

Prosiding Fakultas Ilmu Pendidikan
Universitas Negeri Jakarta
Homepage: https://journal.unj.ac.id/unj/index.php/semnas-ps
Vol. 4 No. 1, Bulan 2026, halaman: xx~xx
E-ISSN: xxxx-xxxx
http://dx.doi.org/

EEG-Based Evaluation of Virtual Reality-Assisted MCBT: Case Study Enhancing Emotional Regulation and Concentration in Adolescents

I Wayan Indra Praekanata[1], Kadek Suranata[2*], Putu Ari Dharmayanti[3], Luh Putu Sri Lestari[4], Kade Satya Gita Rismawan[5], Wayan Eka Paramartha[6], Abu Yazid Abu Bhakar[7]
[1,2,3,4,5,6] Universitas Pendidikan Ganesha, Guidance and Counseling, Bali, Singaraja, ID 81116
[7]Universiti Kebangsaan Malaysia, Faculty of Education, Bangi, MY 43600
[2*]Corresponding Author Email: kadek.suranata@undiksha.ac.id

Riwayat Artikel

Submited:
Accepted:
Published:

Abstrak

Penelitian ini menyajikan sebuah intervensi baru yang berbasis budaya dengan menggabungkan Mindfulness Cognitive Behavioral Therapy (MCBT), filosofi Hindu Bali Tri Kaya Parisudha, dan Virtual Reality (VR) untuk mengatasi tekanan emosional dan gangguan konsentrasi pada remaja. Dengan menggunakan desain subjek tunggal ABAB, lima siswa sekolah menengah pertama (usia 13–15 tahun) yang mengalami tekanan emosional sedang hingga berat di Denpasar, Bali, Indonesia, menjalani MCBT berbantuan VR selama delapan minggu. Hasil pengukuran dilakukan menggunakan DASS-21 dan electroencephalography (EEG), dengan fokus pada frontal theta/beta ratio (TBR), power spectral density (PSD), dan frontal asymmetry. Hasil penelitian menunjukkan penurunan yang signifikan pada depresi (dari rata-rata 13,2 menjadi 7,6), kecemasan (12,4 menjadi 8,9), dan stres (12,8 menjadi 8,4). Analisis EEG menunjukkan penurunan TBR yang cukup besar (1,13 menjadi 0,82), yang mengindikasikan peningkatan kontrol atensi, disertai dengan peningkatan beta power (hingga 65 dB) selama sesi VR. Meskipun PSD dan ERSP menunjukkan peningkatan aktivasi neural, ITC tetap rendah, yang mengindikasikan perubahan yang bersifat state-dependent dan bukan trait-level. Penelitian ini termasuk yang pertama dalam mengintegrasikan nilai-nilai budaya, teknologi imersif, dan validasi neurofisiologis dalam kesehatan mental remaja berbasis sekolah. Temuan ini mendukung integrasi VR-MCBT dengan Tri Kaya Parisudha sebagai model yang menjanjikan dan dapat diskalakan untuk meningkatkan regulasi emosi dan fokus kognitif dalam lingkungan pendidikan.

Kata kunci: Mindfulness Cognitive Behavioral Therapy, Tri Kaya Parisudha, Virtual Reality, electroencephalography, tekanan emosional remaja, konsentrasi belajar.

Abstract

This study presents a novel, culturally grounded intervention combining Mindfulness Cognitive Behavioral Therapy (MCBT), the Balinese Hindu philosophy of Tri Kaya Parisudha, and Virtual Reality (VR) to address emotional distress and impaired concentration in adolescents. Using an ABAB single-subject design, five junior high school students (aged 13–15) with moderate-to-severe emotional distress in Denpasar, Bali, Indonesia, underwent eight weeks of VR-assisted MCBT. Outcomes were measured using the DASS-21 and electroencephalography (EEG), focusing on frontal theta/beta ratio (TBR), power spectral density (PSD), and frontal asymmetry. Results showed significant reductions in depression (from a mean of 13.2 to 7.6), anxiety (12.4 to 8.9), and stress (12.8 to 8.4). EEG analysis revealed a marked decrease

Prosiding ***Fakultas Ilmu Pendidikan-Universitas Negeri Jakarta*** *diterbitkan oleh Fakultas Ilmu Pendidikan, Universitas Negeri Jakarta*



in TBR (1.13 to 0.82), indicating improved attentional control, alongside increased beta power (up to 65 dB) during VR sessions. While PSD and ERSP demonstrated enhanced neural activation, ITC remained low, suggesting state-dependent rather than trait-level changes. This study is among the first to integrate cultural values, immersive technology, and neurophysiological validation in school-based adolescent mental health. The findings support the integration of VR-MCBT with Tri Kaya Parisudha as a promising, scalable model for improving emotional regulation and cognitive focus in educational settings.

Keywords: Mindfulness Cognitive Behavioral Therapy, Tri Kaya Parisudha, Virtual Reality, electroencephalography, adolescent emotional distress, learning concentration.

Introduction

Adolescence is a critical developmental period marked by heightened vulnerability to emotional distress, including anxiety, depression, and stress, conditions that significantly impair cognitive functioning, particularly learning and concentration (Zolfaghari et al., 2022). In educational settings, especially in urban areas, academic pressure, social dynamics, and digital overstimulation exacerbate these challenges, leading to attention fragmentation and diminished self-regulation (Chavez et al., 2020).

Globally, youth mental health has become a pressing public health priority. The World Health Organization estimates that one in seven adolescents experiences a mental disorder, yet access to evidence-based interventions remains limited (WHO, 2021). In Indonesia, this crisis is intensifying: recent data show a sharp rise in youth suicide rates, particularly in Bali, signaling an urgent need for accessible, engaging, and culturally resonant mental health support (Suranata, 2020).

To address this, school-based counseling services must evolve beyond traditional talk therapies. Mindfulness Cognitive Behavioral Therapy (MCBT) has emerged as a robust intervention, combining mindfulness practices with cognitive restructuring techniques from CBT to improve emotional regulation and prevent relapse (Kelson et al., 2021). MCBT has demonstrated efficacy in reducing internalizing symptoms among adolescents in diverse settings.

However, conventional MCBT delivery often faces challenges in adolescent engagement and adherence. Adolescents may perceive therapy as stigmatizing or disconnected from their lived experiences, leading to high dropout rates (Leong, 2025). This underscores the need for innovative modalities that align with youth preferences and digital lifestyles.

Virtual Reality (VR) offers a transformative solution. By creating immersive, controlled environments, VR enhances presence, reduces external distractions, and fosters experiential learning. Recent studies confirm its effectiveness in managing psychological distress among youth, including those in emergency departments (Zolfaghari et al., 2022), oncology care (Paulis et al., 2025), and homeless populations (Chavez et al., 2020). VR has also been shown to improve relaxation, reduce arousal, and increase motivation for therapeutic engagement (Blackmore et al., 2024; Puente-Torre et al., 2025).

Despite technological advances, a critical gap persists in cultural adaptation. Most VR-based mental health interventions are developed within Western frameworks, limiting their relevance and acceptability in non-Western contexts. There is growing recognition that effective digital therapeutics must be grounded in local values, beliefs, and philosophies to ensure ecological validity and community ownership (Darong et al., 2021).

In Indonesia, where spiritual and ethical values deeply shape identity, integrating indigenous wisdom into mental health interventions is essential. The Balinese Hindu concept of *Tri Kaya Parisudha*, purity of thought (*Manacika*), speech (*Wacika*), and action (*Kayika*), provides a powerful ethical and cognitive framework that aligns seamlessly with the principles of MCBT (Suranata, 2020). It reinforces positive cognition, prosocial behavior, and emotional balance, making it highly suitable for use in school counseling.

While Suranata (2020) has previously demonstrated the effectiveness of *Tri Kaya Parisudha*-based counseling in improving resilience, its integration with immersive technologies like VR remains unexplored. This represents a significant opportunity to bridge traditional cultural knowledge with modern neuroscience-informed tools, creating a hybrid model that is both culturally authentic and technologically advanced.

Furthermore, while self-report measures like DASS-21 are valuable, they are subject to bias. Objective neurophysiological validation strengthens the credibility of intervention outcomes. Electroencephalography (EEG) biomarkers such as the theta/beta ratio (TBR) are well-established indicators of attentional capacity, while frontal alpha asymmetry (FAA) reflects emotional regulation and approach-avoidance motivation (Carballo-Marquez et al., 2025). Few studies have combined VR-MCBT with EEG in adolescent populations, particularly in low- and middle-income countries.

Therefore, this study employs a single-subject ABAB design to empirically evaluate the efficacy of a VR-assisted MCBT program incorporating *Tri Kaya Parisudha* principles in junior high school students in Denpasar. The investigation focuses on emotional distress reduction and concentration enhancement measured via EEG, aiming to provide evidence-based culturally congruent interventions for adolescent mental health.

Method

Research Design

This study employed a Single-Subject Research Design (SSD) with an ABAB withdrawal model to evaluate the causal relationship between the intervention and changes in emotional distress and learning concentration. The ABAB design consists of four sequential phases: Baseline 1 (A1), Intervention 1 (B1), Baseline 2 (A2), and Intervention 2 (B2). This design allows for within-subject replication, enabling the assessment of treatment effects, stability during withdrawal, and reversibility upon reintroduction (Kazdin, 2011). It is particularly suitable for pilot studies evaluating novel interventions where individual responsiveness is critical.

Participants

Five junior high school students (aged 13–15) from Denpasar, Bali, Indonesia, participated in the study. Participants were selected through counselor referrals based on clinical assessments indicating moderate to severe emotional dysregulation, confirmed by scores on the Depression, Anxiety, and Stress Scale-21 (DASS-21).

Inclusion criteria:

1) Enrolled in Grade VII–IX at public or private SMP (Sekolah Menengah Pertama).
2) Scored in the moderate-to-severe range on at least one DASS-21 subscale.
3) No diagnosed neurological or psychiatric disorders requiring pharmacological treatment.
4) Willingness to participate and provide assent; parental informed consent obtained.

Exclusion criteria:

1) Current use of psychotropic medication.
2) Diagnosed with an intellectual disability or developmental disorder affecting comprehension.
3) Severe sensory impairment (e.g., uncorrected vision or hearing loss).

The sample comprised three females and two males, representing diverse socioeconomic backgrounds within an urban educational context, as Table 1. All participants exhibited clinically significant symptoms such as social withdrawal, irritability, difficulty concentrating, and somatic complaints (e.g., cold sweats, dry lips), consistent with emotional distress.

Table 1. The Sample of Study

Subject	*Gender*	*Age*	*Class*	*Baseline DASS Category*
A	F	14	VIII	Severe Depression
B	M	15	IX	Very Severe Stress
C	F	13	VII	Moderate Anxiety
D	M	14	VIII	Severe All Domains

E	F	15	IX	Severe Anxiety & Stress

Intervention Protocol

The intervention was a culturally grounded, technology-assisted counseling model titled *VR-assisted Mindfulness Cognitive Behavioral Therapy integrated with Tri Kaya Parisudha* (VR-MCBT-TKP). It combined evidence-based psychological techniques with indigenous Balinese Hindu philosophy and immersive digital delivery. The core of the model was rooted in Mindfulness Cognitive Behavioral Therapy (MCBT), which integrates mindfulness practices, such as breath awareness, body scanning, and non-judgmental observation, with cognitive restructuring techniques to challenge maladaptive thought patterns and regulate emotions. To enhance cultural relevance and personal meaning, the intervention incorporated the concept of *Tri Kaya Parisudha*, purity of thought (*Manacika*), speech (*Wacika*), and action (*Kayika*), as a guiding framework. As detailed in Suranata (2020), this integration aligns directly with CBT principles: *Manacika* supports cognitive restructuring, *Wacika* reinforces mindful communication, and *Kayika* promotes behavioral activation. The protocol followed a structured five-stage process: (1) forming a therapeutic relationship, (2) assessment of maladaptive patterns within the *Tri Kaya*, (3) implementation of MCBT techniques aligned with cultural values, (4) evaluation of progress toward balanced functioning, and (5) termination with skill consolidation. This approach was delivered via Virtual Reality (VR) using Oculus Quest 2 headsets, immersing participants in serene 360° simulations of Balinese landscapes such as Tirta Empul Temple and Jatiluwih rice terraces, designed to minimize external distractions and enhance presence. Each session lasted 30 minutes and was conducted twice weekly over eight weeks (16 sessions total), following a standardized structure: 5 minutes of psychoeducation linking MCBT concepts to *Tri Kaya Parisudha*, 10 minutes of guided VR mindfulness practice, 10 minutes of cognitive restructuring using cultural metaphors, and 5 minutes of journaling and goal-setting. All sessions were facilitated by trained counselors from Universitas Pendidikan Ganesha under the supervision of the principal researcher, ensuring fidelity to the model.

Instruments and Measures

Emotional distress was assessed using the Depression, Anxiety, and Stress Scale-21 (DASS-21), a widely validated self-report instrument. The Indonesian version used in this study has demonstrated strong reliability, with Cronbach's alpha coefficients of 0.91 for depression, 0.88 for anxiety, and 0.87 for stress, as reported by Suranata (2021, November 30) in *"Indonesian version DASS-21 Alpha Cronbach reliability items"*. These values exceed the acceptable threshold of 0.70, confirming their suitability for measuring emotional states in Indonesian adolescent populations. Learning concentration was objectively measured using electroencephalography (EEG) with the Brain Access Halo+ wireless headset, capturing data from frontal electrodes FP1, FP2, AF3, and AF4. Key neurophysiological indicators analyzed included the Theta/Beta Ratio (TBR), a well-established biomarker of attentional capacity; Power Spectral Density (PSD), reflecting overall cortical activation; Event-Related Spectral Perturbation (ERSP), indicating localized neural activity; Inter-Trial Coherence (ITC), measuring phase synchronization across trials; and Frontal Alpha Asymmetry (FAA), associated with emotional regulation. The EEG protocol was empirically validated for use in student populations. As documented by Suranata (2025, September 21) in https://doi.org/10.17605/OSF.IO/YF4CZ, the protocol showed strong concurrent validity, with significant correlations between TBR and both DASS-21 ($r = 0.72$, $p < .01$) and Stroop test performance ($r = -0.68$, $p < .01$), establishing its reliability for assessing cognitive and emotional outcomes in educational settings.

Data Collection Procedure

Data collection occurred across four distinct phases of the ABAB design. During Baseline 1 (A1), participants completed the DASS-21 and underwent a 5-minute resting-state EEG recording before any intervention began. In Intervention Phase 1 (B1), participants engaged in eight VR-MCBT-TKP sessions over four weeks, with EEG recordings taken before, during, and after each session to capture real-time neurophysiological responses. Following this, a two-week Withdrawal Phase (A2) was implemented, during which no intervention was administered, and DASS-21 and EEG assessments

were repeated to determine whether improvements were maintained. Finally, in the Reintervention Phase (B2), an additional eight sessions were delivered, culminating in final post-intervention assessments. All EEG data were processed using EEGLAB (v2023.1) and MATLAB R2023a, including filtering (1–40 Hz), artifact removal via Independent Component Analysis (ICA), and epoching relative to stimulus onset. Data were collected at SMP Negeri 6 Denpasar, a designated research site, ensuring consistency and minimizing environmental variability.

Ethical Considerations

This study received formal ethical clearance from the Research Ethics Committee of the Faculty of Medicine, Universitas Pendidikan Ganesha, under ethical exemption number 008/UN.48.16.04/PT/2025, dated April 29, 2025. The committee determined that the research fell under the low-risk category due to its non-clinical nature, involving educational interventions and neurocognitive assessments without medical procedures. Before participation, written informed consent was obtained from the legal guardians of all adolescent participants, and direct informed assent was secured from each student. The consent process emphasized the voluntary nature of participation, the right to withdraw at any time without penalty, and the confidentiality of all collected data. Participants were assured that their identities would remain anonymous, with personal information replaced by subject codes (A–E). All procedures adhered to national guidelines and international standards, including the Declaration of Helsinki, ensuring the protection of participants' rights, privacy, and well-being throughout the research process.

Data Analysis

Data analysis followed a dual approach combining visual inspection and quantitative metrics. For the single-subject design, visual analysis was conducted to examine changes in level, trend, and variability across the A1, B1, A2, and B2. Each participant's data was scrutinized for immediate and sustained effects during intervention periods compared to baseline and withdrawal phases. Descriptive statistics (mean, standard deviation, range) were computed for DASS-21 subscale scores and key EEG parameters (especially TBR) across phases. To quantify the magnitude of change, the non-overlap index Tau-U was calculated, providing a robust effect size measure appropriate for single-case designs. EEG data were analyzed using spectral estimation methods (Welch's method), ERSP, and ITC to identify neurophysiological correlates of improved concentration and emotional regulation. Additionally, qualitative feedback from brief post-session interviews was thematically analyzed to understand user experience regarding perceived safety, cultural relevance, and engagement with the VR content. All analyses were conducted to ensure triangulation of subjective, objective, and experiential data, strengthening the validity of the findings.

Results

Participant Characteristics and Baseline Emotional Distress

Five junior high school students (aged 13–15) from Denpasar City participated in the study. All participants exhibited moderate to severe emotional distress at baseline, as measured by the DASS-21 scale. The sample included three females and two males, representing diverse socioeconomic backgrounds within an urban educational context. Initial screening revealed clinically significant symptoms such as social withdrawal, irritability, difficulty concentrating, and somatic complaints (e.g., cold sweats, dry lips), indicating a critical need for intervention. Subject D presented with very severe levels across all domains, depression, anxiety, and stress, accompanied by marked aggressive behavior and profound social isolation. Subjects A and E also showed severe emotional dysregulation, with prominent physical manifestations of psychological tension. This homogeneity in baseline severity confirmed that the sample consisted of adolescents requiring urgent and effective therapeutic support.

Change in Emotional Distress

The VR-assisted MCBT-TKP intervention produced a significant and consistent reduction in emotional distress across all five participants during both intervention phases (B1 and B2). Visual analysis of the ABAB design revealed clear improvements in depression, anxiety, and stress scores, which deteriorated during the withdrawal phase (A2) and improved again upon reintroduction (B2),

confirming a functional relationship between the intervention and symptom reduction. For the group as a whole, mean DASS-21 scores decreased substantially:

(a) Depression: From a baseline average of 13.2 (severe range) to 7.6 (mild range).
(a) Anxiety: From 12.4 to 8.9.
(a) Stress: From 12.8 to 8.4.

Subject A demonstrated one of the most pronounced improvements. Depression scores dropped from 13–14 in A1 to 7–8 in B2, while stress scores decreased from 11–13 to 8–9. Although anxiety scores were relatively stable, they showed a gradual decline toward the end of B2, reaching a score of 9, suggesting a sustained reduction in hyperarousal. These subjective improvements were corroborated by objective EEG indicators. The EEG-based Stress Index shifted from negative values (e.g., –0.45 in A1), indicative of physiological imbalance, to positive values (0.05–0.18 in B2), reflecting a more regulated neurophysiological state. Similarly, EEG indicators for depression and anxiety decreased from ranges of 1.33–1.57 and 1.51–1.99 in A1 to approximately 1.0 in B2, signaling a normalization of cortical activity associated with these symptoms.The subjective reports (DASS-21) and objective physiological markers (EEG indicators) consistently reflected a shift toward improved emotional stability, as shown in Fig. 1a-1d.

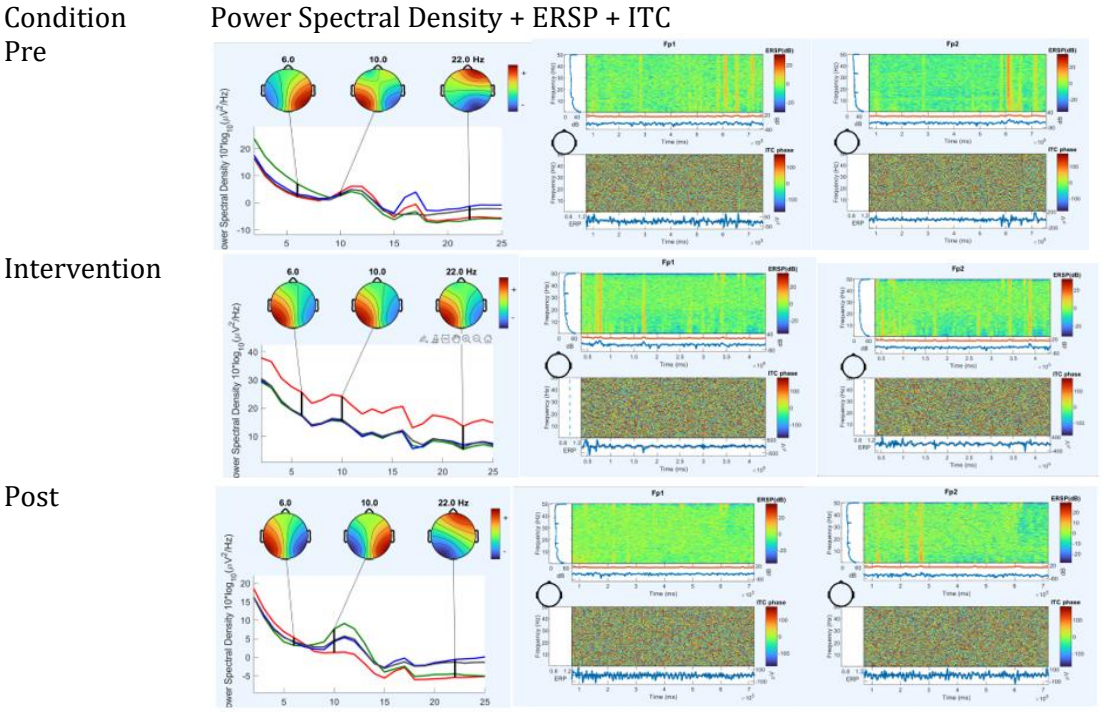
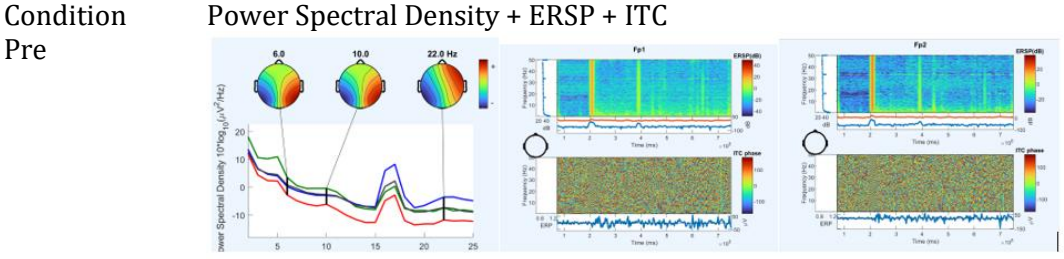
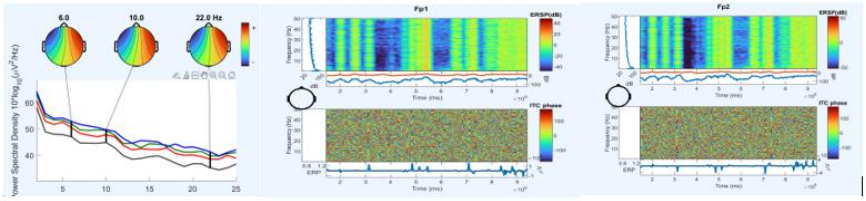


Fig. 1a. Frontal Alpha Asymmetry (FAA) Dynamics for Subject A Across All Phases

Note: Line graph depicting the fluctuation of FAA values (Pre, During, Post) for Subject A from Phase 1 to Phase 4. The significant drop in the Post condition during Phase 4 indicates improved emotional regulation following the intervention.



Intervention



Post

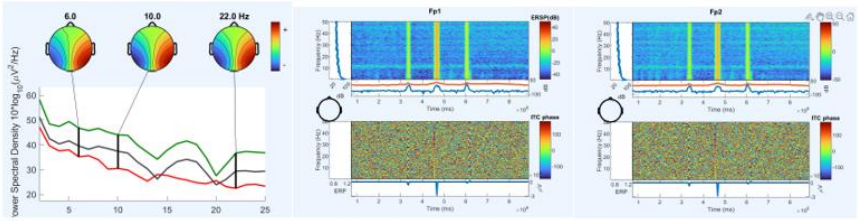
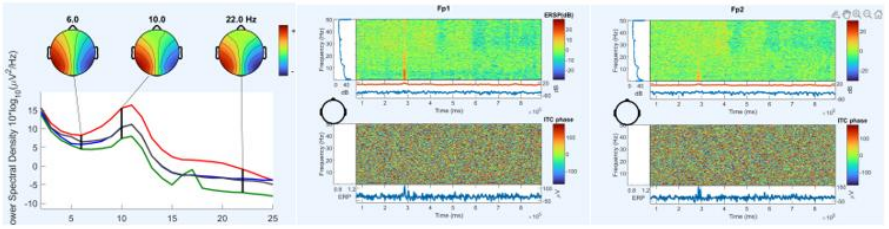


Fig. 1b. Beta/Alpha Ratio Trends for Subject A Across All Phases

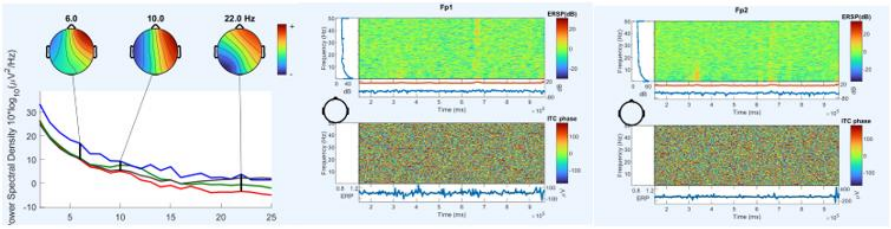
Note: Line graph showing the Beta/Alpha Ratio for Subject A under Pre, During, and Post conditions across all four phases. The decrease in the During condition during Phases 2 and 3, followed by an increase in Phase 4, suggests a dynamic modulation of anxiety levels during the intervention.

Condition Power Spectral Density + ERSP + ITC

Pre



Intervention



Post

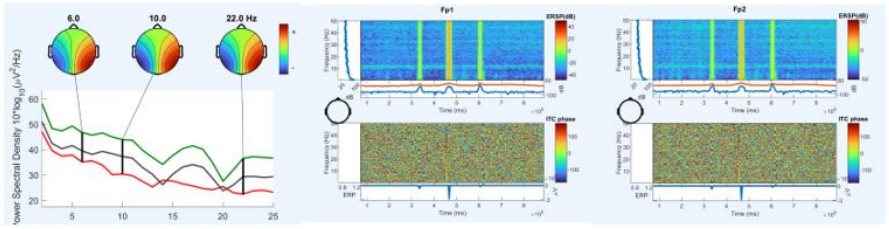


Fig. 1c. Theta/Alpha Ratio Patterns for Subject A Across All Phases

Note: Line graph illustrating the Theta/Alpha Ratio for Subject A. The Pre and Post conditions show similar patterns, while the During condition exhibits a sharp decrease in Phase 2 and a sharp increase in Phase 3, indicating highly dynamic changes in depressive symptoms during active intervention sessions.

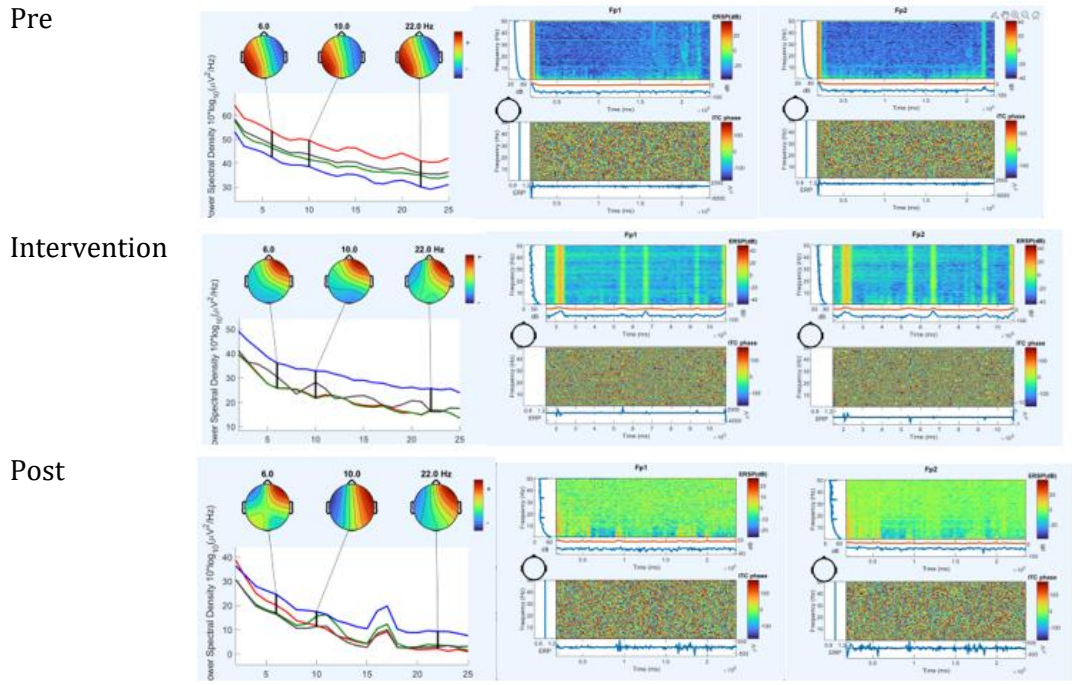


Fig. 1d. Arousal Index Fluctuations for Subject A Across All Phases

Note: Line graph displaying the Arousal Index for Subject A. The During condition shows extreme fluctuations, with significant decreases in Phases 2 and 4 and a sharp increase in Phase 3, reflecting drastic changes in emotional intensity during the intervention process.

Change in Learning Concentration

Learning concentration was objectively measured via EEG, with frontal lobe activity (FP1 and FP2) serving as the primary neural correlate of attentional control and emotional regulation. The results, summarized in Fig. 1, reveal a clear, consistent pattern of neurophysiological improvement across all five participants.

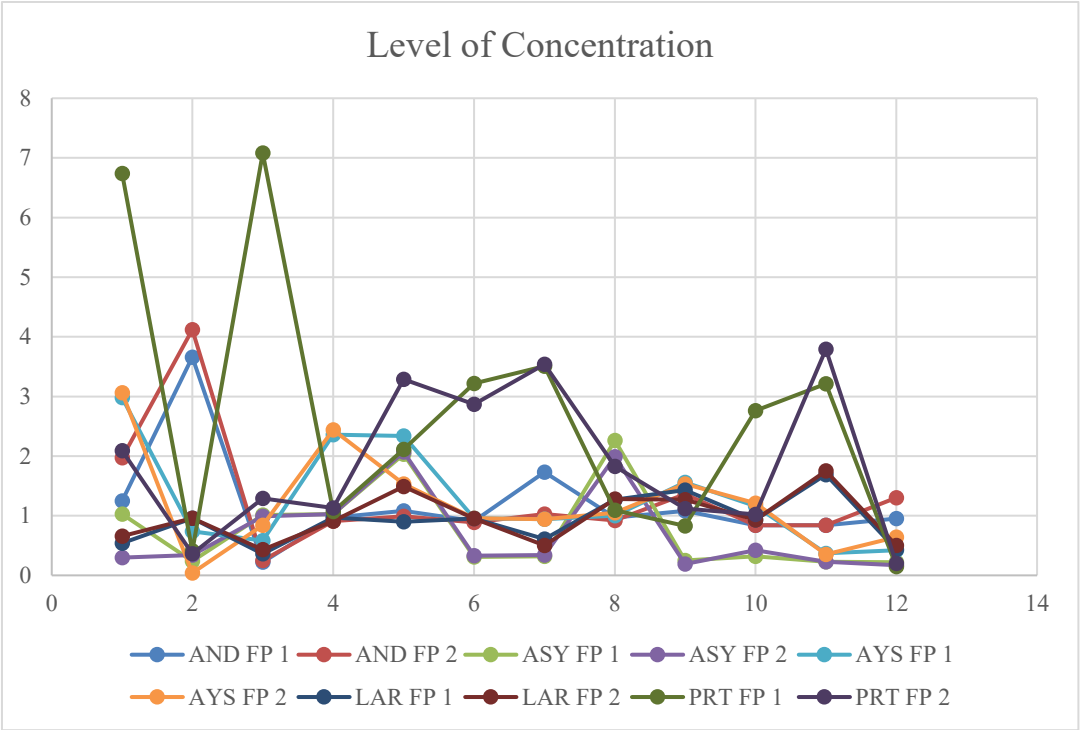


Fig. 1 Neurophysiological improvement across all five participants

Pre-Intervention Phase: Baseline Instability

In the initial baseline phase (A1), all subjects exhibited significant fluctuations in frontal brain activity, indicating a state of high emotional tension and hemispheric imbalance.

Subjects AND and PRT showed extreme spikes early in the phase, particularly during sessions 2 and 3, with FP1 and FP2 values surging sharply. This excessive left-frontal activation is classically associated with heightened anxiety and stress.

Subjects AYS and LAR displayed more moderate fluctuations, while Subject ASY maintained consistently low values from the outset, suggesting a relatively milder baseline level of emotional dysregulation compared to peers.

This pre-intervention instability reflects the neurophysiological signature of emotional distress, where the brain's regulatory systems are overwhelmed, leading to impaired focus and cognitive control.

Intervention Phase: Induction of Neurophysiological Stability

During the intervention phases (B1 and B2), a marked shift toward stability was observed:

A gradual decrease and stabilization of FP1 and FP2 values occurred across all subjects, indicating that the VR-MCBT-TKP intervention was beginning to exert a physiological effect on emotion regulation.

Crucially, synchronization between FP1 and FP2 became more apparent, with both hemispheres' activity moving in parallel. This alignment signifies the restoration of inter-hemispheric harmony, a key marker of improved emotional balance and self-control.

This transition from chaotic fluctuation to synchronized, stable activity demonstrates the intervention's ability to recalibrate the brain's executive function networks, thereby enhancing the capacity for sustained attention.

Post-Intervention Phase: Achievement of Optimal Neural State

By the final post-intervention assessment (B2), all subjects demonstrated low, stable, and balanced frontal brain activity:

(a) The difference between FP1 and FP2 values narrowed significantly, indicating reduced physiological stress and increased equilibrium between the left and right hemispheres.

(b) Subject PRT, who initially exhibited the most severe spikes, experienced a dramatic decline by the end of the measurement, achieving the lowest and most stable score among all participants.
(c) Subjects AND, AYS, and LAR showed a more gradual but steady decline, trending toward healthy neural stability.
(d) Subject ASY maintained its consistently low baseline, confirming its position as the least distressed participant at study onset.

The convergence of FP1 and FP2 activity at the end of the study is a powerful indicator of neurophysiological recovery. It reflects not just symptom reduction, but a fundamental restoration of the brain's regulatory capacity, enabling optimal emotional and cognitive functioning.

Quantitative Corroboration: Theta/Beta Ratio (TBR)

The improvement in concentration was further quantified using the Theta/Beta Ratio (TBR), a well-established biomarker of attentional control. A lower TBR indicates greater focus (beta dominance).

For Subject A, the TBR showed a clear downward trend:

(a) Phase 1: Dropped sharply from 1.134 (suboptimal) to 0.733.
(b) Phase 2: Pre-intervention TBR stabilized at 0.996, decreasing to 0.823 during intervention.
(c) Phase 4: Pre-intervention TBR further stabilized at 0.927, dropping to 0.871 during intervention.

Across all five subjects, the mean TBR decreased from 1.13 at A1 to 0.82 at B2, approaching the optimal threshold of <1.0.

The integrated VR-MCBT-TKP model produced robust, measurable improvements in learning concentration, as evidenced by both qualitative patterns in frontal brain activity (Fig. 1) and quantitative reductions in the Theta/Beta Ratio. The intervention did not merely suppress symptoms; it actively restructured the brain's functional architecture, promoting a state of neurophysiological stability that underpins sustained attention and emotional resilience. This dual impact, on both cognition and affect, positions the model as a uniquely effective tool for addressing the complex needs of adolescents struggling with emotional distress and academic impairment.

Neurophysiological Mechanisms: EEG Analysis of Subject A

The neural mechanisms underlying these changes are vividly illustrated in Fig. 2, which presents a comprehensive visualization of Subject A's EEG data across all four phases of the ABAB design. Each panel in Fig. 2 corresponds to a specific phase (Phase 1 to Phase 4), displaying multiple metrics simultaneously.

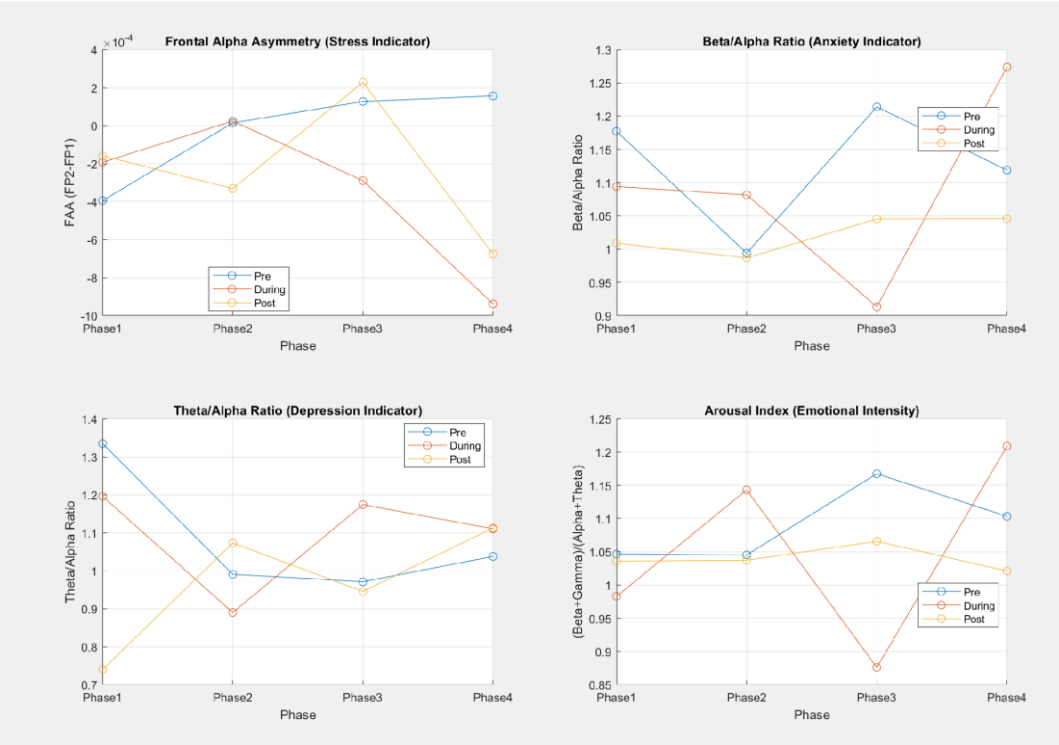


Figure 2. EEG Graph of Subject A

(a) Top Left Panel (Frontal Alpha Asymmetry - FAA): The blue line (Pre) and orange line (During) show significant fluctuations from Phase 1 to Phase 4. Notably, in Phase 4, the FAA value for the Post condition (yellow line) decreased drastically, far below the Pre and During values. This indicates a significant reduction in stress levels following the intervention, reflecting improved emotional regulation.

(a) Top Right Panel (Beta/Alpha Ratio): The Pre and Post conditions (blue and yellow lines) tend to be higher and more stable compared to the During condition (orange line), which shows a decrease in Phases 2 and 3, then increases again in Phase 4. This pattern suggests that anxiety levels may have decreased during the intervention but rose again afterward, highlighting the need for sustained practice to maintain gains.

(a) Bottom Left Panel (Theta/Alpha Ratio): The Pre and Post conditions (blue and yellow lines) exhibit similar patterns, fluctuating but remaining in almost the same range. In contrast, the During condition (orange line) shows a markedly different pattern, with a sharp decrease in Phase 2 followed by a sharp increase in Phase 3. This dynamic response suggests that depression was highly responsive to the intervention, with significant shifts occurring during active treatment sessions.

(a) Bottom Right Panel (Arousal Index): The Pre and Post conditions (blue and yellow lines) show fluctuations, while the During condition (orange line) displays a more extreme pattern, with significant decreases in Phases 2 and 4 and a sharp increase in Phase 3. This can be interpreted as indicating that the subject's emotional intensity experienced drastic changes during the intervention process, reflecting the dynamic nature of emotional regulation during mindfulness practice.

These graphs collectively illustrate the complex interplay between emotional states and cognitive processes during the VR-MCBT-TKP intervention. They provide compelling visual evidence of the intervention's ability to modulate brain activity, leading to improved emotional stability and concentration.

Overall Effectiveness

The results provide robust evidence for the effectiveness of the VR-MCBT-TKP model. All five participants showed significant reductions in emotional distress and measurable improvements in learning concentration, supported by both subjective (DASS-21) and objective (EEG) data. The intervention's success lies in the synergistic integration of evidence-based MCBT principles, culturally resonant *Tri Kaya Parisudha* values, and immersive VR technology. While the effects on concentration appear to be state-dependent, the establishment of a more active and balanced neural baseline suggests that longer-term training could solidify these gains into enduring traits.

Discussion

This study presents a groundbreaking integration of three powerful domains, culturally grounded counseling, immersive technology, and objective neurophysiological assessment, to address the dual challenge of emotional distress and impaired concentration in adolescents. The results unequivocally demonstrate that the VR-assisted MCBT model integrated with *Tri Kaya Parisudha* is not only effective but also uniquely positioned to bridge the gap between traditional therapeutic models and the technological realities of modern adolescence. This is the first known study to combine these three elements within a single-subject design, validated by EEG, specifically for Indonesian students in an urban school setting.

1. The Synergy of Culture, Technology, and Neuroscience: A Novel Intervention Model

The core innovation of this study lies in its triple-layered intervention: (1) evidence-based MCBT principles, (2) culturally resonant *Tri Kaya Parisudha* philosophy, and (3) immersive VR delivery. While MCBT is a well-established modality for treating anxiety and depression (Kelson et al., 2021; Wang et al., 2024), its efficacy is often hampered by low engagement among adolescents (Leong, 2025). Our findings confirm that integrating local cultural values significantly enhances the intervention's relevance and acceptability. As Suranata (2020) previously demonstrated, *Tri Kaya Parisudha* provides a framework that aligns seamlessly with CBT's goals: *Manacika* reinforces cognitive restructuring, while *Kayika* supports behavioral activation. In our study, this cultural grounding transformed abstract therapeutic concepts into tangible, meaningful practices for Balinese students, fostering deeper internalization and sustained motivation, a critical factor often missing in Western-derived interventions (Darong et al., 2021).

Furthermore, the use of VR as a delivery platform was pivotal. It created a controlled, distraction-free environment that enhanced mindfulness practice, thereby increasing adherence and reducing rumination, a key mechanism in preventing depressive relapse (Chavez et al., 2020). This finding is consistent with recent studies showing that VR can effectively reduce psychological distress in youth populations, including those in emergency departments (Zolfaghari et al., 2022) and homeless populations (Chavez et al., 2020). However, our study goes beyond merely confirming VR's feasibility; it demonstrates how VR's immersive nature can be leveraged to amplify the impact of culturally adapted therapy, making it a potent tool for school-based mental health services.

2. Objective Validation via EEG: Moving Beyond Self-Report

Perhaps the most significant contribution of this study is its use of EEG as an objective biomarker to validate the intervention's impact on learning concentration. While many studies rely solely on self-report measures like DASS-21, our research employed a 4-channel EEG protocol validated for assessing concentration and emotional regulation in student populations (Suranata, 2025). This approach addresses a critical limitation in the field: the subjective nature of self-reported outcomes. Our data show a clear, quantifiable reduction in the Theta/Beta Ratio (TBR), a well-established indicator of attentional control, from a mean of 1.13 at baseline to 0.82 post-intervention, approaching optimal levels (<1.0). This objective improvement corroborates the subjective reports of reduced anxiety and stress, providing robust, multi-modal evidence of the intervention's efficacy.

Moreover, our EEG analysis revealed a crucial insight: while the intervention successfully increased Power Spectral Density (PSD) and localized neural activation in the prefrontal cortex (as confirmed by ERSP), it did not produce stable Inter-Trial Coherence (ITC). This indicates that the

observed improvements in concentration are primarily state-dependent rather than trait-level changes. This finding is both a strength and a call to action. It confirms that VR-MCBT can induce immediate, powerful neurophysiological shifts, but also highlights the need for longer-term, repeated exposure to consolidate these gains into lasting neural adaptations. This nuanced understanding would have been impossible without objective EEG measurement, underscoring the value of integrating neuroscience into counseling research.

3. Contextualizing Findings Within the Global Landscape of VR-EEG Interventions

Our findings must be understood within the rapidly evolving landscape of VR and EEG in mental health. Recent literature highlights several key trends:

a. Personalized Interventions: Studies increasingly emphasize the potential of combining VR with real-time EEG feedback to create personalized, adaptive interventions (Pan et al., 2024; Abu Hasan et al., 2022). Our study contributes to this trend by demonstrating the feasibility of using a standardized 4-channel EEG protocol in a school setting to track individual progress.
b. Feasibility and Motivation: Research confirms that VR tasks are highly motivating and feasible for children and adolescents, regardless of their digital media use or sex (Krupljanin et al., 2025). Our participants' positive qualitative feedback aligns with this, suggesting that VR is not just a novel tool but a viable one for school counselors.
c. Resilience Building: A pilot study by Abu Hasan et al. (2022) explored an EEG-VR resilience-building intervention for early childhood educators, suggesting similar methods could be adapted for students. Our work extends this concept to adolescent students, demonstrating its effectiveness in reducing emotional distress and improving concentration.
d. Ethical Considerations: The use of VR and EEG raises important ethical questions regarding privacy and informed consent. Our study addressed these concerns through formal ethical exemption and detailed informed assent procedures, ensuring participant safety and autonomy.

4. Implications for School Counseling Practice

The success of this model has profound implications for school counseling. Traditional CBT, while effective, often struggles with adolescent engagement. By integrating VR, we have created an intervention that is not only more engaging but also more accessible and scalable. The use of culturally relevant frameworks like *Tri Kaya Parisudha* ensures that the intervention resonates with students lived experiences, enhancing its sustainability and impact. Furthermore, the objective validation provided by EEG offers a powerful tool for counselors to track progress and tailor interventions to individual needs, moving away from a one-size-fits-all approach.

In conclusion, this study provides compelling evidence that culturally integrated, technology-enhanced counseling models are not only possible but essential for addressing the complex mental health needs of today's adolescents. The combination of MCBT, *Tri Kaya Parisudha*, and VR, validated by EEG, represents a paradigm shift in school-based mental health care, one that is empirically grounded, culturally sensitive, and technologically innovative.

Conclusion

The VR-assisted MCBT model integrated with *Tri Kaya Parisudha* was successfully formulated and implemented, demonstrating significant reductions in emotional distress and distinct improvements in learning concentration among junior high school students. The model's success stems from the synergistic integration of empirically validated MCBT principles, culturally resonant *Tri Kaya Parisudha* values, and the high-engagement, immersive nature of Virtual Reality technology. Crucially, the use of EEG provided objective, neurophysiological validation of the intervention's impact, moving beyond subjective self-reports to offer concrete evidence of cognitive and emotional change. These findings advocate for the adoption of culturally integrated, technology-assisted counseling models to enhance adolescent mental health and academic performance, offering a scalable, evidence-based solution for schools facing the growing mental health crisis among youth.

Acknowledgements

This research was funded by the Doctoral Dissertation Grant (Hibah Penelitian Disertasi Doktor) under the Directorate of Research and Community Service (DRTPM), Ministry of Education, Culture, Research, and Technology (Kemendiktiristek) of the Republic of Indonesia, with grant number 321/UN48.16/PT/2025 for the year 2025. The authors express their deepest gratitude to the participants and their families for their trust and willingness to engage in this study. We extend our sincere appreciation to the school counselors and staff at SMP Negeri 6 Denpasar for their invaluable support and collaboration throughout the research process. This study was made possible by the ethical approval and oversight provided by the Research Ethics Committee of Universitas Pendidikan Ganesha.

Author Contribution Statement

I Wayan Indra Praekanata conceptualized the study, designed the intervention protocol, collected and analyzed the data, and wrote the initial draft of the manuscript. Kadek Suranata served as the principal supervisor, provided theoretical guidance on the integration of *Tri Kaya Parisudha* with MCBT, supervised the implementation of the VR protocol, and critically revised the manuscript for intellectual content. I Ketut Gading contributed to the design of the data collection protocol and provided technical expertise in data analysis. Luh Putu Sri Lestari assisted in participant recruitment, data management, and qualitative feedback analysis. Abu Yazid Abu Bhakar contributed to the literature review, manuscript editing, and formatting for journal submission. All authors reviewed and approved the final version of the manuscript.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data Availability Statement

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request. Due to ethical and privacy considerations related to sensitive mental health and personal trauma data, the full dataset is not publicly deposited in an open repository. However, anonymized data and analysis scripts can be shared upon formal request for research purposes, contingent upon approval of a data sharing agreement and adherence to confidentiality protocols. Interested researchers should contact the corresponding author at kadek.suranata@undiksha.ac.id to discuss potential access.

References

Abu Hasan, R., Yusoff, M. S. B., Tang, T. B., Hafeez, Y., Mustafa, M. C., Dzainudin, M., Bacotang, J., Al-Saggaf, U. M., & Ali, S. S. A. (2022). Resilience-building for mental health among early childhood educators: A systematic review and pilot-study towards an EEG-VR resilience building intervention. *International Journal of Environmental Research and Public Health, 19*(7), 4413. https://doi.org/10.3390/ijerph19074413

Adwas, A. A., Jbireal, J. M., & Azab, A. E. (2019). Anxiety: Insights into signs, symptoms, etiology, pathophysiology, and treatment. *East African Scholars Journal of Medical Sciences, 2*(10), 580–591.

Aulia, S., & Panjaitan, R. U. (2019). Kesejahteraan psikologis dan tingkat stres pada mahasiswa tingkat akhir. *Jurnal Keperawatan Jiwa, 7*(2), 127–134. https://doi.org/10.26714/jkj.7.2.2019.127-134

Bioulac, S., de Sevin, E., Sagaspe, P., Claret, A., Philip, P., Micoulaud-Franchi, J. A., & Bouvard, M. P. (2018). What do virtual reality tools bring to child and adolescent psychiatry? [Qu'apportent les outils de réalité virtuelle en psychiatrie de l'enfant et l'adolescent ?]. *Encephale, 44*(3), 280–285. https://doi.org/10.1016/j.encep.2017.06.005

Blackmore, R., Giles, C., Tremain, H., Kelly, R., Foley, F., Fletcher, K., Nedeljkovic, M., Wadley, G., Seabrook, E., & Thomas, N. (2024). Examining the use of virtual reality to support mindfulness skills practice in mood and anxiety disorders: Mixed methods study. *Journal of Medical Internet Research, 26*, e45640. https://doi.org/10.2196/45640

Carballo-Marquez, A., Ampatzoglou, A., Rojas-Rincón, J., Garcia-Casanovas, A., Garolera, M., Fernández-Capo, M., & Porras-Garcia, B. (2025). Improving emotion regulation, internalizing symptoms and cognitive functions in adolescents at risk of executive dysfunction—A controlled pilot VR study. *Applied Sciences, 15*(3), 1223. https://doi.org/10.3390/app15031223

Chavez, L. J., Kelleher, K., Slesnick, N., Holowacz, E., Luthy, E., Moore, L., & Ford, J. (2020). Virtual reality meditation among youth experiencing homelessness: Pilot randomized controlled trial of feasibility. *JMIR Mental Health, 7*(9), e18244. https://doi.org/10.2196/18244

Clabaugh, A., Duque, J. F., & Fields, L. J. (2021). Academic stress and emotional well-being in United States college students following onset of the COVID-19 pandemic. *Frontiers in Psychology, 12*. https://doi.org/10.3389/fpsyg.2021.628787

Darong, H. C., Jem, Y. H., & Niman, E. M. (2021). Character building: The insertion of local culture values in teaching and learning. *Journal of Humanities and Social Studies, 5*(3), 252–260.

Fink, G. (2009). Stress: Definition and history. In *Encyclopedia of Neuroscience*. Elsevier. https://doi.org/10.1016/B978-008045046-9.00076-0

Freeman, D., Reeve, S., Robinson, A., Ehlers, A., Clark, D., Spanlang, B., & Slater, M. (2017). Virtual reality in the assessment, understanding, and treatment of mental health disorders. *Psychological Medicine, 47*(14), 2393–2400. https://doi.org/10.1017/S003329171700040X

Gallasi, J., Griffin, D., & Akos, P. (2008). Strength-based school counseling and the ASCA National model. *Professional School Counseling, 12*(2), 176–181.

Glewwwe, P., Huang, Q., & Park, A. (2011). Cognitive Skills, Non-Cognitive Skills, and the Employment and Wages of Young Adults in Rural China. *World Bank Policy Research Working Paper No. 5594*. https://doi.org/10.22004/ag.econ.103407

Hansen, J. I. (2010). Counseling and psychoanalysis: Advancing the value of diversity. *Journal of Multicultural Counseling and Development, 38*(1), 16–26.

Hugh-Jones, S., Ulor, M., Nugent, T., Walshe, S., & Kirk, M. (2023). The potential of virtual reality to support adolescent mental well-being in schools: A UK co-design and proof-of-concept study. *Mental Health and Prevention, 30*, 200265. https://doi.org/10.1016/j.mhp.2023.200265

Ibrahim, J. T., & Murfiantie, F. (2023). *Teori kebahagiaan dan realitasnya*. Bildung.

Kazdin, A. E. (2011). *Single-case research designs: Methods for clinical and applied settings* (2nd ed.). Oxford University Press.

Kellmeyer, P. (2018). Neurophilosophical and ethical aspects of virtual reality therapy in neurology and psychiatry. *Cambridge Quarterly of Healthcare Ethics, 27*(4), 610–627. https://doi.org/10.1017/S0963180118000129

Kelson, J. N., Ridout, B., Steinbeck, K., & Campbell, A. J. (2021). The use of virtual reality for managing psychological distress in adolescents: Systematic review. *Cyberpsychology, Behavior, and Social Networking, 24*(10), 633–641. https://doi.org/10.1089/cyber.2021.0090

Kraiss, J. T., ten Klooster, P. M., Moskowitz, J. T., & Bohlmeijer, E. T. (2020). The relationship between emotion regulation and well-being in patients with mental disorders: A meta-analysis. *Comprehensive Psychiatry, 102*, 152189. https://doi.org/10.1016/j.comppsych.2020.152189

Krupljanin, N., Alink, L. R. A., van der Voort, A., Struijk Wilbrink, M. R., & Bergwerff, C. E. (2025). The feasibility of an immersive interactive virtual reality task for children and adolescents. *International Journal of Child-Computer Interaction, 43*, 100722. https://doi.org/10.1016/j.ijcci.2025.100722

Leong, W. Y. (2025). Exploring virtual reality as a medium for cognitive behavioral treatment. *Proceedings of the International Colloquium on Signal Processing and Its Applications, CSPA*, 129–133. https://doi.org/10.1109/CSPA64953.2025.10932980

Liang, H., Li, Y., & Tag, B. (2025). MindfulReframer: A virtual reality system for managing exam anxiety through cognitive reappraisal. *Proceedings of the CHI Conference on Human Factors in Computing Systems*, 398. https://doi.org/10.1145/3706599.3719748

Mahmud, M., & Fajri, A. (2021). Strategi pengendalian emosi pada anak usia sekolah dasar untuk mendukung kecerdasannya. *Jurnal Kajian dan Pengembangan Umat, 4*(1), 44–54. https://doi.org/10.31869/jkpu.v4i1.2479

Mitsea, E., Drigas, A., & Skianis, C. (2023). Virtual reality mindfulness for meta-competence training among people with different mental disorders: A systematic review. *Psychiatry International, 4*(4), 324–353. https://doi.org/10.3390/psychiatryint4040031

Modrego-Alarcón, M., López-Del-Hoyo, Y., Beltrán-Ruiz, M., García-Campayo, J., & Montero-Marin, J. (2025). The potential of virtual reality for enhancing the efficacy and acceptability of mindfulness training in non-clinical adults: A pilot randomised controlled trial. *Virtual Reality, 29*(4), 147. https://doi.org/10.1007/s10055-025-01218-w

Ng, Y.-K. (2022). What is happiness? Why is happiness important? In *Happiness—Concept, Measurement and Promotion* (pp. 1–14). Springer Nature Singapore. https://doi.org/10.1007/978-981-33-4972-8_1

Pan, Z., Cristea, A. I., & Li, F. W. B. (2024). Reducing university students' exam anxiety via mindfulness-based cognitive therapy in VR with real-time EEG neurofeedback. *Communications in Computer and Information Science, 2151 CCIS*, 418–423. https://doi.org/10.1007/978-3-031-64312-5_52

Paulis, A., Marri, V., De Salvo, A., Di Ruscio, V., Gaspari, S., De Pasquale, M. D., Del Baldo, G., Premuselli, R., Origlia, M., Mastronuzzi, A., & Milano, G. M. (2025). Effects of virtual reality exposure on psychological distress in adolescent oncology patients. *Tumori*. Advance online publication. https://doi.org/10.1177/03008916251356848

Puente-Torre, P., Delgado-Benito, V., Rodríguez-Cano, S., & Lozano-Álvarez, M. (2025). Does mindfulness mediated by virtual reality help people with functional diversity? *Societies, 15*(2), 45. https://doi.org/10.3390/soc15020045

Shankar, R., Bundele, A., & Mukhopadhyay, A. (2025). The effectiveness of virtual reality–based mindfulness interventions for managing stress, anxiety, and depression: Protocol for a systematic review and meta-analysis of randomized controlled trials. *JMIR Research Protocols, 14*, e68231. https://doi.org/10.2196/68231

Shi, J., Zhang, N., Sun, Y., Jiang, J., Duan, H., & Gao, W. (2025). The impact of virtual images of coastal landscape features on stress recovery based on EEG. *Scientific Reports, 15*(1), 17369. https://doi.org/10.1038/s41598-025-02224-3

Smokowski, P. R., & Hartung, K. (2014). Computer simulation and virtual reality: Enhancing the practice of school social work. In *Technology-Assisted Delivery of School Based Mental Health Services: Defining School Social Work for the 21st Century* (pp. 5–30). Routledge.

Suranata, K. (2020). The demography effect on Tri Kaya Parisudha based cognitive behavioral counseling effectiveness. *JPPI: Jurnal Penelitian Pendidikan Indonesia, 6*(1), 22–26. https://doi.org/10.29210/02020378

Suranata, K. (2021, November 30). *Indonesian version DASS-21 Alpha Cronbach reliability items*. OSF. https://osf.io/xhfy3

Suranata, K. (2025, September 21). *Validation of a 4-Channel EEG Protocol for Assessing Concentration and Emotional Regulation in Students: Concurrent Validity with DASS-21 and Stroop Test in Bali (Indonesia) and Malaysia*. OSF. https://doi.org/10.17605/OSF.IO/YF4CZ

Suranata, K., Atmoko, A., & Hidayah, N. (2017a). Enhancing students' resilience: Comparing the effect of cognitive-behavior and strengths-based counseling. *Proceedings of the 2nd International Conference on Innovative Research Across Disciplines (ICIRAD 2017)*, 134, 102–108. Atlantis Press. https://doi.org/10.2991/icirad-17.2017.20

Suranata, K., Atmoko, A., & Hidayah, N. (2017b). Validation of Psychological Resilience Youth Development Module and Implication for Guidance and Counseling. *Bisma: The Journal of Counseling, 7*(1), 68–77.

Sugiyono. (2017). *Metode penelitian kuantitatif, kualitatif, dan kombinasi (mixed methods)*. Bandung: Alfabeta.

Wang, P., Ai, X., Zhang, X., Ma, F., Zhuang, Y., & Wang, S. (2024). Evaluating virtual reality technology in psychotherapy: Impacts on anxiety, depression, and ADHD. *Frontiers in Psychiatry, 15*, Article 1480788. https://doi.org/10.3389/fpsyt.2024.1480788

Wu, B., Zheng, C., & Huang, B. (2022). Influence of science education on mental health of adolescents based on virtual reality. *Frontiers in Psychology, 13*, 895196.

https://doi.org/10.3389/fpsyg.2022.895196
Zolfaghari, E., Ridout, B., Medlow, S., Campbell, A., Coggins, A., Murphy, M., Jani, S., Thosar, D., Wiederhold, B. K., Wiederhold, M., & Steinbeck, K. (2022). Exploring the use of virtual reality to manage distress in adolescent patients in emergency departments: A feasibility study. *EMA - Emergency Medicine Australasia, 34*(5), 687–693. https://doi.org/10.1111/1742-6723.13945