or return to the main menu. This simple yet engaging structure was designed to offer a sense of achievement while reinforcing mindfulness and focus.

Mushroom Phase Flow

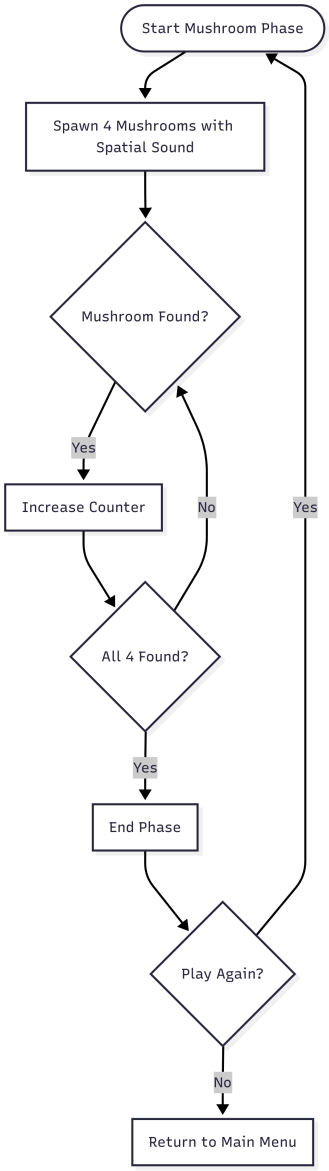

Figure 3.3: Flowchart of the Mushroom Phase.

Figure 3.3 presents the logic of the Mushroom phase. In this activity, four mushrooms are spawned around the user and emit spatial audio cues. The player must explore the environment and rely on directional sound to locate each mushroom. Upon finding one, the system updates the count, and once all mushrooms are collected, the player is offered the choice to repeat the phase or return to the main menu. This activity is designed to promote focus and sensory awareness through auditory engagement.

Breathing Phase Flow

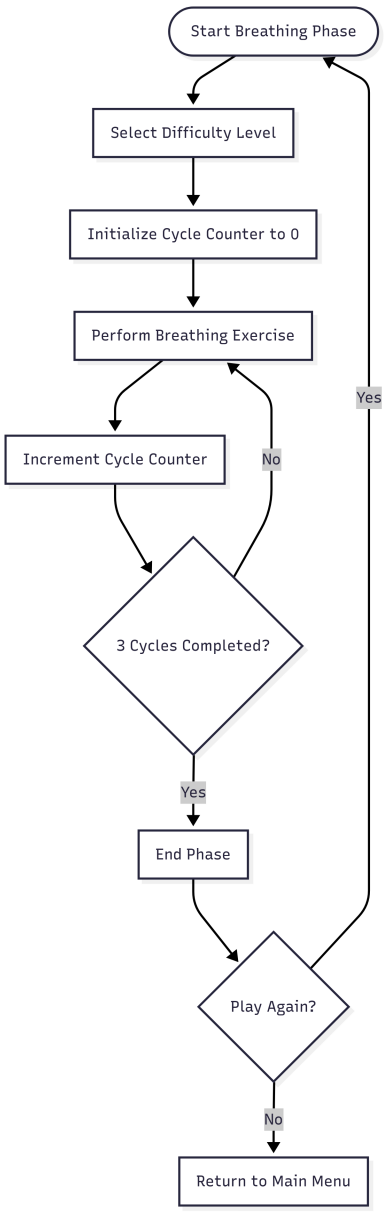

Figure 3.4: Flowchart of the Breathing Phase.

Figure 3.4 illustrates the structure of the Breathing Phase. At the beginning of the activity, users select a difficulty level, which influences the duration and pacing of the breathing instructions. The game then guides the player through three complete breathing cycles. After each cycle, the system increments a counter and checks for completion. Once all cycles are finished, the user may choose to repeat the exercise or return to the main menu. This phase aims to promote calmness and emotional regulation through paced breathing.

Petting Phase Flow

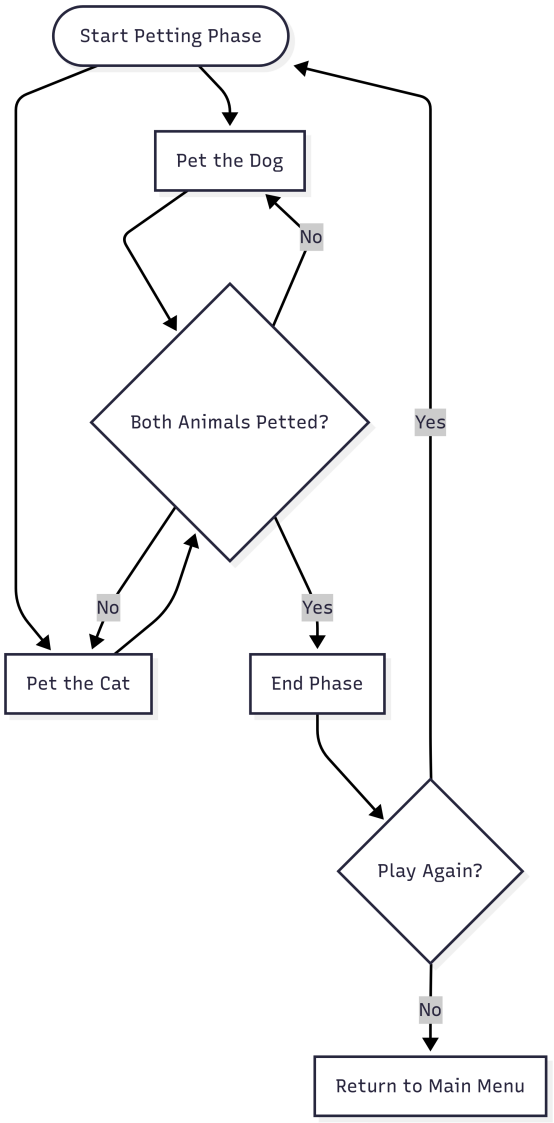

Figure 3.5: Flowchart of the Petting Phase.

Figure 3.5 represents the Petting Phase, a calming activity where the player interacts with two virtual animals: a dog and a cat. The user can choose the order of interaction, and the phase ends once both animals have been petted. This mechanic emphasizes gentle interaction and promotes a sense of emotional safety and comfort. After completing the phase, the user may choose to repeat the experience or return to the main menu.

Guided Meditation Phase Flow

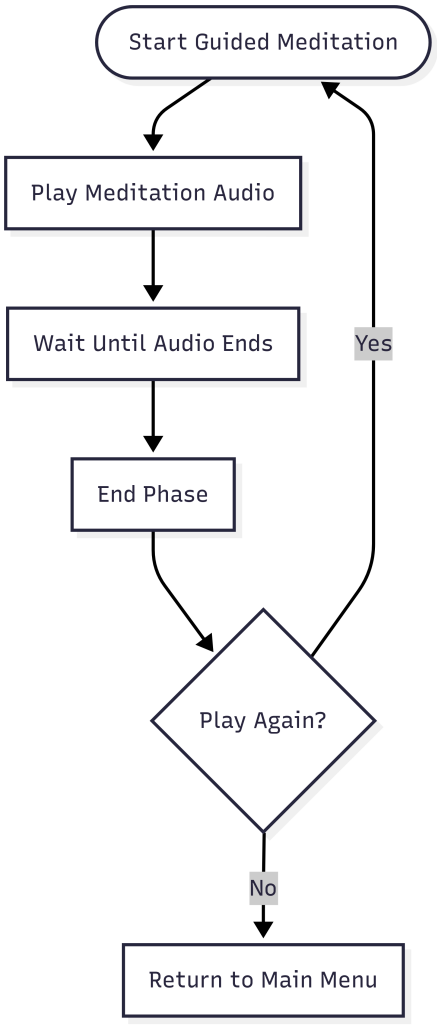

Figure 3.6: Flowchart of the Guided Meditation Phase.

Figure 3.6 illustrates the Guided Meditation Phase, where the user passively listens to a calming meditation audio. The experience begins with the user initiating the session, which then plays a pre-recorded audio track designed to promote mindfulness and relaxation. Once the audio ends, the user can choose to replay the session or return to the main menu. This phase serves as a soothing break from interaction, helping regulate breathing and focus.

54321 Mode Sequence Phase Flow

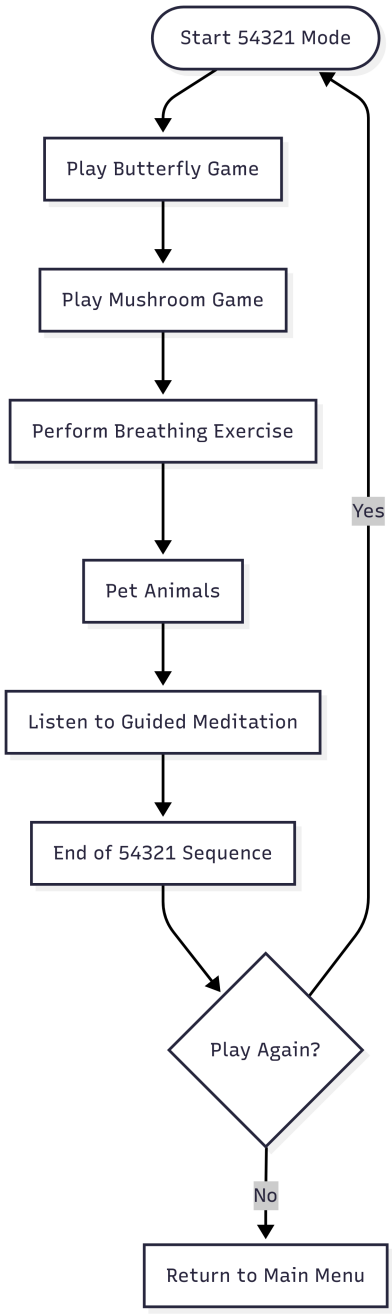

Figure 3.7: Flowchart of the 54321 Mode Sequence.

Figure 3.7 depicts the 54321 Mode, a structured sequence where users engage in five consecutive activities designed to gradually reduce anxiety and promote mindfulness. The mode includes catching butterflies, locating mushrooms through sound, performing guided breathing exercises, petting virtual animals, and ending with a guided meditation session. Each activity flows seamlessly into the next, creating a continuous and calming experience. Upon completing the full sequence, users may either restart the cycle or return to the main menu.

3.2.3 Gamification and Motivation Strategy

To promote engagement and increase adherence to daily relaxation routines, several gamification elements were integrated into the system:

- **Daily Streak Tracker:** A system that records the number of consecutive days the user engages with the application. This feature encourages habit formation and provides intrinsic motivation by offering visual rewards or milestones.
- **Progress Feedback:** During gameplay, the user receives continuous feedback about their progress in each phase. For example, how many butterflies have been caught, or how many breathing cycles are left. This helps maintain focus and a sense of achievement.
- **Custom Notifications:** Users can schedule daily reminders to practice relaxation exercises. These reminders appear at the chosen time and aim to gently encourage the user to return to the app without creating stress.

These elements follow behavioral design principles that favor consistency over pressure, allowing the user to feel rewarded without feeling judged or monitored.

Gamification Strategy

The application integrates a gamified structure inspired by the 54321 grounding technique, which is widely used in anxiety regulation. This technique encourages individuals to focus on their surroundings and sensations through a structured sequence of sensory engagement. The gamification strategy transforms each step into an interactive phase with playful and immersive elements, reinforcing emotional regulation through engagement and flow.

3.2.4 Mapping the 54321 Technique to Game Phases

Each phase of the 54321 method has been mapped to a specific game mechanic:

- **5 things you see** → *Butterflies:* The player locates and collects five butterflies, encouraging visual attention and spatial exploration.
- **4 things you hear** → *Mushrooms:* Interactive mushrooms emit distinct relaxing sounds. The player listens and activates four different ones to sharpen auditory focus.
- **3 things you feel** → *Breathing Exercise:* A slow breathing cycle phase with visual and auditory cues helps the user reconnect with bodily sensations.
- **2 things you touch** → *Petting Phase:* The player interacts gently with a dog and a cat, promoting tactile engagement and emotional comfort.
- **1 thought** → *Guided Meditation:* A final short meditation leads the user to reflect on a single positive or grounding thought, completing the cycle.

3.2.5 Conclusion

The design of the application prioritizes clarity, emotional impact, and ease of use. Through structured interaction flows and engaging mini-games, the system offers users both flexibility and therapeutic value. By combining visual, auditory, and emotional stimuli across well-defined phases, the application effectively supports users in managing anxiety in both routine

and emergency contexts. This thoughtful design lays a solid foundation for meaningful interaction and long-term engagement.

3.3 Implementation

This section presents the technical implementation of the proposed solution, including the platforms, tools, and methodologies used throughout development. Details how each component was developed, integrated and tested to produce a functional prototype that supports anxiety management through immersive experiences.

3.3.1 Technology Stack

The development was carried out using the following core technologies:

- **Unity (C Sharp)** - Used as the primary engine for both VR and mobile platforms due to its versatility and support for both devices.
- **Oculus SDK** - Integrated to support standalone VR experiences on Oculus Quest devices.
- **Unity PlayerPrefs** - Used to persist user preferences and profile data locally.
- **GitHub** - Used for version control and collaborative code management.

3.3.2 Architecture and Project Structure

The system adopts a modular and user-centric architecture, structured around two primary gameplay modes and enhanced by gamification mechanisms to promote engagement and adherence. Each gameplay phase, whether visual, auditory, physical, emotional, or mental, is implemented as an independent Unity script, encapsulated to ensure reusability and maintainability. A central game manager orchestrates phase transitions, tracks user progress, and controls the overall application flow.

Upon launching the application, the user is greeted with a main menu that offers access to two distinct experiences: **Normal Mode** and **SOS Mode**.

- **Normal Mode:** This is the core gameplay experience, located in an open-world environment where the player can freely explore and interact with various exercises. Users have the freedom to initiate individual activities, such as breathing routines, guided meditations, or grounding tasks, or opt to play the full 5-4-3-2-1 sequence. A teleportation mechanic allows players to navigate between predefined locations in the environment. This spatial freedom reinforces immersion and supports personalized usage patterns.
- **SOS Mode:** Tailored for moments of acute distress, this mode instantly places the user in a calming, preconfigured scenario. Prior to activation, users can personalize key elements of this mode, such as the preferred type of relaxation activity (e.g., breathing or meditation), the virtual skybox (visual ambiance), and the destination environment. The primary goal of this mode is to minimize cognitive load and deliver a soothing intervention as quickly and intuitively as possible during a crisis.

The main menu further enables users to configure system preferences, sound levels, music choices and visual settings.

To enhance user motivation and long-term engagement, two key gamification features were implemented:

- **Motivational Tracker:** A tracking system logs user engagement across sessions and highlights progress, specifically by recording the number of consecutive days the user completes at least one exercise. This encourages habit formation and offers a sense of accomplishment through visual indicators or subtle rewards.
- **Customizable Notifications:** Users can opt to receive daily reminders to engage with the app. These notifications are fully configurable—users can define the specific time at which they want the notification to appear, aligning with their personal routines and preferences.

Together, these architectural and gamification components contribute to a personalized, accessible, and effective user experience, aligned with the therapeutic goals of the application.

3.3.3 Development Methodology

The game was developed using an iterative, self-driven process inspired by Agile principles. The solo development allowed for rapid prototyping and continuous integration of feedback received from psychologists and testers.

Each gameplay phase was tested independently before full integration. Adjustments were made after internal tests and expert validation sessions.

3.3.4 Interaction and Input Handling

The interaction system was architected to be fundamentally hardware-agnostic, ensuring maximum compatibility. Although initial development used the Oculus Quest controllers as a reference, VR interactions such as trigger presses and raycasting, are mappable to any model of Virtual Reality controller.

To further increase accessibility, the system is also compatible with conventional console controllers (gamepads). On the mobile platform, these interactions were intuitively adapted for touch-based controls.

3.3.5 User Profile and Preferences Management

User profiles were managed locally using Unity's `PlayerPrefs` system, which allowed saving key preferences such as breathing pace, selected environment, and difficulty levels. This personalization ensured that returning users could seamlessly continue their experience with retained settings tailored to their needs.

Although the current implementation stores data locally, the system was architected with future scalability in mind. It is fully prepared to integrate a remote database and support user authentication, enabling features such as cross-device synchronization, cloud-stored progress, and secure login functionality. This would allow the transition to a multi-device ecosystem with personalized access and longitudinal tracking of therapeutic engagement.

3.3.6 UI/UX Considerations

Significant effort was invested in designing a clear, minimal, and calming interface. UI choices avoided clutter and excessive animation to reduce the risk of overwhelming the user—particularly important in a solution targeting anxiety and panic.

Color schemes, button placement, and fonts were selected in collaboration with psychologists to maintain a soothing aesthetic.

3.3.7 Challenges Faced

The main challenge was to balance interactivity and clarity in a therapeutic context. Complex UI interactions had to be simplified, and feedback from psychologists was crucial in identifying elements that could trigger confusion or stress.

Maintaining consistency across both VR and mobile versions, while ensuring a seamless and comfortable experience, required repeated refinements.

3.3.8 Phase-by-Phase Implementation

Each phase of the game was designed as an independent module with a distinct focus area, built using Unity and C#. These modules encapsulate all the logic and assets required for their operation, promoting modularity and ease of testing. Below is a detailed breakdown of the implementation for each phase.

Butterfly Phase – Visual Focus ("5")

This phase is designed to encourage visual engagement and attentional focus through the task of locating and catching butterflies in a calming virtual environment.

Figure 3.8: A first-person view of the Butterfly Phase, where the player is surrounded by butterflies.

Upon activation, the player is surrounded by a predefined number of butterflies, instantiated using the `ButterflySpawner.cs` script. Each butterfly is positioned randomly within a circular area around the player, at a specific height, ensuring visibility and accessibility. The spawning logic uses the position of the player's head to define the central reference point.

Butterflies move in looping, circular paths that simulate a natural flight pattern. This movement is manually controlled (rather than using Unity's `NavMeshAgent`) by adjusting position values with sine and cosine functions in the `Butterfly.cs` script. Vertical fluttering is added using a sinusoidal Y-axis offset, and slight randomization in speed and radius ensures organic, non-repetitive behavior.

To catch a butterfly, the player must physically move their VR controller near it. The detection of capture is handled via trigger collision using Unity's physics system. When contact with a hand or player collider is detected, a sound is played, the butterfly is destroyed, and the counter is incremented through a callback to the spawner. Once all butterflies are caught, the system automatically transitions to the next phase.

Scripts Used:

- `ButterflySpawner.cs` - Instantiates and positions butterflies, tracks capture count, and manages transitions.
- `Butterfly.cs` – Controls butterfly movement and collision-based capture logic.
- `MindfulnessProgressUI.cs` – Displays the capture progress to the user in real-time.

Mushroom Phase – Auditory Focus ("4")

This phase encourages auditory focus by guiding the player to locate mushrooms using spatial sound. Unlike the butterfly phase, which emphasizes visual tracking, this stage relies entirely on listening skills to find and approach hidden interactive elements.

When the challenge starts, mushrooms are instantiated around the player within a defined radius. Their position is calculated using the XR origin and the player's head location as a reference point, and then adjusted vertically to align with the ground using raycasting. Each mushroom emits a spatial audio cue via a looping sound, implemented using Unity's 3D audio system.

The player must explore the environment and follow the sound source using audio localization techniques. Upon approaching a mushroom and triggering a collision with the player's hand or body, a confirmation sound is played, and the mushroom is destroyed. Progress is updated via the UI, and when all mushrooms are collected, the game automatically transitions to the next phase (typically the breathing exercise in 54321 mode).

Scripts Used:

- `MushroomManager.cs` – Handles mushroom spawning, interaction tracking, and game progression.
- `Mushroom.cs` – Manages individual mushroom behavior, collision detection, and pickup logic.
- `MindfulnessProgressUI.cs` – Displays the player's progress in real-time.

Breathing Phase – Physical Focus ("3")

This phase is designed to support users in regulating their breathing through synchronized visual and optional auditory cues. Upon starting, the player is asked to choose a difficulty level—easy, medium, or hard—which adjusts the duration of each breathing cycle. Easier

levels use shorter inhale, hold, and exhale intervals, while harder levels require prolonged breath control.

- A progress bar and a water surface animation guide the user through the breathing cycle by expanding (inhale), pausing (hold), and contracting (exhale).
- The breathing sequence is composed of two full cycles per round: *inhale*, *hold*, *exhale*, *hold*. Timing is managed using Unity coroutines and LeanTween animations.
- Visual cues include color transitions during hold phases and synchronized vertical movement of a water plane.
- The duration of each phase varies according to difficulty:
  - **Easy:** 5s inhale, 5s hold, 5s exhale, 5s hold
  - **Medium:** 7s inhale, 7s hold, 7s exhale, 7s hold
  - **Hard:** 10s inhale, 10s hold, 10s exhale, 10s hold
- After completing five cycles, the game either transitions to the next 54321 phase (if enabled) or returns to the main menu. A "New Record" message is shown if more cycles were completed than in past sessions.

Scripts Used:

- `BreathingCycle.cs` – Controls the entire flow, timing, UI updates, animations, and mode transitions.
- `BreathingDifficultySelector.cs` – Applies the chosen difficulty level and initiates the breathing session.
- `BreathingProgressUI.cs` – Updates progress indicators throughout the exercise.
- `BreathingSoundPlayer.cs` – (Optional) Plays guided breathing sounds for additional focus.

Petting Phase – Tactile/Emotional Focus ("2")

This phase fosters emotional grounding through the act of petting virtual animals. It is designed to simulate a calm, rewarding interaction by requiring the user to gently place their hand over a dog and then a cat.

- A dog and a cat are spawned in front of the user using directional projection based on the VR headset's orientation.
- Each animal includes a collider zone that detects if the player's hand (tagged `"PlayerHand"`) stays within range for a set duration (typically 3 seconds).
- The interaction is validated in real-time via a timer: if the player exits the collider too early, the timer resets, encouraging steady hand presence.
- Once a petting task is completed, an optional audio clip plays, the animal disappears, and the next step is triggered (e.g., from dog to cat).
- After both animals have been successfully petted, the system transitions to the final guided meditation phase.

Scripts Used:

- `PettingSequence.cs` – Controls the sequence and flow between animals, UI feedback, and phase transition.
- `PettableAnimal.cs` – Manages the detection of the user's hand within the collider and validates sustained petting time.
- `MindfulnessProgressUI.cs` – Provides visual instructions and congratulatory messages after each step.

Guided Meditation – Mental Focus ("1")

This final phase of the experience promotes inner calm through a guided meditation. The user is placed in a tranquil setting, where they can relax and listen to a pre-recorded audio without performing any active task.

- A serene virtual environment is activated (e.g., forest or sunset scene), reinforcing the meditative atmosphere through visuals.
- A guided meditation script is played using a spatialized `AudioSource`, leading the user through a calm and reflective experience.
- The user is not required to perform any actions; their only task is to remain present and attentive.
- The session ends either automatically when the audio completes or manually via an optional "End Meditation" button, after which the main menu is reactivated.

Scripts Used:

- `MeditationPhase.cs` – Manages environment activation, audio playback, and session flow, including optional early termination.
- `MindfulnessProgressUI.cs` – Displays the final message upon completion.

Progress Feedback – Game 54321

Throughout the 54321 game mode, the user receives real-time feedback via a floating UI element that updates dynamically according to the current phase of the experience.

- The `MindfulnessProgressUI.cs` script is responsible for displaying task-specific progress indicators, such as the number of butterflies or mushrooms collected, the current breathing cycle, or instructions during petting and meditation.
- The interface appears at the beginning of each phase using `Show()`, and it is hidden or reset with `Hide()` once the phase ends.
- The progress text adapts automatically based on context through specific methods such as `SetButterflyProgress()`, `SetMushroomProgress()`, or `SetBreathingCycle()`.
- The component also supports instructional and motivational messages using `ShowPetInstruction()`, `ShowFinalMessage()` and `SetSecondaryMessage()`.
- It follows a singleton pattern to ensure centralized access from any gameplay script.

Script Used:

- `MindfulnessProgressUI.cs` – Centralized UI manager for guiding and informing the player through each mindfulness activity in the 54321 sequence.

SOS Mode

This mode provides instant relief in moments of acute anxiety or distress by immediately launching a pre-configured calming activity.

- Upon activation, the application skips all menus and directly starts a selected activity such as breathing or guided meditation.
- The user's preferences are stored using `PlayerPrefs`, including the preferred activity (`SOS_Game`), skybox environment (`SOS_Time`), and spawn position (`SOS_Position`).
- The player is repositioned to a predefined location and the environment's skybox is adjusted accordingly to match the desired ambiance (e.g., day or night).
- The selected activity is launched automatically if the corresponding component is found and active in the scene.

Scripts Used:

- `SOSLoader.cs` – Reads stored preferences, sets player position and environment, and triggers the appropriate calming activity without user interaction.
- `SkyboxSwitcher.cs` – Changes the visual skybox based on the user's selected time of day.
- `BreathingCycle.cs` and `MeditationPhase.cs` – These are used depending on the chosen SOS activity.

Menu System, Skybox Settings, and Teleportation Tools

The menu structure and environmental controls play a key role in ensuring accessibility and immersion throughout the experience. The system was designed to enable smooth navigation between gameplay modes and dynamic environmental adjustments.

Navigation Menu and Game Launching The `StartupModeSelector.cs` class is responsible for presenting users with the initial choice between Normal and SOS modes. This startup menu is automatically positioned in front of the player's camera at runtime, ensuring immediate visibility and accessibility.

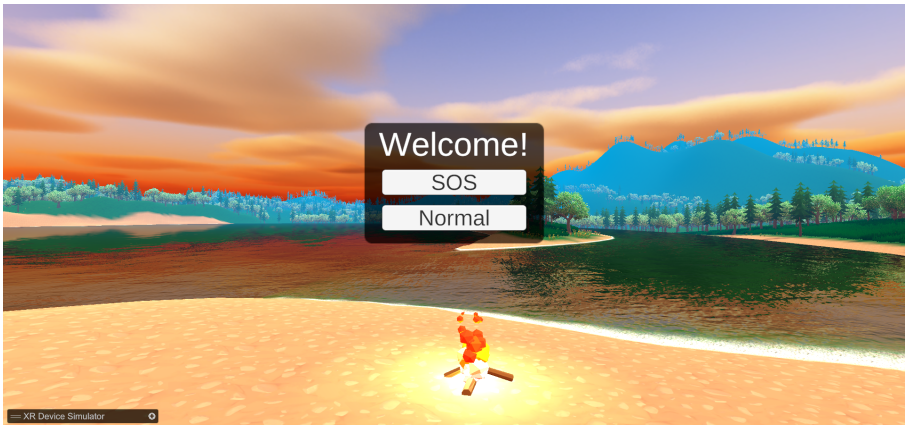

Figure 3.9: The initial startup menu presenting the choice between Normal and SOS modes.

The `MainMenuActions.cs` script manages the logic behind the main menu buttons, allowing users to start any of the available activities — including meditation, breathing, petting, or the 54321 game mode. The menu also provides options to set background music, adjust the time of day (via Skybox), or teleport to predefined locations. All menus are dynamically repositioned based on the player's orientation.

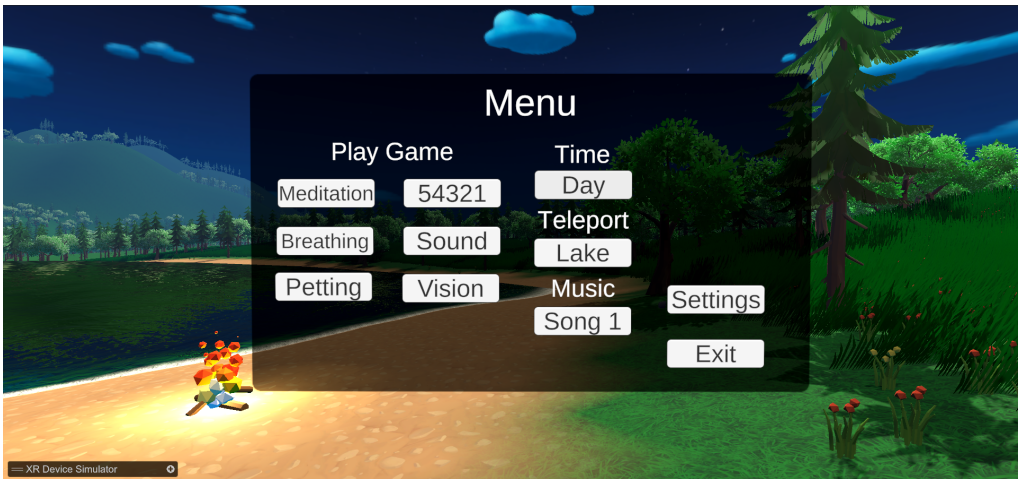

Figure 3.10: The main menu interface, providing access to all activities and settings within the Normal Mode.

Environmental Visuals – Dynamic Skybox The `SkyboxSwitcher.cs` class enables seamless transitions between different environmental themes such as "Day" or "Sunset." Each preset includes a skybox material along with fog settings to enhance depth and atmosphere. The system automatically adjusts fog color based on sky brightness, ensuring visual coherence across environments.

Figure 3.11: Comparison of the different environmental themes (skyboxes) available in the application.

Spatial Teleportation To improve user mobility, the `TeleportManager.cs` script allows for seamless teleportation between multiple virtual locations. The application includes three predefined destinations: a tranquil Lake, a sunny Beach, and a minimalist White Room, which serves as a neutral starting space. The system is designed to be easily extensible, allowing for more locations to be added in the future. Each destination includes a predefined rotation to ensure the player is correctly oriented upon arrival. After teleportation, the main menu is automatically repositioned in front of the player to remain accessible and easy to interact with.

Figure 3.12: The White Room, a neutral and minimalist environment serving as one of the key teleportation hubs.

3.4 Conclusion

This chapter detailed the complete journey from the conceptualization to the technical implementation of the proposed anxiety management solution. Grounded in the insights from mental health experts and established design principles, a robust, user-centric architecture was designed. This design was then translated into a functional prototype, featuring two core modules (Normal and SOS Mode) and a gamified structure based on the 5-4-3-2-1 grounding technique.

The result of this phase is a cohesive and functional application, developed in Unity for both VR and mobile platforms, ready for the crucial next stage of evaluation. The following chapter will focus precisely on this validation process, presenting the results from testing with both experts and end-users to assess the solution's usability, effectiveness, and overall therapeutic potential.

Chapter 4

Testing, Validation and Discussion

4.1 Testing and Validation

This section describes the evaluation phase of the project, including both expert validation and user testing. It is structured in two parts: first, the expert feedback from two psychologists (P1 and P2) based on their direct experience with the implemented prototype; second, a summary of the feedback collected from end-users through a structured questionnaire.

4.1.1 Expert Evaluation of the Game

Following the development of the prototype, two professional psychologists were invited to test the game and provide their insights. They interacted with each phase of the experience and subsequently responded to a structured interview composed of both standardized usability questions and gameplay specific reflections.

The validation instrument was divided into three key sections:

- **Game Usability Assessment (adapted SUS scale):** Psychologists were asked to rate usability using a 10-point Likert scale (1 = Strongly Disagree, 10 = Strongly Agree) across several dimensions such as ease of use, clarity of instructions, and consistency.
- **Gameplay Phase Assessment:** Each interactive phase of the game was evaluated for its effectiveness, intuitiveness, relaxation potential, and therapeutic value. Psychologists also assessed how well the mechanics reflected their intended sensory or cognitive focus (e.g., visual for the butterfly phase).
- **Validation of Interview Questions:** For each item in the evaluation framework, psychologists were asked to judge whether the question was clear, appropriate, and effective for end-user assessment. They were also invited to suggest improvements.

System Usability Scale (SUS) Interview Items

- I found the game unnecessarily complex.
- I found the game easy to use.
- I needed the help of a technical person to use this game.
- The different functions in this game are well integrated.
- I found there was too much inconsistency in the game.
- I feel confident using this game.

- I would need to learn a lot of things before I could use this game.
- The various aspects of this game are well integrated.
- I think I would need technical support to be able to use this game.
- How would you rate the usability of this game?

Gameplay Phase Evaluation Items

Butterfly Phase (Visual Focus – "5")

- I found the butterflies easy to locate.
- Catching them was satisfying and intuitive.
- This phase helped me focus visually and be present.
- I felt relaxed while looking for the butterflies.

Mushroom Phase (Auditory Focus – "4")

- The sound feedback helped me locate the mushrooms.
- The challenge of relying on sound was enjoyable.
- I found this task relaxing despite not relying on visuals.
- This activity made me more aware of sound and surroundings.

Breathing Phase (Physical Focus – "3")

- The breathing pace felt natural and easy to follow.
- The water animation helped me control my breath.
- I felt calmer and more grounded after this activity.
- I could focus on the breathing without distractions.

Petting Phase (Tactile/Emotional Focus – "2")

- The interaction with the animals felt realistic.
- Holding my hand to pet felt intuitive.
- I felt a positive emotional connection during this task.
- The instructions for this phase were clear.

Guided Meditation (Mental Focus – "1")

- The audio voice was clear and soothing.
- I was able to stay focused throughout the meditation.
- The meditation helped me calm my mind.
- I would use this meditation again in moments of stress.

SOS Mode Evaluation

- I found the SOS mode easy to access when I needed it.

- Editing my favorite safe spot or support settings was intuitive.
- The SOS mode worked well and as expected.
- I believe this mode could be useful in a moment of panic or crisis.
- I felt safer knowing that the SOS mode was available.

Open Feedback Questions

- What part of the experience did you enjoy the most?
- Is there anything that confused or frustrated you during the game?
- Do you have any suggestions to improve the game?
- How do you evaluate the effectiveness of the relaxation techniques used in the game?
- How do you think playing this game affects your overall stress levels?
- Do you have more questions that you find relevant to add?

Expert Evaluation Results - System Usability Scale

System Usability Scale (SUS) Question	Score
I found the game unnecessarily complex.	2
I found the game easy to use.	8
I needed the help of a technical person to use this game.	2
The different functions in this game are well integrated.	9
I found there was too much inconsistency in the game.	1
I feel confident using this game.	9
I would need to learn a lot of things before I could use this game.	3
The various aspects of this game are well integrated.	9
I think I would need technical support to be able to use this game.	3
How would you rate the usability of this game?	9

Table: Results of the System Usability Scale (SUS) completed by expert psychologists. Ratings range from 1 (Strongly Disagree) to 10 (Strongly Agree). The scores reflect high usability, with minor concerns regarding initial complexity.

These results suggest that the game is generally intuitive and well-integrated, with minimal perceived complexity or technical barriers.

Expert Evaluation Results – Gameplay Phase

Butterfly Phase – Visual Focus ("5")	**Score**
I found the butterflies easy to locate.	9
Catching them was satisfying and intuitive.	9
This phase helped me focus visually and be present.	10
I felt relaxed while looking for the butterflies.	10
Mushroom Phase – Auditory Focus ("4")	**Score**
The sound feedback helped me locate the mushrooms.	10
The challenge of relying on sound was enjoyable.	8
I found this task relaxing despite not relying on visuals.	8
This activity made me more aware of sound and surroundings.	10
Breathing Phase – Physical Focus ("3")	**Score**
The breathing pace felt natural and easy to follow.	10
The water animation helped me control my breath.	8
I felt calmer and more grounded after this activity.	10
I could focus on the breathing without distractions.	8
Petting Phase – Tactile/Emotional Focus ("2")	**Score**
The interaction with the animals felt realistic.	7
Holding my hand to pet felt intuitive.	8
I felt a positive emotional connection during this task.	7
The instructions for this phase were clear.	10
Guided Meditation – Mental Focus ("1")	**Score**
The audio voice was clear and soothing.	9
I was able to stay focused throughout the meditation.	8
The meditation helped me calm my mind.	9
I would use this meditation again in moments of stress.	10
SOS Mode Evaluation	**Score**
I found the SOS mode easy to access when I needed it.	10
Editing my favorite safe spot or support settings was intuitive.	8
The SOS mode worked well and as expected.	10
I believe this mode could be useful in a moment of panic or crisis.	8
I felt safer knowing that the SOS mode was available.	9

Table: Consolidated expert feedback across all gameplay phases, reflecting their ratings on clarity, effectiveness, and emotional impact. Ratings range from 1 (Strongly Disagree) to 10 (Strongly Agree).

Expert Evaluation Results - Open Feedback

- **What part of the experience did you enjoy the most?**
  "What I appreciated the most was the possibility of experiencing the exercises in different virtual environments and times of day. Being able to choose a relaxing setting offers users a sense of control and personalization, which can significantly enhance emotional safety. I believe this feature can be especially helpful for individuals dealing with anxiety, as it allows them to associate the exercises with places they find soothing, making the intervention more effective."

- **Is there anything that confused or frustrated you during the game?**
  "At first, exploring all the different game modes was a bit challenging. With so

many options available, including Normal Mode, SOS Mode, and various exercises — it can be somewhat confusing, especially for users who are anxious or less familiar with technology. While it's great to have so much flexibility, I believe a more guided introduction or a brief tutorial could help make the experience smoother and less frustrating, particularly for more sensitive patients."

- **Do you have any suggestions to improve the game?**
  "Yes, I believe adding short demonstrative tutorials at the beginning would greatly enhance the experience."
- **How do you evaluate the effectiveness of the relaxation techniques used in the game?**
  10/10

Conclusion: The expert feedback confirms the therapeutic potential and usability of the application, emphasizing the importance of personalization, environmental choice, and structured gameplay phases. Visual and auditory activities were particularly well received for their calming and intuitive nature, while the SOS mode stood out as an effective tool for managing moments of acute anxiety. The professionals also highlighted the need for onboarding support, suggesting the inclusion of demonstrative tutorials to reduce potential confusion for new users. Overall, all evaluated items were validated and approved for inclusion in the end-user questionnaire, ensuring the instrument's relevance and clarity for future testing phases.

4.1.2 User Evaluation Phase

To complement expert feedback, a user evaluation phase was conducted involving participants from the target demographic. This step aimed to assess the real-world usability, emotional impact, and therapeutic potential of the game in a non-clinical but relevant setting. The data collected helps validate the design assumptions and guide future iterations.

The respondents were individuals aged between 20 and 30 years old, with varying levels of prior experience with virtual reality, some being first-time users and others having moderate familiarity with VR environments.

Questionnaire Structure

The questionnaire applied to end users included three core sections:

- **System Usability Scale (SUS):** Standardized 10-item usability assessment adapted to the context of the game.
- **Gameplay Phase Evaluation:** Phase-specific rating questions designed to measure user engagement, ease of interaction, and the calming effect of each activity.
- **Open Feedback:** Qualitative questions about overall experience, suggestions, and perceived impact.

System Usability Scale (SUS) Items

Participants rated each statement below using a 10-point Likert scale (1 = Strongly Disagree, 10 = Strongly Agree).

- I found the game unnecessarily complex.
- I found the game easy to use.
- I needed the help of a technical person to use this game.
- The different functions in this game are well integrated.
- I found there was too much inconsistency in the game.
- I feel confident using this game.
- I would need to learn a lot of things before I could use this game.
- The various aspects of this game are well integrated.
- I think I would need technical support to be able to use this game.
- How would you rate the usability of this game?

Gameplay Phase Evaluation Items

Butterfly Phase (Visual Focus – "5")

- I found the butterflies easy to locate.
- Catching them was satisfying and intuitive.
- This phase helped me focus visually and be present.
- I felt relaxed while looking for the butterflies.

Mushroom Phase (Auditory Focus – "4")

- The sound feedback helped me locate the mushrooms.
- The challenge of relying on sound was enjoyable.
- I found this task relaxing despite not relying on visuals.
- This activity made me more aware of sound and surroundings.

Breathing Phase (Physical Focus – "3")

- The breathing pace felt natural and easy to follow.
- The water animation helped me control my breath.
- I felt calmer and more grounded after this activity.
- I could focus on the breathing without distractions.

Petting Phase (Tactile/Emotional Focus – "2")

- The interaction with the animals felt realistic.
- Holding my hand to pet felt intuitive.
- I felt a positive emotional connection during this task.
- The instructions for this phase were clear.

Guided Meditation (Mental Focus – "1")

- The audio voice was clear and soothing.
- I was able to stay focused throughout the meditation.
- The meditation helped me calm my mind.
- I would use this meditation again in moments of stress.

SOS Mode Evaluation

- I found the SOS mode easy to access when I needed it.
- Editing my favorite safe spot or support settings was intuitive.
- The SOS mode worked well and as expected.
- I believe this mode could be useful in a moment of panic or crisis.
- I felt safer knowing that the SOS mode was available.

Open Feedback Questions

- What part of the experience did you enjoy the most?
- Is there anything that confused or frustrated you during the game?
- Do you have any suggestions to improve the game?
- How do you evaluate the effectiveness of the relaxation techniques used in the game?
- How do you think playing this game affects your overall stress levels?

User Evaluation Results - System Usability Scale (SUS)

System Usability Scale (SUS) Question	Average	Std. Dev.
I found the game unnecessarily complex.	3.1	2.3
I found the game easy to use.	8.4	1.4
I needed the help of a technical person to use this game.	1.5	0.7
The different functions in this game are well integrated.	8.2	1.3
I found there was too much inconsistency in the game.	2.4	1.8
I feel confident using this game.	8.6	1.2
I would need to learn a lot of things before I could use this game.	2.6	1.4
The various aspects of this game are well integrated.	8.3	1.4
I think I would need technical support to be able to use this game.	2.2	1.3
How would you rate the usability of this game?	8.7	1.1

Table: Results of the System Usability Scale (SUS) completed by end users. Ratings range from 1 (Strongly Disagree) to 10 (Strongly Agree). The data shows high usability perception across the board.

User Evaluation Results - Gameplay Phase

Gameplay Phase Item	Avg.	Std. Dev.
Butterfly Phase		
I found the butterflies easy to locate.	8.4	1.5
Catching them was satisfying and intuitive.	8.2	1.7
This phase helped me focus visually and be present.	8.5	1.5
I felt relaxed while looking for the butterflies.	8.7	1.5
Mushroom Phase		
The sound feedback helped me locate the mushrooms.	8.3	1.3
The challenge of relying on sound was enjoyable.	7.6	2.1
I found this task relaxing despite not relying on visuals.	7.7	2.4
This activity made me more aware of sound and surroundings.	8.3	2.0
Breathing Phase		
The breathing pace felt natural and easy to follow.	9.4	0.7
The water animation helped me control my breath.	8.3	1.9
I felt calmer and more grounded after this activity.	9.2	0.8
I could focus on the breathing without distractions.	8.8	1.6
Petting Phase		
The interaction with the animals felt realistic.	8.2	2.0
Holding my hand to pet felt intuitive.	8.6	1.5
I felt a positive emotional connection during this task.	9.0	1.2
The instructions for this phase were clear.	8.9	1.2
Guided Meditation		
The audio voice was clear and soothing.	8.8	1.2
I was able to stay focused throughout the meditation.	8.7	1.2
The meditation helped me calm my mind.	8.9	1.2
I would use this meditation again in moments of stress.	9.2	1.1
SOS Mode		
I found the SOS mode easy to access when I needed it.	9.1	1.1
Editing my favorite safe spot or support settings was intuitive.	8.6	1.3
The SOS mode worked well and as expected.	8.8	1.2
I believe this mode could be useful in a moment of panic or crisis.	9.3	0.7
I felt safer knowing that the SOS mode was available.	9.3	1.0

Table: Summary of user feedback across gameplay phases. Ratings indicate a positive reception, especially for the breathing and SOS phases.

User Evaluation Results - Open Feedback

- **What part of the experience did you enjoy the most?**
  "The breathing and petting phases were very relaxing. The animals were cute and calming."
- **Is there anything that confused or frustrated you during the game?**
  "At first I didn't know how to interact with some elements. A tutorial would help."
- **Do you have any suggestions to improve the game?**
  "Add more customization options and clearer instructions at the beginning."
- **How do you evaluate the effectiveness of the relaxation techniques used in the game?**
  "Very effective. I felt calm and immersed in most phases."
- **How do you think playing this game affects your overall stress levels?**
  "It helps reduce stress and makes me more aware of my body and breathing."

Conclusion: The feedback from users confirms the high usability and emotional impact of the game. The breathing, petting, and guided meditation phases stood out as particularly effective, while the SOS mode was praised for its perceived usefulness in moments of stress. Suggestions centered on improving onboarding and adding personalization. Overall, the results support the game's potential as a supportive tool for emotional regulation.

4.2 Results Analysis

This section analyzes the feedback gathered through expert interviews and user testing. The responses suggest that the application is effective in promoting relaxation, grounding, and stress reduction. Both psychologists (P1 and P2) recognized the therapeutic value of each phase, particularly highlighting the alignment between the game's mechanics and psychological strategies such as mindfulness, grounding, and guided breathing.

User responses reinforced these findings: most participants reported a strong sense of immersion and relaxation. The petting and breathing phases were especially well-received, and the SOS mode was seen as a valuable addition in crisis situations. Suggestions for improvement included more customization options and clearer instructions, which were noted and documented for future iterations.

Comparison Between Experts and Users

Both expert and user groups identified the same phases (breathing and petting) as particularly impactful. Experts emphasized the therapeutic rationale behind these interactions, while users described their immediate emotional and physiological effects. Users tended to focus more on the immersive experience and intuitive design, whereas experts highlighted clinical aspects and suggested improvements based on therapeutic models.

The following key similarities and differences were observed:

- **Shared Positive Feedback:** Both groups appreciated the calming nature of the activities, especially the breathing and meditation components.

- **Usability Comments:** Experts provided more detailed feedback about the need for guided onboarding, while users reported occasional confusion with instructions.
- **Customization and Safety:** Both groups valued the SOS mode. Experts emphasized its clinical potential, while users saw it as a comfort and safety tool.

This triangulation of perspectives strengthens the validity of the design and provides a clear roadmap for future improvements.

4.3 Comparison with Objectives

One of the primary objectives of this project was to develop a therapeutic tool that leverages gamification and immersive technologies to support individuals in managing anxiety. Based on expert and user feedback, the application met this goal by:

- Delivering a VR and mobile experience that is intuitive, relaxing, and engaging.
- Integrating scientifically supported techniques, such as mindfulness and deep breathing.
- Including emergency support via an SOS mode.
- Allowing some degree of personalization and emotional connection.

Overall, the findings suggest that the system aligns with the intended therapeutic outcomes. While usability could be improved in certain areas, the feedback confirms the effectiveness of the design in supporting anxiety regulation.

4.4 Ethical and Regulatory Implications

The use of virtual reality (VR) and mobile applications in mental health raises important ethical and regulatory considerations. This section explores the existing norms and codes, identifies gaps in their application to these technologies, and discusses the implications for the proposed solution.

4.4.1 Existing Norms and Regulations

Relevant regulations include the General Data Protection Regulation (GDPR) for data protection in the EU, the Health Insurance Portability and Accountability Act (HIPAA) in the US, and guidelines from the American Psychological Association (APA). These frameworks address user consent, data privacy, and the ethical use of digital mental health tools.

4.4.2 Challenges and Gaps

Although data privacy regulations such as GDPR offer strong protections, they are not fully adapted to the unique challenges posed by immersive environments. For example, physiological and behavioral data collected in VR contexts may require more nuanced protection. Similarly, ethical concerns arise around user dependency, especially in prolonged VR exposure.

Another challenge is ensuring inclusivity: VR and mobile interventions must be accessible to individuals with disabilities or varying levels of digital literacy. Furthermore, continuous clinical validation is essential to ensure safety and effectiveness across diverse user profiles.

4.4.3 Recommendations for Ethical and Regulatory Alignment

To align with ethical and legal standards, the application should:

- Ensure transparent and informed consent procedures.
- Minimize data collection and store sensitive information securely.
- Offer grounding strategies and exit mechanisms to avoid dependency.
- Involve mental health professionals in the development and validation loop.
- Design with accessibility and inclusion in mind.

Chapter 5

Conclusion and Future Work

5.1 Conclusions and Contributions

This thesis presented the design, development, and evaluation of an application that aims to support people with anxiety and panic attacks. By integrating Virtual Reality (VR), mobile technology, and gamification, this research explored how immersive environments can be leveraged to promote emotional self-regulation. The findings confirm that this approach is highly effective. Positive outcomes are directly related to a user-centric design that includes calming sensory stimuli, intuitive interfaces, and a critical emergency support feature (the SOS mode).

The key contributions of this work are as follows:

- Definition of a conceptual framework grounded in psychological theory, expert interviews, and user-centered design methodology.
- Development of a functional prototype integrating immersive VR environments, interactive relaxation exercises, and a responsive mobile system.
- Expert validation through structured interviews with two clinical psychologists, confirming the therapeutic relevance, usability, and design alignment with cognitive and emotional regulation strategies.
- Empirical evaluation with end-users, demonstrating the prototype's ability to promote relaxation, emotional grounding, and intuitive interaction in a non-clinical context.

Feedback from psychologists emphasized the importance of personalization, simplicity, and a balanced gamified structure to avoid cognitive overload. Users reported high levels of relaxation and immersion, especially during the breathing and petting phases. Overall, the application fulfilled its core objectives: to serve as a relaxing, intuitive, and accessible platform capable of promoting short-term emotional regulation through evidence-informed digital strategies. This project bridges theory and implementation and contributes a replicable model for future development in the field of digital mental health tools.

5.2 Limitations and Future Directions

While the prototype received positive feedback, several limitations and opportunities for improvement were identified:

- **Sample size:** Both expert and user testing involved a limited number of participants, which restricts generalizability.

- **Instruction clarity:** Some users found the instructions unclear in certain phases, suggesting a need for improved onboarding and guidance.
- **Mobile platform coverage:** The mobile version was not fully tested across a broad range of devices and configurations.
- **Lack of longitudinal data:** The long-term impact of the intervention on anxiety symptoms and emotional resilience remains untested.
- **Absence of physiological metrics:** No biometric data (e.g., heart rate) were collected to objectively assess stress reduction.

Based on these limitations, the following future directions are proposed to enhance the system's effectiveness and applicability:

- **Longitudinal studies:** Evaluate the sustained impact of regular use on emotional resilience and anxiety symptomatology.
- **Broader user testing:** Expand the participant base to include varied age groups, cultural backgrounds, and VR experience levels.
- **Clinical collaborations:** Partner with mental health professionals and institutions for supervised deployment in clinical settings.
- **Content expansion:** Develop new environments, guided meditations, and adaptive mini-games tailored to diverse psychological needs.
- **Accessibility enhancements:** Implement inclusive features such as voice control, captions, and simplified interfaces.
- **Biometric feedback:** Integrate wearable technology to track physiological data and dynamically adjust the experience in real time.

Pursuing these directions will improve the scalability, inclusivity, and therapeutic potential of the proposed solution, contributing to the broader landscape of digital mental health interventions.

5.3 Answers to the Research Questions

Based on the design, development, and evaluation of the proposed solution, the following answers are provided to the initial research questions:

- **How can immersive and mobile technologies be used to promote emotional well-being in users with anxiety?**
  Through the integration of Virtual Reality and mobile platforms, users were able to engage in guided relaxation and mindfulness exercises. The evaluation confirmed that these tools can promote short-term emotional regulation and a sense of calm, especially when personalization and gamification elements are applied.
- **What design strategies best support intuitive, calming, and emotionally safe user experiences in this context?**
  Strategies such as minimalistic interfaces, customizable environments, slow-paced interactions, and multisensory feedback proved effective in supporting a calming and emotionally safe experience. Expert input emphasized the importance of simplicity and user control to avoid overstimulation.

- **How can digital tools provide effective and accessible support during moments of high emotional distress?** The inclusion of an SOS mode that immediately immerses the user in a calming environment and guides them through grounding and breathing exercises demonstrated the potential for digital tools to provide real-time crisis support.
- **What ethical and regulatory measures are necessary to ensure safe and responsible use of such technologies in mental health?**
  The system incorporates measures such as clear consent flows and adherence to GDPR principles. Nevertheless, future work should continue addressing privacy, data protection, and the prevention of psychological dependency on digital tools.

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