Emirati Journal of Applied Psychology
Vol 1 Issue 1 (2025)
Pages (227- 237)

Available at
www.emiratesscholar.com

AI-Driven Multimodal Therapeutic System with Virtual Reality Integration for Anxiety Disorders in Adolescents

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ARTICLE HISTORY

Received: 24 August 2025.
Accepted: 27 November 2025.
Published: 29 December 2025.

PEER - REVIEW STATEMENT:

This article was reviewed under a double-blind process by three independent reviewers.

HOW TO CITE

Walid, Z. ., & Mahrous, A. . (2025). AI-Driven Multimodal Therapeutic System with Virtual Reality Integration for Anxiety Disorders in Adolescents. *Emirati Journal of Applied Psychology*, *1*(1), 227-237. https://doi.org/10.54878/6rx96k50

ABSTRACT

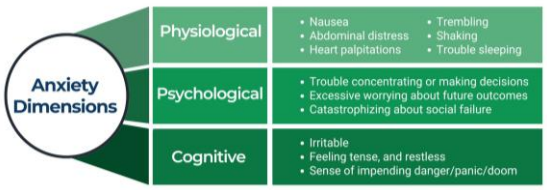
Anxiety disorders are increasingly prevalent, especially in the Middle East, with a prevalence of 6.33%, where social stigma often discourages individuals from seeking medical help. Traditional clinical interviews frequently lead to misdiagnoses, and single-approach therapies typically address only one or two of the three dimensions of anxiety (cognitive, psychological, and physiological). To address these challenges, a mobile application was developed to provide accessible, effective mental health support for adolescents aged 13-19. The app features an AI chatbot that diagnoses users based on the DSM-V and SCIDRV-V criteria to design an unstructured diagnostic model integrating four therapeutic approaches: Cognitive Behavioral Therapy (CBT), Acceptance and Commitment Therapy (ACT), Mindfulness-Based Cognitive Therapy (MBCT), and Mindfulness-Based Stress Reduction (MBSR) by utilizing the flexibility of the Gemini API to address the multidimensional nature of anxiety. The app includes a journaling page to allow adolescents to document thoughts, a history page to provide context for diagnosis, and video-based group therapy to enhance social skills. To ensure a successful group therapy experience, the Adolescent Group Therapy Readiness Questionnaire (AGTRQ), an adapted form of the Group Therapy Questionnaire (GTQ) and Group Readiness Questionnaire (GRQ), is filled by users to place them in suitable groups. Additionally, the app supports all languages, including Egyptian dialects, and ensures privacy through encrypted chat histories, wiΔM=-7.5, 95% CI [-8.2, -6.8]), exceeding the 4-6 point Minimal Clinically Important Difference (MCID) threshold used in pediatric anxiety measures, with anxiety reductions 4.5× greater than the control group, outperforming standalone iCBT. The app demonstrates its potential as a scalable, evidence-based solution for regions with stigma or limited access to mental health services, offering both accessibility and effectiveness in managing adolescents' anxiety disorders.

Keywords: *Anxiety, Artificial Intelligence, Adolescents, Chatbot Mental Health, Multimodal Therapy, Virtual Reality*

1. Introduction

Anxiety disorders, characterized by excessive fear and worry, affect 4.71% of the global population, with a higher prevalence of 6.33% in North Africa and the Middle East (Institute for Health Metrics and Evaluation [IHME], 2021). Despite their prevalence, many adolescents remain undiagnosed due to high therapy costs and social stigma associated with seeking mental health care (Javaid et al., 2023). Anxiety manifests across three dimensions—physiological, psychological, and cognitive—requiring comprehensive therapeutic approaches to address all aspects effectively (Bandelow et al., 2017). Traditional therapies, such as Cognitive Behavioral Therapy (CBT), often target only one or two dimensions, limiting their efficacy (Curtiss et al., 2021). Additionally, conventional clinical interviews for diagnosing anxiety disorders can be inconsistent, leading to misdiagnoses (First et al., 2015). To overcome these barriers, this study developed and evaluated an AI-driven mobile application integrating multimodal therapies and advanced diagnostic tools tailored for adolescents aged 13-19, with a focus on culturally adapted features for Middle Eastern populations.

Figure 1: Summary of the three anxiety dimensions and their symptoms



2. Background Research

Current therapeutic approaches for anxiety disorders include CBT, which focuses on cognitive restructuring and behavioral modification; ACT, which emphasizes acceptance and value-based actions; MBCT, which integrates mindfulness with cognitive techniques; and MBSR, which employs mindfulness to enhance emotional regulation (Ayes & Pierson, 2005; Niazi & Niazi, 2011; Peter et al., 2022; Williams et al., 2008). However, these therapies typically address only one or two of the three anxiety dimensions (physiological, psychological, cognitive), as summarized in Table 1 (Bandelow et al., 2017). To address this limitation, the proposed application integrates these therapies with AI-driven diagnostics and Virtual Reality Exposure Therapy (VRET) to create a comprehensive, multidimensional intervention.

Table 1: Comparison between the four therapeutic approaches and the anxiety dimensions they mitigate

	Cognitive Behavioral Therapy (CBT)	Mindfulness-Based Cognitive Therapy (MBCT)	Mindfulness-Based Stress Reduction (MBSR)	Acceptance and Commitment Therapy (ACT)
Physiological				Reduced emotional distress and avoidance behaviors (Hayes-Skelton et al.,2013).
Psychological		Reduced muscle tension and heart rate variability, with a moderate to large effect size (Hofmann et al., 2010).		
Cognitive	Reduced excessive worry and rumination (Liu et al, 2022).			

3. Research questions

- Does the multilingual AI-driven application, integrating the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) and Structured Clinical Interview for DSM-V Disorders Research Version (SCIDRV-V), achieve higher diagnostic sensitivity, specificity, and overall accuracy for anxiety disorders in adolescents aged 13-19 years compared to traditional clinical interviews?
- Does the integration of multimodal therapeutic approaches—CBT, Acceptance and Commitment Therapy (ACT), Mindfulness-Based Cognitive Therapy (MBCT), Mindfulness-Based Stress Reduction (MBSR), and Virtual Reality Exposure Therapy (VRET)—result in greater reductions in anxiety symptoms, as measured by the Spence Children's Anxiety Scale (SCAS), compared to standalone internet-based CBT (iCBT)?
- Do the app's culturally adapted features, including multilingual support and AI-based facial expression analysis, improve

- engagement rates and reduce stigma-related barriers to accessing care among Middle Eastern adolescents?

4. Hypotheses

- The AI-driven application integrating DSM-V and SCIDRV-V will demonstrate significantly higher diagnostic sensitivity (≥80%), specificity (≥90%), and overall accuracy (≥85%) compared to traditional clinical interviews for diagnosing anxiety disorders in adolescents.
- Adolescents using the app's multimodal therapy integration—including CBT, ACT, MBCT, MBSR, and VRET—will exhibit a mean reduction of 7-8 points on SCAS scores over eight weeks, significantly surpassing reductions observed in control groups receiving iCBT alone.
- The app's culturally adapted features, such as multilingual support and AI-based facial expression analysis, will lead to higher retention rates, session adherence, and reduced stigma-related barriers compared to conventional treatment modalities for anxiety disorders in Middle Eastern adolescents.

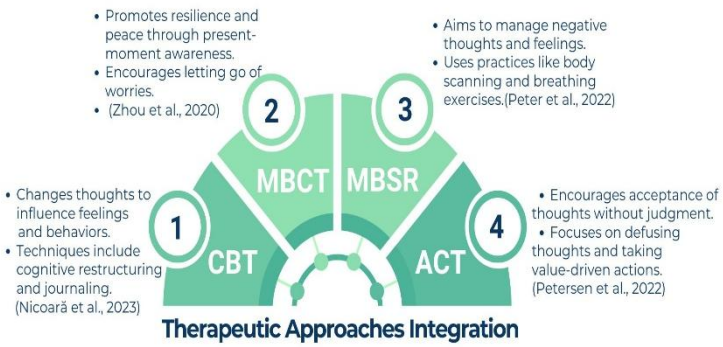
5. Ideation & Integration

Four therapeutic approaches—Cognitive Behavioral Therapy (CBT), Mindfulness-Based Cognitive Therapy (MBCT), Mindfulness-Based Stress Reduction (MBSR), and Acceptance and Commitment Therapy (ACT)— were chosen for their complementary strengths in targeting different anxiety facets, as supported by systematic reviews and meta-analyses demonstrating their efficacy in youth populations.

Concurrently, technological components were ideated to overcome barriers such as misdiagnosis in traditional interviews, limited accessibility, and low engagement (First et al., 2015). Four key technologies were prioritized: a mobile application platform for secure delivery, Artificial Intelligence (AI) for personalized diagnostics and support, Virtual Reality Therapy (VRT, also referred to as Virtual Reality Exposure Therapy or VRET) for immersive interventions, and Natural Language Processing (NLP) for sentiment analysis and multilingual capabilities. These were selected based on emerging evidence of their potential to enhance mental health outcomes, including predictive AI systems and VR's role in controlled exposure (Tutun et al., 2023; Zeng et al., 2025). The overall design aimed for a scalable, user-centered system tailored to adolescents aged 13-19, with cultural adaptations like Egyptian dialect support to reduce stigma in high-prevalence areas (Ren et al., 2025).

The integration stages involved fusing these eight core components into a cohesive app ecosystem, leveraging the flexibility of the Gemini API to dynamically blend therapies based on AI-driven assessments. Below, the therapeutic and technological approaches are detailed, followed by their synergistic integration.

Figure 2: Illustration of the integrated technologies and therapeutic approaches



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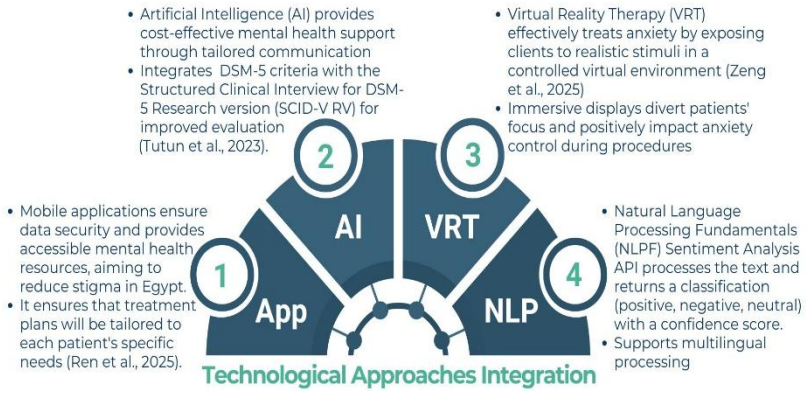

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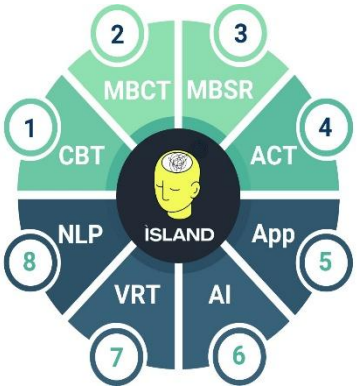


6. Implementation

The final mobile application, named Ísland, was developed using Flutter programing language with eight core components: (1) CBT, (2) ACT, (3) MBCT, (4) MBSR, (5) an AI-powered chatbot, (6) VRET, (7) a mobile app platform, and (8) sentiment analysis technology. The chatbot utilizes the Gemini API to integrate DSM-V and SCIDRV-V criteria for unstructured diagnostic assessments (Tutun et al., 2023); based on system instructions shown in Figure 3. Additional features include a journaling page for thought documentation, a history page for diagnostic context, and video-based group therapy facilitated by the Adolescent Group Therapy Readiness Questionnaire (AGTRQ), an adapted version of the Group Therapy Questionnaire (GTQ) and Group Readiness Questionnaire (GRQ). The app supports multilingual interfaces, including Egyptian dialects, and employs encrypted chat histories to ensure privacy, with psychiatrist access limited to diagnostic purposes. AI-driven facial expression and voice-tone analysis provide real-time emotional feedback, while VRET enhances engagement through immersive exposure scenarios (D'Alfonso, 2020; Holohan & Fiske, 2021).

Figure 3: AI chatbot system instructions framework

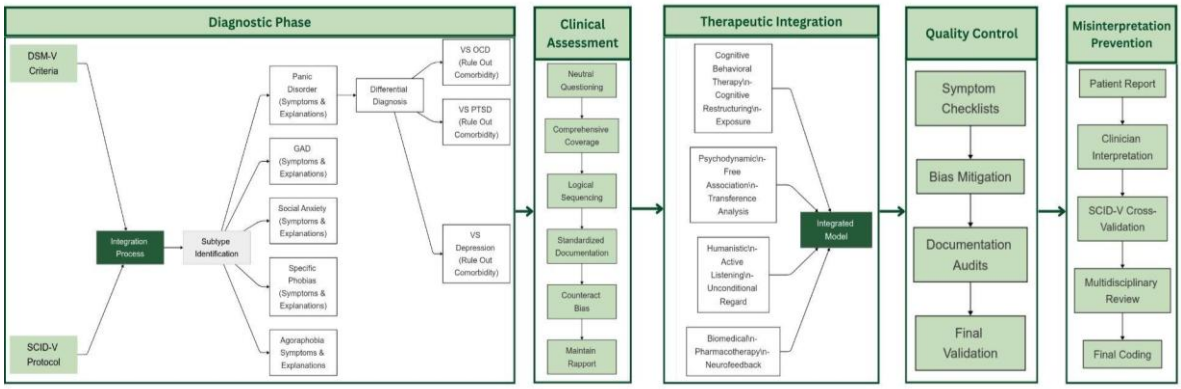
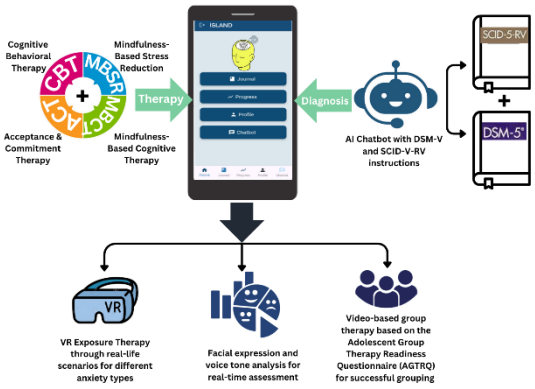


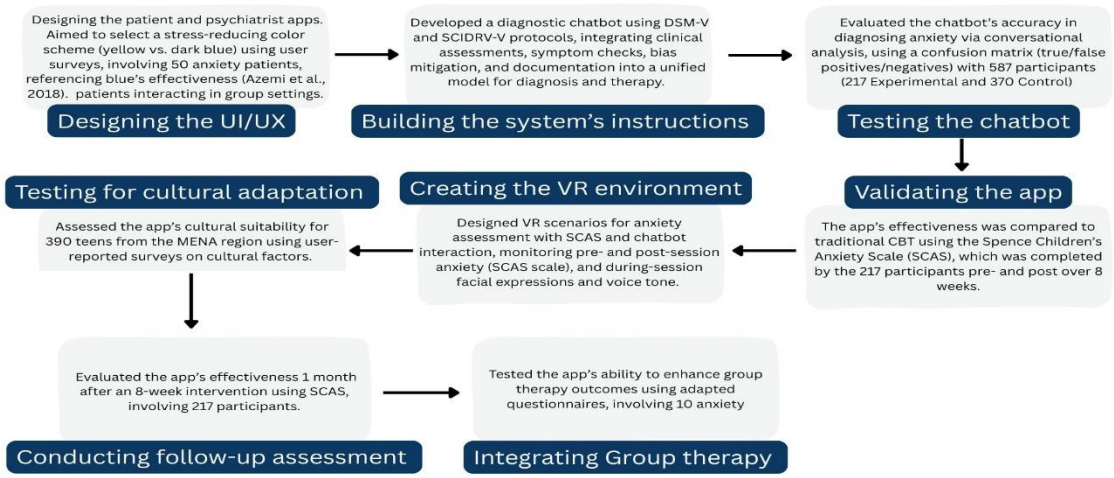
Figure 4: Summary of the application features and components



7. Experimentation

The experimentation unfolded in sequential stages, aligning with app development and validation:

Figure 5: *Summary of the experimentation procedures*



- UI/UX Design and Color Scheme Selection:

To optimize the app's interface for stress reduction, a user survey compared two color schemes (yellow with blue accents vs. dark blue as primary). Fifty participants interacted with mockups and rated anxiety levels pre- and post-exposure using a brief self-report scale. This was informed by evidence on blue's calming effects (Azeemi et al., 2018). Results guided the final UI choice (74% preference for blue, as noted in results).

- Chatbot Development and Testing:

The AI chatbot was built using the Gemini API, integrating DSM-V criteria and SCIDRV-V protocols for unstructured interviews. It incorporated symptom checks, bias mitigation (e.g., cultural sensitivity training data), and documentation. Diagnostic accuracy was tested via conversational simulations with 587 participants. The experimental group interacted with the chatbot within the app, while controls underwent standard clinical interviews. Outcomes were classified using a confusion matrix (true positives/negatives, false positives/negatives) to compute sensitivity, specificity, PPV, NPV, accuracy, Matthews Correlation Coefficient, F1 score, Cohen's Kappa, and Youden's J.

- App Validation and Efficacy Comparison:

Over 8 weeks, the experimental group (n=217) used Ísland's full features (AI diagnostics, integrated therapies, journaling, history tracking, group therapy, VRET, facial/voice analysis). The control group (n=370) received a standalone iCBT via a basic platform. Pre- and post-intervention anxiety was measured, with weekly check-ins for adherence.

- VR Environment Creation and Testing:

VR scenarios were designed for exposure therapy, incorporating anxiety triggers (e.g., social situations) tailored to adolescents. Participants (subset of the experimental group) completed sessions, with anxiety monitored pre/post via SCAS and during-session via AI-analyzed facial expressions and voice tones for real-time feedback.

- Cultural Adaptation Testing:

To ensure suitability for MENA users, 200 teens tested the app (including multilingual features and Egyptian dialects) and completed surveys on cultural relevance, stigma reduction, and usability. Questions covered language accessibility, content relatability, and privacy perceptions.

- Stigma Assessment:

A dedicated survey with 200 MENA teens evaluated anxiety therapy stigma and its influence on app continuation. Items assessed demographic impacts (age, gender, origin) on help-seeking tendencies and system usage intent.

- Follow-Up Assessment:

One month post-8-week intervention, the core 587 participants recompleted the SCAS to evaluate sustained effects.

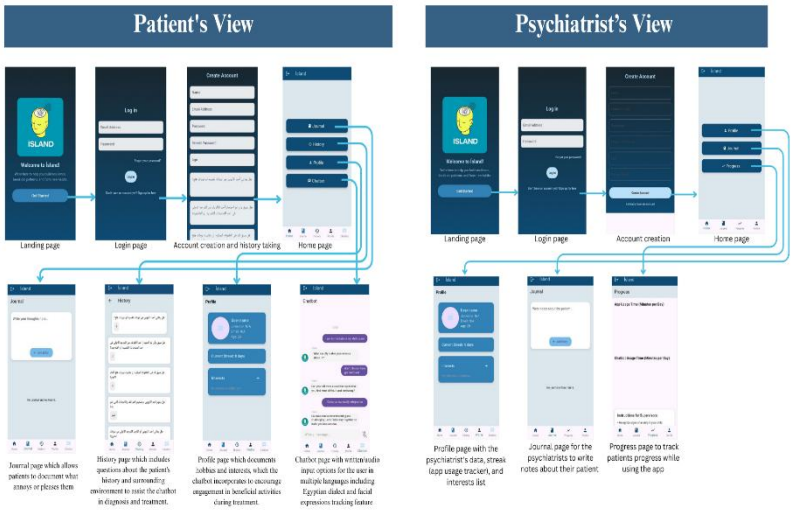
- Group Therapy Integration and Questionnaire Validation:

The AGTRQ (adapted from GTQ and GRQ) was validated with 10 participants to assess readiness and optimize group placements. Pre- and post-group sessions measured engagement and anxiety outcomes, comparing questionnaire-informed vs. baseline placements.

- Patient and Psychiatrist App Design:

Dual interfaces were developed: patient-facing for self-use (therapy access, journaling) and psychiatrist-facing for diagnostic oversight (encrypted access only). Integration ensured seamless data flow while prioritizing privacy.

Figure 6: Application usage flow for the patient and the psychiatrist with UI/UX modifications



8. Results & Analysis

The Ísland app demonstrated a diagnostic sensitivity of 91.24%, specificity of 93.51%, PPV of 89.19%, NPV of 94.8%, and overall accuracy of 92.67%, correctly classifying 544 out of 587 interactions. Performance metrics included a Matthews Correlation Coefficient of 84.39%, Cohen's Kappa of 84.41%, and Youden's J of 84.75%, indicating robust diagnostic reliability (Figure 7: Confusion matrix heat map; Figure 8: Forest plot of chatbot performance metrics).

Figure 7: Confusion matrix heat map for the AI chatbot

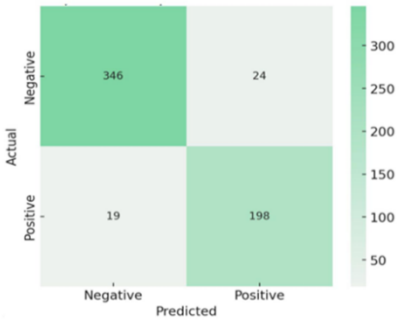
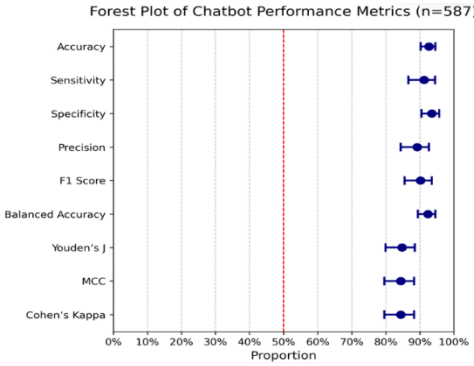


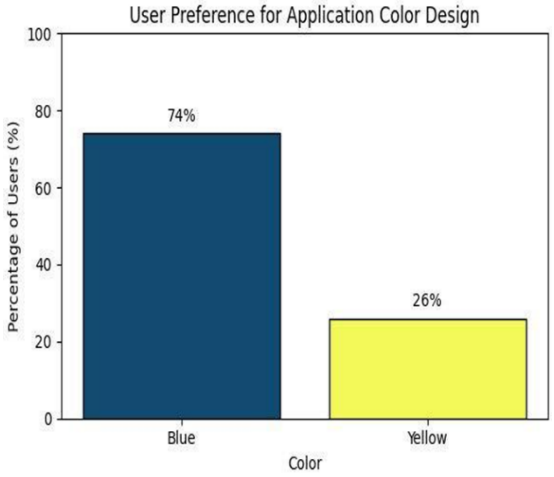
Figure 8: Forestplot of chatbot performance metrics



Metric	Value (%)	95% CI
Accuracy	92.67	[90.24, 94.59]
Sensitivity	91.24	[86.62, 94.48]
Specificity	93.51	[90.47, 95.69]
Precision	89.19	[84.38, 92.69]
F1 Score	90.18	[85.53, 93.53]
Balanced Accuracy	92.38	[89.46, 94.59]
Youden's J	84.75	[79.98, 88.53]
MCC	84.39	[79.56, 88.28]
Cohen's Kappa	84.41	[79.59, 88.29]

User surveys showed 74% preferred a blue UI over yellow, influencing design choices (Figure 9: Participants' responses for preferred app UI color).

Figure 9: Participants responses for their preferred app UI color



The experimental group exhibited a clinically significant SCAS reduction (ΔM = -7.5, 95% CI [-8.2, -6.8]), surpassing the Minimal Clinically Important Difference (MCID) threshold of 4-6 points (Figure 10: SCAS scale scores reduction). The Mann-Whitney U test confirmed the app's superiority over iCBT (U = 8,203, p < 0.00001, r = 0.78), with anxiety reductions 4.5× greater than the control group (Figure 11: SCAS scale scores for experimental group pre- and post-intervention).

Figure 10: SCAS scale scores reduction intervention

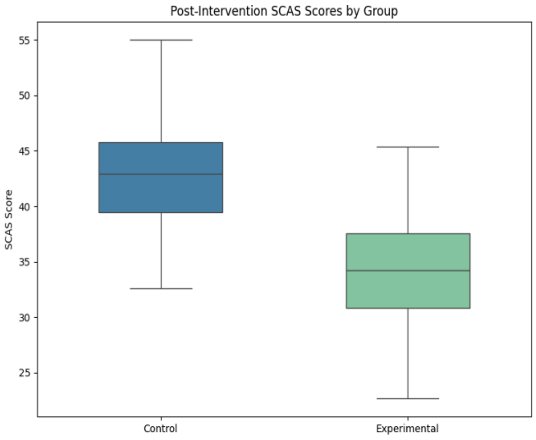
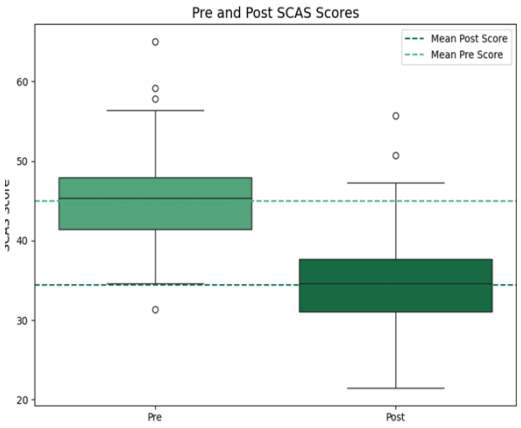
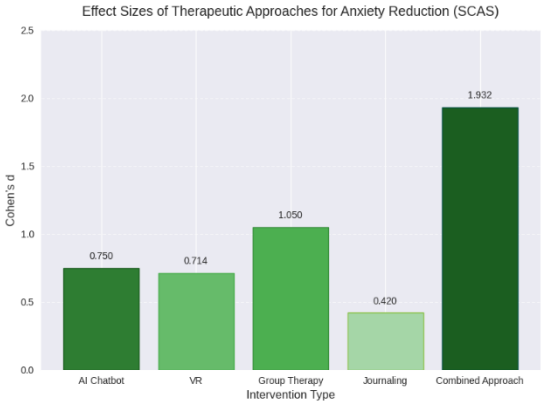


Figure 11: SCAS scores for the experimental group pre and post



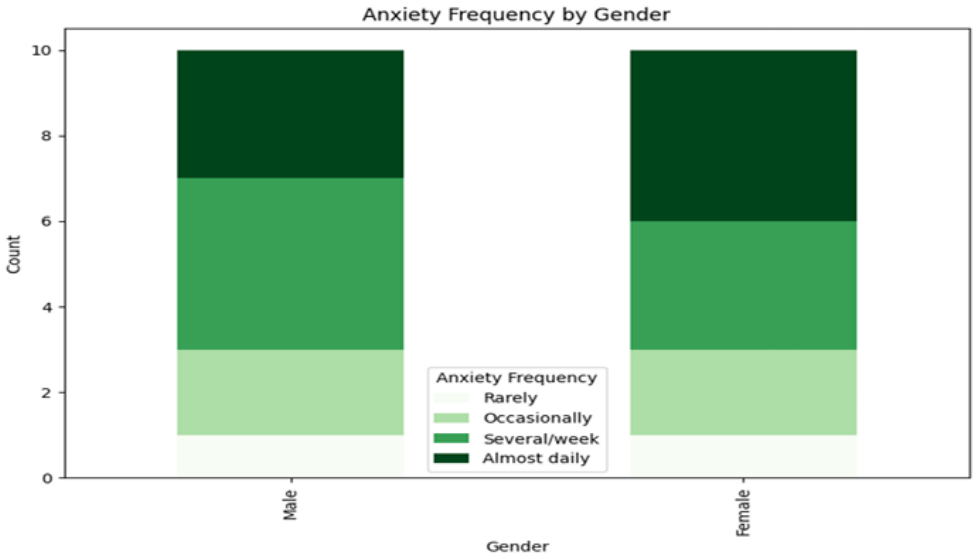
The AI Chatbot achieved a 7.5-point reduction (17.86% efficiency, Cohen's d = 0.75), indicating a medium to large effect. Reductions for individual components included VR (7.14 points, 17%, d = 0.714, medium to large), Group Therapy (10.5 points, 25%, d = 1.05, large), and Journaling (4.2 points, 10%, d = 0.42, small to medium). The Combined Approach yielded a 19.32-point reduction (46%, d = 1.932, very large), suggesting significant synergy among components.

Figure 12: SCAS scale scores for the combined therapeutic approaches in comparison between each individual approach



Correlation analysis for the stigma assessment survey revealed a negative correlation between anxiety frequency and comfort discussing mental health (r = -0.45, p < 0.05), while age had minimal impact (r = -0.15, not significant). Chi-square tests indicated no significant gender-based variance in anxiety frequency (p ≈ 0.95), supporting a gender-neutral app design (Figure 13: Anxiety frequency by gender). Stigma perception strongly predicted prevented help-seeking (p < 0.05), highlighting the app's role in reducing stigma-related barriers.

Figure 13: Anxiety frequency by gender as reported by the participants through the survey



9. Discussions

The Ísland app's integration of CBT, ACT, MBCT, MBSR, and VRET addresses all three dimensions of anxiety, overcoming the limitations of single-modality therapies (Curtiss et al., 2021). Its AI-driven chatbot achieved diagnostic accuracy comparable to or exceeding traditional clinical interviews, supporting the first hypothesis (First et al., 2015). The significant SCAS reduction in the experimental group (ΔM = -7.5) confirms the second hypothesis, demonstrating superior efficacy compared to iCBT (Ritola et al., 2021). Culturally adapted features, including multilingual support and real-time emotional feedback, enhanced engagement and reduced stigma, particularly in high-stigma regions like the Middle East, supporting the third hypothesis (Javaid et al., 2023). The preference for blue UI and shorter usage periods highlights the importance of user-centered design and rapid intervention strategies (Azeemi et al., 2018; Lubos, 2012).

Limitations include the study's focus on Middle Eastern adolescents, which may limit generalizability, and the eight-week intervention period, which may not capture long-term outcomes. Future research should explore broader populations and extended follow-up periods.

10. Conclusions

The Ísland app represents a scalable, evidence-based solution for adolescent anxiety disorders, offering high diagnostic accuracy (92.7%) and significant symptom reduction (ΔM = -7.5). Its multimodal approach, cultural adaptability, and innovative features like VRET and AI-driven diagnostics make it a promising tool for regions with limited mental health access and high stigma. The app's ability to address all three anxiety dimensions and reduce barriers to care underscores its potential to transform mental health interventions for adolescents.

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