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Article

A Gamified Virtual Reality Approach to Support Anxiety Management

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Abstract

Anxiety and panic attacks are among the most prevalent mental health challenges today, significantly impacting individuals’ lives, emotional stability, and overall well-being. Despite the availability of effective therapeutic techniques many individuals struggle to 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 article presents the design, development, and evaluation of a digital solution that leverages Virtual Reality (VR) to assist individuals in managing anxiety. To maximize user engagement, the solution incorporates gamification elements grounded in psychological principles. The prototype was evaluated through usability testing and qualitative feedback from both mental health experts and end-users. The results confirmed the high usability and therapeutic potential of the approach as participants reported increased feelings of calmness and being better able to cope with anxiety issues.

Keywords: virtual reality (VR); anxiety management; mental health technology; mobile applications; gamification; immersive therapy

1. Background/Objectives

Anxiety disorders represent a significant and widespread global health issue: in 2019, an estimated 301 million people were living with an anxiety disorder, including 58 million children and adolescents [1]. While prevalence varies across regions, higher rates are often observed in high-income countries [2] and women are more frequently affected than men, with a ratio of approximately 1.66:1 [1].

Anxiety disorders are characterized by excessive fear or worry, which may be specific to certain situations (e.g., social interactions or specific events) or more generalized across everyday scenarios. The symptoms typically persist over several months and often lead to avoiding those anxiety-provoking situations. The disorders manifest through various physical, emotional, and cognitive symptoms, including:

- Difficulty concentrating or making decisions [3].
- Irritability, tension, or restlessness [4].
- Physical symptoms such as nausea, abdominal distress, heart palpitations, sweating, trembling, or trouble sleeping [1].
- A pervasive sense of imminent danger, panic, or doom [3].

Anxiety disorders often co-occur with depression, substance use disorders, and an increased risk of suicidal thoughts or behaviors [3]. It is also common for individuals to experience more than one type of anxiety disorder simultaneously, including [3,5,6]:

- Generalized Anxiety Disorder (GAD): Persistent worry about daily activities or events.
- Panic Disorder: Recurring panic attacks and fear of future episodes.
- Social Anxiety Disorder: Intense fear of social situations due to potential humiliation or rejection.

- Agoraphobia: Fear and avoidance of places that can cause feelings of panic or helplessness.
- Separation Anxiety Disorder: Excessive fear of being separated from loved ones.
- Specific Phobias: Irrational fears of specific objects or situations, leading to avoidance.
- Selective Mutism: Inability to speak in specific social settings, despite being able to speak in others.

Symptoms often begin in childhood or adolescence and persist into adulthood [4]. Panic attacks, as symptoms of an extreme anxiety disorder, are sudden episodes of intense fear or discomfort that peak in minutes and are accompanied by a range of physical and cognitive symptoms. These attacks can occur unexpectedly, without an obvious trigger. During a panic attack, individuals may experience at least four of the following symptoms [6]:

- 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. Although panic attacks can occur without a clear cause, several factors can trigger or increase the likelihood of an episode [5,6]:

- 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.
- Medical Conditions: Certain health issues, including thyroid problems or cardiovascular conditions, may be associated with panic attacks.
- Substance Use: Consumption of caffeine, alcohol, or illicit drugs, as well as withdrawal from certain medications, can trigger attacks.
- Environmental Factors: Situations like being in crowded places, driving, or even sleeping can sometimes act as triggers.

Early identification and appropriate treatment are crucial to mitigate these impacts and improve outcomes for individuals with anxiety disorders. Currently, 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 [4]. It focuses on identifying and modifying negative thought patterns and behaviors that contribute to anxiety and it has been shown to be highly effective across various anxiety disorders, including generalized anxiety disorder, panic disorder, and social anxiety disorder. Key components include:
 - Cognitive Restructuring: Identifying irrational or distorted thoughts and replacing them with more realistic and positive perspectives [6].
 - Exposure Therapy: Gradual and controlled exposure to anxiety-provoking situations or triggers to desensitize the individual and reduce avoidance behaviors [7].

- Behavioral Techniques: Developing healthier coping strategies to manage anxiety in challenging situations.
- 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 [8]. Mindfulness-based approaches are particularly effective for reducing stress and enhancing emotional resilience [9]. These therapies emphasize:
 - Breathing Exercises: Controlling breath to regulate the autonomic nervous system and reduce physiological symptoms of anxiety.
 - Body Scans: Paying attention to physical sensations to ground oneself in the present moment.
 - Meditation: Developing a non-reactive awareness of thoughts and feelings.
- Relaxation Techniques: Relaxation strategies and techniques aim to alleviate physical tension and calm the mind, which can be beneficial for managing anxiety symptoms. Common methods include [10]:
 - Progressive Muscle Relaxation (PMR): Alternating between tensing and relaxing different muscle groups to promote relaxation.
 - Guided Imagery: Visualizing calming scenes or experiences to reduce stress and anxiety.
 - Deep Breathing Exercises: Practicing slow, diaphragmatic breathing to counteract hyperventilation and induce a sense of calm.

These techniques are often used in conjunction with other therapies to provide holistic anxiety management. But, while these therapies are highly effective for many individuals, challenges remain: some people may have trouble accessing trained professionals, and the effectiveness of these methods can vary depending on the severity of the disorder and individual differences. In fact, access to professional therapy is one of the most significant barriers to effective anxiety management. Key issues include [2]:

- 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.
- Financial Constraints: The high cost of therapy sessions and limited insurance coverage for mental health services often prevent individuals from seeking help.
- Stigma: Social stigma surrounding mental health can deter individuals from acknowledging their struggles and seeking professional support.

Even when therapy is accessible, maintaining consistent use of therapeutic techniques poses challenges [4,6]:

- Lack of Motivation: Anxiety can lead to avoidance behaviors, making it difficult for individuals to practice the strategies learned in therapy.
- Difficulty in Self-Regulation: During high-anxiety episodes, individuals may struggle to recall or apply calming techniques effectively.
- Limited Follow-Up Support: Without continuous guidance from therapists, individuals may fail to integrate these techniques into their daily lives.
- Cultural Beliefs: In some cultures, discussing mental health openly is discouraged, limiting awareness and support.
- Varied Responses to Treatment: Individual differences in biology, personality, and life experiences mean that not all therapeutic approaches are equally effective for everyone.

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. Digital tools for managing anxiety, such as mobile applications and online

therapy platforms, have shown potential and have gained popularity as accessible tools for managing anxiety and improving mental health. Some of the most used apps include:

- **Calm:** Provides guided meditation, 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.

Unfortunately, these tools also face limitations:

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

The use of gamification can serve as a powerful tool to engage individuals in different activities, making them more approachable and enjoyable [11]. By gamifying daily exercises for anxiety management, it is possible to significantly enhance motivation and adherence to therapeutic practices [12]. Integrating gamification 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.

On the other side, 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 [13]. However, challenges such as cost, motion sickness, and accessibility remain significant barriers to widespread adoption [14].

In this project, gamification and VR play a central role in motivating users to perform daily anxiety-reduction exercises. The game mechanics were 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.

By incorporating game mechanics, the project aimed 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. Materials and Methods

Design-Based Research (DBR) was chosen as the research methodology as it is an iterative methodology that bridges theory and practice, making it highly suitable for projects addressing complex challenges and leveraging emerging technologies [15,16]. The choice of DBR was 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.
- **Contextual Relevance:** Focuses on creating solutions applicable to real-world scenarios, such as providing tools for anxiety management.
- **Stakeholder Involvement:** Integrates feedback from stakeholders, ensuring the solution meets their needs and expectations.
- **Theory-Practice Integration:** Combines theoretical insights with practical development to produce scientifically grounded and functional tools.

To guide the development and evaluation of the research process, the following research questions were 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?

The research process started with a Systematic Review organized under PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology was employed to ensure reproducibility. Figure 1 outlines the PRISMA flowchart, detailing the systematic review process, from initial identification to final selection of articles.

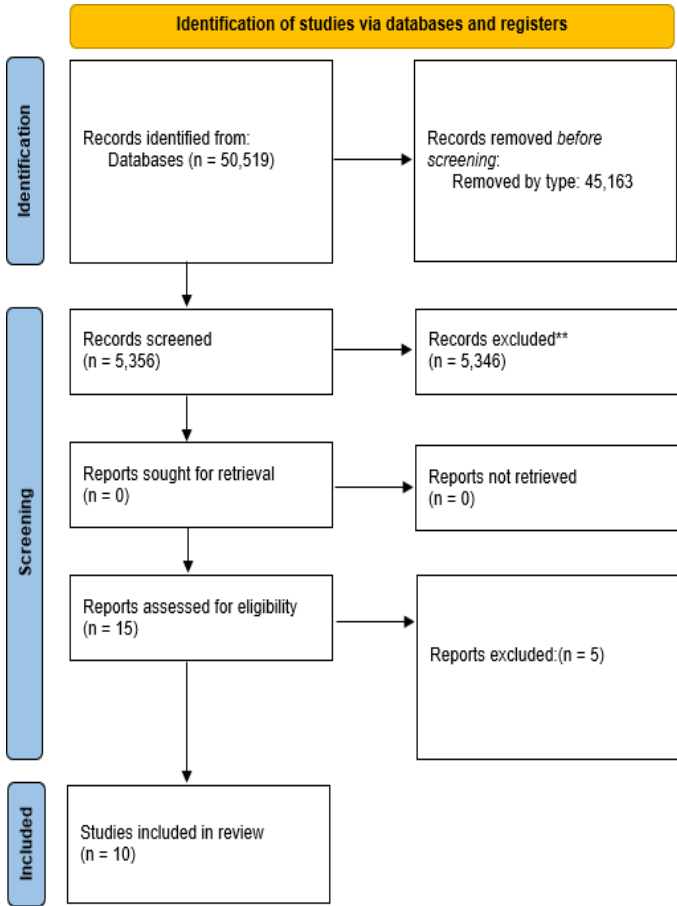


Figure 1. PRISMA Flowchart for Systematic Literature Review.

The systematic search was conducted with IEEE Xplore, as it is a reputable database for technology-focused research and offers a robust collection of related studies. 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 Criteria:
 - Articles focused on mental health applications, specifically anxiety and panic at- tack 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 method- ologies.

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. The following table summarizes the final selection.

Table 1. Summary of selected articles related to anxiety management using VR and mobile technologies.

Article	Summary
Smith and Doe, 2023 [17]	Demonstrates the efficacy of VR-based exposure therapy in reducing symptoms of generalized anxiety disorders.
Taylor and Lee, 2020 [18]	Highlights the benefits of mobile applications using real-time notifications for anxiety grounding techniques.
Chen and Zhang, 2023 [19]	Proposes an integrated VR and mobile solution for stress and anxiety relief.
Brown and Green, 2021 [20]	Shows how gamified elements in therapy apps increase engagement and adherence.
Miller and White, 2019 [21]	Explores the use of VR to simulate safe spaces for panic attack management.
Anderson and Garcia, 2023 [22]	Investigates the use of VR for immersive relaxation training to enhance mindfulness.
Kumar and Patel, 2022 [23]	Provides evidence supporting the effectiveness of mobile-based CBT for anxiety reduction.
Williams1 and Lin, 2023 [24]	Discusses ethical issues in VR mental health apps, including data privacy and informed consent.
Nguyen and Davis, 2023 [25]	Reports sustained improvements in anxiety symptoms after long-term VR interventions.
Lopez and Wang, 2023 [26]	Proposes algorithms to personalize content in mobile health apps based on user behavior.

These articles show that, despite the advancements in these technological solutions for mental health, several gaps and challenges persist, limiting the effectiveness and accessibility of current tools. Namely, these solutions often fail to provide real-time, personalized interventions during acute anxiety episodes or panic attacks. This lack of personalization and immediate accessibility highlights the need for tools that dynamically adapt to the user’s emotional and physiological state. 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 [27].
- 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 [28].

Furthermore, 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 [29,30].

Addressing these challenges requires collaboration between developers, mental health professionals, and policymakers to create clear, ethical frameworks for digital health tools. This project stands out by directly addressing several of the identified gaps and challenges in those articles:

- 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 using 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.

2.1. Solution Design

The design process was supported by psychological theory, existing technological practices, and direct input from mental health professionals. Attention was given to personalization, accessibility, and the integration of evidence-based therapeutic strategies into an interactive and user-friendly environment. 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 had several 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. The following summarizes the key insights from participants, reformulated to improve clarity and academic consistency.

- 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.
- 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.
- 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.
- Both psychologists emphasized the importance of nature-based environments, highlighting that users should have the ability to select their preferred settings. They proposed adopting 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.
- Other 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.
- Guided meditation was suggested as a powerful technique. They recommended creating scripts and validating them with experts before integration into the platform.
- The environment should 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.
- The solution should maintain interactivity (e.g., use of vibration feedback), disable external notifications during use, and apply gamification to ensure ongoing engagement.
- 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.
- 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.

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.

The gamification approach was 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.

Although the game is not based on performance metrics, minimal progression elements were 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 re- turn 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.

The application was structured around two primary modes: the Normal Mode, designed for daily relaxation and emotional regulation, and 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.

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. Figure 2 shows the main navigation flow diagram.

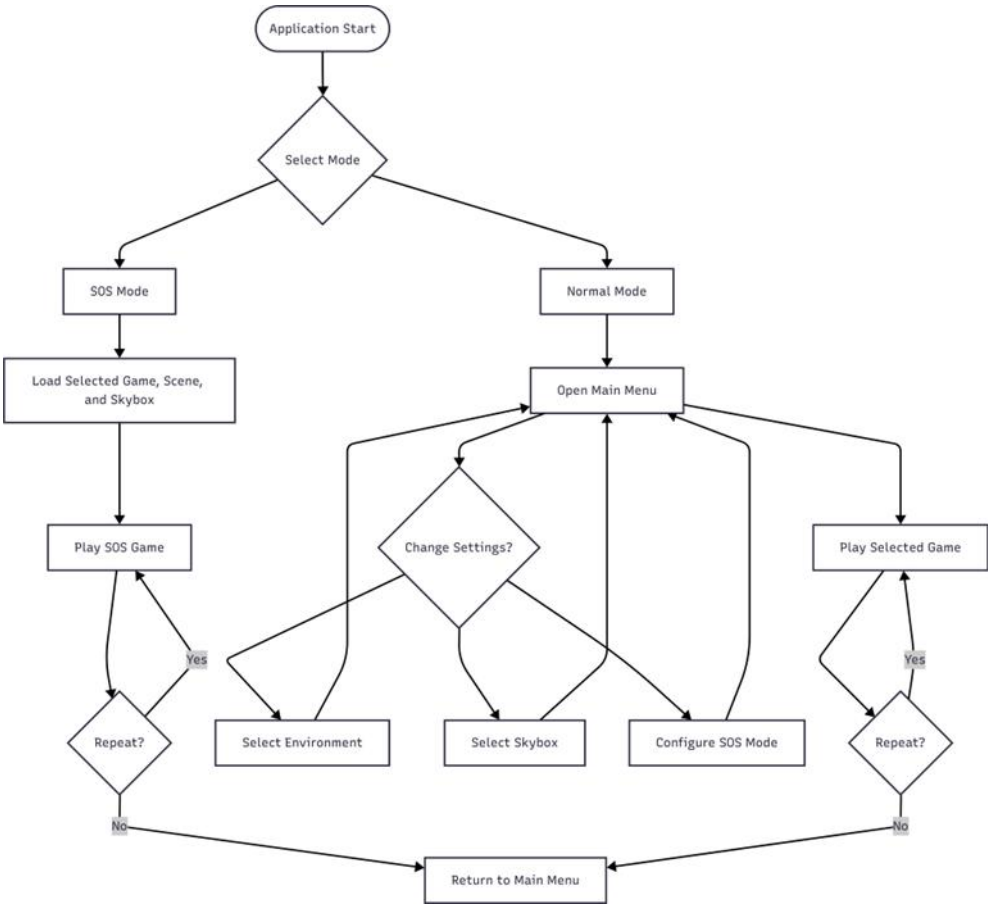


Figure 2. Main flow diagram.

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.

The gamified structure was 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. 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.

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. Upon activation, the player is surrounded by a predefined number of butterflies. 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. To catch a butterfly, the player must physically move their VR controller near it. Once all butterflies are caught, the system automatically transitions to the next phase.

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. Each mushroom emits a spatial audio cue via a looping sound. 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. When all mushrooms are collected, the game automatically transitions to the next phase.

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. 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.

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. 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.

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 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 leading the user through a calm and reflective experience. The session ends either automatically when the audio completes or manually via an optional "End Meditation" button, after which the main menu is reactivated.

The SOS 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 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.

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. 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 refinement.

2.2. Technical Development

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.

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.

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 ray casting, 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.

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. Results

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 (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.

Table 2. 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

The individual scores and SUS score (83 – Excellent) 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.

Table 3. Expert Evaluation Results - Gameplay.

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

Scores for the gameplay were consistently high, close to the positive maximum.

From the structured interview with the experts was also possible to get additional comments from the experts.

- What part of the experience did you enjoy the most?** "What I appreciated the most was the possibility of experiencing 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."

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.

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. 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.

Table 4. 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

The data and the SUS score (80.4 – Excellent) show high usability perception across the board. Next users provided their perception on the gameplay (Table 5)

Table 5. User Evaluation Results - Gameplay.

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 breathing without distractions.	8.8	1.6
Petting Phase		

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.	9.3	0.7
I felt safer knowing that the SOS mode was available.	9.3	1.0

Ratings indicate a positive reception, especially for the breathing and SOS phases. Users finally provided some open feedback on the questionnaire:

- **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."

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. This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

4. Discussion

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 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.

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

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.

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 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.

5. Conclusions

This work 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 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 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. 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.

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.

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