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Article

A cognitive mindfulness intervention using virtual reality and artificial intelligence for academic procrastination: A pilot waitlist randomised controlled trial

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Abstract: Research examining the role of mindfulness in addressing academic procrastination and engagement is gaining momentum. However, registered trials remain sparse, particularly those employing immersive virtual reality (VR). This study evaluated 30 university students in a waitlist-controlled randomised trial (WLC-RCT) featuring active and delayed intervention groups, combined with a content analysis of qualitative participant feedback. Participants engaged in a weekly 25-min cognitive mindfulness VR intervention over four weeks, supplemented by an independent AI-based mindfulness application between sessions. Quantitative measures of perceived academic stress, academic self-efficacy, academic engagement, cognitive mindfulness, academic procrastination, and physiological heart rate were collected at Weeks 0, 4, and 12. The mixed-design analyses revealed a significant Time × Group interaction effect uniquely for cognitive mindfulness ($p < 0.05$), reflecting earlier improvements in the active group at Week 4 and comparable cognitive mindfulness scores in the delayed group following receipt of the intervention at Week 12. Significant main effects of time suggested that both groups achieved comparable improvements from baseline to Week 12 across all remaining outcomes ($p < 0.05$). Specifically, academic procrastination and perceived academic stress were significantly reduced, while academic self-efficacy and academic engagement significantly increased. Average heart rate also systematically decreased within both cohorts across successive intervention sessions. Content analysis of qualitative feedback aligned with these findings, revealing that the VR platform was perceived as highly engaging and motivating, while simultaneously expanding participants' reflective awareness of their procrastination habits. Although these preliminary findings require replication in larger-scale longitudinal trials, they suggest possible psychological and physiological benefits of integrating immersive cognitive mindfulness VR and AI-based applications within educational settings to mitigate student procrastination and foster long-term academic engagement.

Keywords: immersive VR cognitive mindfulness; AI mindfulness app; academic procrastination; academic engagement; self-efficacy; perceived academic stress

1. Introduction

Virtual reality (VR) is a technology that simulates immersive or non-immersive environments tailored for pedagogical applications (Hamad and Jia, 2022). Although the integration of VR into pedagogy remains in its developmental stages, it is gaining popularity across diverse educational landscapes. In a systematic review examining

VR configurations in educational designs, only a small minority explicitly incorporated core pedagogical frameworks, such as experiential and constructivist learning theories, into the underlying software architecture (Radianti et al., 2020).

Implementing a blended learning approach—where digital applications serve as a practical adjunct to physical teaching models—is critical to modern curricular success (Stephan et al., 2017). Furthermore, three-dimensional VR environments introduce heightened interactivity, which has been associated with personal development, instructional delivery, and student learning outcomes (Chen et al., 2023). By introducing an element of novelty, VR enables students to repeatedly rehearse complex, stressful tasks in a safe, highly affordable environment.

From a pedagogical perspective, scaffolding task complexity within a virtual ecosystem provides users with visible opportunities for iterative practice, thereby fostering student autonomy (Mallek et al., 2024). Within the university landscape, academic procrastination represents a pervasive behavioural barrier to student success (Rozental et al., 2022). Procrastination is characterised by the voluntary avoidance or postponement of a necessary task, despite expecting worse consequences from the delay (Sirois, 2023). This behavioural sequence of avoidance and postponement frequently compromises long-term student well-being (Garg et al., 2025; Sirois, 2023).

Procrastination functions as a multi-dimensional dispositional trait or fluctuating state comprising distinct cognitive, emotional, and behavioural components (Garg et al., 2025). While active procrastinators may purposefully defer tasks to thrive under immediate time pressure, passive procrastinators face debilitating cognitive blockages that directly interfere with assignment completion and submission deadlines (Chun Chu and Choi, 2005). Beyond inflating student procrastination, chronic task avoidance severely degrades academic self-efficacy and self-regulation. This maladaptive cycle is strongly linked to institutional disengagement and elevated student dropout rates, which carry severe adverse financial and reputational consequences for both individuals and universities (Vlachopanou et al., 2025). For instance, Bäulke et al. (2022) identified that diminished student satisfaction and heightened procrastination were direct, significant predictors of student attrition.

Longitudinal evidence suggests that academic procrastination indirectly accelerates dropouts by systematically eroding academic satisfaction over time (Scheunemann et al., 2022). Mindfulness may offer a therapeutic alternative to address these trends by cultivating deliberate awareness of the present moment, coupled with an attitude of radical acceptance towards internal thoughts, feelings, and bodily sensations. Research suggests that mindfulness interventions mitigate self-critical thoughts and shame while expanding psychological well-being and self-efficacy, thereby stimulating positive behavioural changes (Redwine et al., 2022). Although cognitive behavioural therapy (CBT) remains the historically dominant intervention for chronic procrastination, mindfulness-based approaches are gaining momentum in higher education to support students' emotional regulation.

Specifically, mindfulness promotes a heightened receptivity to acute changes in affective states, which represents a foundational mechanism in healthy emotional regulation (Jose and Geiserman, 2024). This process encourages students to non-judgmentally accept internal idiosyncrasies, cognitive errors, and emotional conflicts (Assi et al., 2022). Consequently, mindfulness mitigates rigid, habitual coping loops—such as anxiety-induced avoidance—and activates more adaptive cognitive processing (Farb et al., 2012). Because a core component of executive functioning involves inhibitory control, the primary step toward initiating an aversive task requires minimising the immediate avoidant response. When students experience anxiety or boredom toward an assessment, processing these unpleasant internal states mindfully can actively disrupt the behavioural urge to procrastinate (Assi et al., 2022). An established link exists between academic stress and procrastination, culminating in adverse downstream physiological and psychological impairments (Sirois, 2014, 2023). However, the specific pathways linking elevated stress to chronic procrastination trajectories remain to be fully elucidated. High trait procrastination correlates with elevated academic stress and depression (Sirois, 2014, 2023).

Integrating cognitive restructuring techniques can enhance mindfulness by training students to acknowledge their internal critical dialogue with acceptance, subsequently reframing the distorted cognitions underlying task avoidance (Saputra, 2017). Cognitive restructuring operates on the premise that behavioural and emotional reactions are directly governed by the cognitive appraisals, beliefs, and attitudes attached to the target behaviour. Academic procrastination has been shown to decrease following a structured, six-week cognitive restructuring intervention protocol (Saputra, 2017). The clinical and practical rationale for embedding mindfulness practice in immersive VR environments, rather than relying exclusively on traditional in-person counselling settings, is rooted in the concept of presence.

Virtual reality generates a sense of psychological presence through highly controlled, synchronised visual and auditory streams that support users' attention in the immediate present. Furthermore, utilising VR as an adjunctive counselling modality may increase user acceptability of treatment and engagement compared with conventional non-technological mental health delivery formats (Li Pira et al., 2023). Theoretically, VR acts as an immersive technological catalyst for mindfulness by blocking out competing physical environmental distractions and intentionally cultivating present-moment awareness (Shankar et al., 2025). Although individual VR programs have shown potential therapeutic promise, no waitlist-controlled randomised studies have evaluated whether a combined AI-guided and VR-based mindfulness intervention mitigates academic procrastination while bolstering student engagement, self-efficacy, and stress management. Within this unified structural framework, targeted increases in trait mindfulness are hypothesised to systematically fortify self-efficacy and engagement while downwardly regulating perceived stress, ultimately minimising manifest procrastination behaviours.

Based on the surrounding literature review, the current study assessed the following hypotheses:

H1. *Over a 12-week framework, time will increase cognitive mindfulness, academic engagement, and academic self-efficacy and decrease academic procrastination and perceived academic stress.*

H2. *Exposure to the immersive VR cognitive mindfulness intervention will decrease the average participant's heart rate following each session.*

2. Materials and methods

2.1. Design

A waitlist-randomised controlled trial (WLC-RCT) was conducted to compare the active intervention group with a delayed (waitlist) group across three assessment points (Weeks 0, 4, and 12). Outcome measures included cognitive mindfulness, perceived academic stress, academic procrastination, self-efficacy, and academic engagement. A waitlist-randomised controlled trial (WLC-RCT) study ensured that all participants received the intervention. The active group received the VR mindfulness and AI intervention being tested, and the delayed group received the same intervention at Week 4, when delivery of the intervention for the active group was terminated. The delayed group completed two baseline assessments before receiving the intervention at Week 4, providing a comparison period prior to intervention delivery.

An inductive content analysis of participant feedback based on 9 questions was conducted at Week 12, in which categories were derived directly from participants' responses, and the frequency of each category was calculated. Two researchers independently reviewed participant responses before agreeing on the final category allocation. Themes were then developed based on the qualitative outcomes.

2.2. Participants

A custom digital Microsoft Form was developed to host the preliminary screening portal, with a secure link to the study overview distributed via LinkedIn. Interested parties subsequently contacted the principal investigator directly. The inclusion and exclusion criteria were explicitly established to minimise potential adverse somatic reactions to virtual reality (VR) environments and to proactively manage psychological distress that could compromise participant well-being.

To be eligible for enrollment, participants were required to meet the following inclusion criteria:

1. Possess normal or corrected-to-normal auditory and visual acuity;
2. Be aged 18 years or older at the time of screening;
3. Possess a personal mobile phone compatible with applications from either the Google Play or Apple App Store;
4. Display a baseline resting heart rate of 60–80 beats per minute (BPM) taken pre-session;
5. Have no personal history of neurological seizures;
6. Score within the mild depression or well-being range (total scores between 0 and 9) on the Patient Health Questionnaire-9 (PHQ-9; Kroenke et al., 2001).

Prospective participants were excluded from the trial if they met any of the following criteria:

1. Reported chronic coordination or balance difficulties, although participants remained seated during VR exposure as a standard safety precaution;

2. Reported a history of claustrophobia or chronic migraine headaches;
3. Displayed a resting heart rate exceeding 80 BPM after an initial acclimation period;
4. Reported photosensitivities or a history of adverse reactions to flashing lights, although no strobe effects were embedded within the VR software;
5. Had a documented personal history of seizures;
6. Were younger than 18 years of age;
7. Scored above the clinical cut-off threshold of 9 on the PHQ-9 (Kroenke et al., 2001).

A total of 30 university students met the eligibility criteria and were enrolled in the trial. A Consolidated Standards of Reporting Trials (CONSORT) diagram illustrating participant flow throughout the study is presented in **Figure 1**, and comprehensive baseline descriptive metadata are outlined in **Table 1**. Given the exploratory nature and limited sample size of this pilot investigation, simple randomisation was employed to allocate participants. To minimise systematic allocation bias, a computer-generated random assignment sequence was created using the SPSS random number generator, assigning participants in a 1:1 ratio to either the active intervention group (n = 15) or the delayed waitlist control group (n = 15).

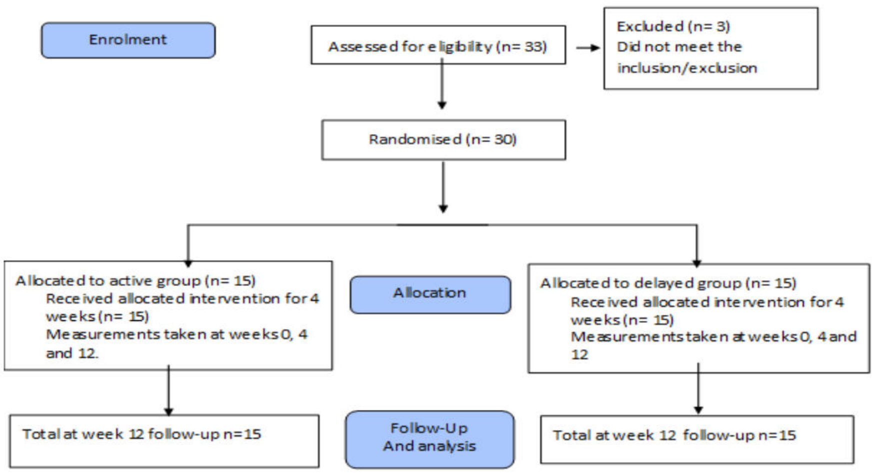

Figure 1. CONSORT 2010 flow diagram showing participant progression through the phases of the study.

Table 1. Demographic characteristics of participants (N = 30).

Variable	Category	*n*	%
Age Group	18–30 years	17	56.7
	31–50 years	10	33.3
	>50 years	3	10.0
Academic Level	Undergraduate students	18	60.0
	Postgraduate students	12	40.0
Gender	Male	20	66.7
	Female	10	33.3
Ethnicity	African Caribbean	15	50.0
	White	9	30.0
	Indian	6	20.0

An exploratory a priori power analysis was executed using G*Power 3.1 to evaluate the statistical adequacy of the sample size framework. Assuming a two-way mixed-design repeated-measures ANOVA evaluating a within–between group interaction, a medium effect size (f = 0.25), an alpha level of 0.05, and a target statistical power ($1 - \beta$) of 0.80 mapped across three distinct longitudinal measurement intervals, the minimum recommended sample size was calculated to be 28 participants. Therefore, the achieved sample size of 30 participants was deemed statistically sufficient for a preliminary pilot investigation and capable of providing indicative parameter estimates to power future large-scale clinical research trials.

The final sample (N = 30) was entirely based within the United Kingdom. Categorical age brackets comprised participants aged 18–30 years (n = 17, 56.7%), 31–50 years (n = 10, 33.3%), and older than 50 years (n = 3, 10.0%). Regarding current institutional standing, the cohort consisted of undergraduate students (n = 18, 60.0%) and postgraduate students (n = 12, 40.0%). Demographically, 20 participants (66.7%) identified as male, and 10 participants (33.3%) identified as female. Self-reported ethnic backgrounds were recorded as African Caribbean (n = 15, 50.0%), White (n = 9, 30.0%), and Indian (n = 6, 20.0%).

2.3. Materials

The intervention was delivered via Meta Quest 3 headsets, providing access to the TRIPP virtual reality mindfulness platform. Regarding TRIPP, the selected intervention was “Focus” VR mindfulness activities, designed to promote decision-making, goal-setting, being present, and working through barriers and blocks. Furthermore, “Calm” was selected to focus on present-moment awareness and mindful observation of thoughts, emotions, and bodily sensations with compassion. After focus or calm, a series of TRIPP breathing exercises followed, during which participants could choose between the “sea” and “land” visuals. Students could also choose between male and female voices to guide the mindfulness experience. Each session lasted approximately 25 min per week for 4 weeks.

The TRIPP mobile app, using Kokua (beta)/AI, provided personalised AI-guided mindfulness exercises. This forms part of the mindfulness intervention designed to support participants between VR sessions. Participants were encouraged to use this outside of the VR. Both TRIPP and Kokua are GDPR-compliant. Outcome measures were collected independently of the VR platform to ensure that participant data were not stored on the headset. Participants independently consented to any optional data requests generated by Meta Quest or the TRIPP platform, with the option to decline. Participants were asked to set reminders using the calendar application on their mobile phones to encourage Kokua use and diary completion. While it was anticipated that the AI app would act as a top-up, the VR headset was intended to provide the primary immersive component of the intervention, enabling a full experience. The combined intervention incorporated mindful breathing, body scanning, mindful stretching, mindful awareness of thoughts and breath sounds, and exercises that target attention to perceived barriers and difficulties.

2.3.1. Measuring heart rate

As part of this preliminary study, resting pulse rate was measured using a portable pulse rate monitor immediately before and after each VR session. Whilst pulse rate was monitored before and after every VR session, statistical analysis was restricted to the data collected at Weeks 0, 4, and 12. Pulse rate was included as an exploratory physiological indicator of relaxation associated with the mindfulness intervention.

2.3.2. Assessment tools

Preliminary screening tool: PHQ-9 for inclusion/exclusion criteria (Kroenke et al., 2001).

The PHQ-9 was used to screen for depression/well-being. Its internal reliability is 0.86–0.89. The 9-item scale measures levels of depression, with a maximum score of 27 and a minimum score of 0. This was used to ensure general well-being among participants as part of the study's ethical considerations.

Demographic information

Demographic information included gender, perceived duration of procrastination, employment status, ethnicity, marital status, sexual orientation, age, and undergraduate/graduate level. TRIPP VR was used once a week. However, engagement with Kokua was monitored with a diary log (see procedure section).

The Perception of Academic Stress Scale (adapted from Bedewy and Gabriel (2015))

This is a 10-item questionnaire which consists of 5 response categories (1 = strongly disagree to 5 = strongly agree, and in reverse 1 = strongly agree to 5 = strongly disagree). Cronbach's alpha = 0.70. Primary subscales include academic expectations and self-perceptions. The higher the score, the higher the level of perceived academic stress experienced by students. Example questions include. "I am confident that I will be a successful student" and "I believe that the amount of work assignments is too much." Cronbach's alpha in this study was 0.81.

The Academic Procrastination Scale (adapted from Mccloskey and Scielzo (2015))

This is a 10-item questionnaire with 5 response categories (1 = disagree to 5 = agree). It assesses procrastination in academic activities and academic settings. Cronbach's alpha ranges from 0.84 to 0.92. The higher the score, the higher the level of perceived procrastination experienced by students. Example questions include, "I get distracted by other, more fun, things when I am supposed to work on my assignments/examination preparation" and "Tests are meant to be studied for just the night before." Cronbach's alpha in this study was 0.86.

The Academic Engagement Scale (adpated from Freda et al. (2023))

This is a 10-item questionnaire with 5 response categories (1 = strongly disagree to 5 = strongly agree). Cronbach's alpha = 0.84. Example questions include, "Despite the difficulties I sometimes encounter in university life, I think it is worth continuing my studies" and "My teachers are interested in my opinions and what I say." The higher the score, the higher the level of academic engagement. Cronbach's alpha in this study was 0.80.

The Academic Self-Efficacy Scale (adapted from Gafoor and Ashraf (2007))

This is a 15-item questionnaire with 5 response categories (1 = strongly disagree to 5 = strongly agree). Cronbach's alpha = 0.85. Example questions include, "I can usually find quite a few solutions when I am confronted with problems in my studies" and "I am confident that I can perform well in examinations." The higher the score, the higher the level of academic self-efficacy. Cronbach's alpha in this study was 0.70.

The Cognitive and Affective Mindfulness Scale-Revised (CAMS-R; Feldman et al. (2007))

This is a 10-item measure with 4 response categories: 1 = rarely/not at all, 2 = occasionally, 3 = sometimes, and 4 = almost always. Higher scores indicate higher levels of mindfulness (scores 4–40). An example question is, "I can accept things I cannot change." Cronbach's alphas range between 0.82 and 0.84. Cronbach's alpha in this study was 0.73.

Feedback questions can be viewed in the results section.

2.4. Procedure

This study was conducted in accordance with the *Code of Ethics and Conduct* published by the British Psychological Society (BPS Ethics Committee, 2021) and received formal ethical approval from the institutional University Research Ethics Review Panel (Approval No. SSSP-2024-016). The clinical trial protocol was registered prospectively at ClinicalTrials.gov (Identifier: NCT06664346). Due to localised recruitment challenges, final formal registration occurred retrospectively; however, the study adhered strictly to the identical, predefined experimental protocol throughout its duration. Study promotional details were advertised via LinkedIn. The recruitment strategy yielded 30 participants aged 18 years and older who were actively experiencing self-reported academic procrastination while attending London-based universities within the United Kingdom.

Prior to enrollment, a comprehensive information sheet and a digital consent form were securely delivered to each prospective participant via a password-protected email. The delayed-intervention and active-intervention groups both completed baseline assessments at Week 0, prior to the official commencement of the study. Repeated measurements were systematically taken at Weeks 0, 4, and 12. Following the secure collection of informed consent and baseline demographic traits, participants completed a structured online survey hosted via Microsoft Forms. The assessment tools were ordered as follows: the Academic Procrastination Scale (adapted), the Perception of Academic Stress Scale (adapted), the Academic Engagement Scale (adapted), the Academic Self-Efficacy Scale (adapted), and the Cognitive and Affective Mindfulness. Each survey concluded with an integrated debriefing page that served as an active reminder of available mental health support services.

The primary intervention protocol was delivered uniformly over a four-week period. Each consecutive week, different dimensions of mindfulness were systematically explored, including mindful breathing, mindful stretching with a body scan, mindful focus on psychological difficulties, and mindful awareness of breath sounds and transient thoughts. Each individual session lasted approximately 25 min. All participants completed the identical structured sequence of VR sessions using a dedicated VR headset, while independent engagement with the Kokua AI app between weekly sessions was actively encouraged but left entirely self-directed. To monitor compliance, participants were instructed to log their app utilisation using their personal mobile phone calendars as a behavioural reminder. Quantitative longitudinal outcomes were evaluated by comparing follow-up data compiled at Weeks 4 and 12 against baseline metrics. As an exploratory physiological indicator of autonomic relaxation, participants' heart rates were recorded immediately pre- and post-session using standard metrics.

Throughout the study, participants were repeatedly assured of the absolute confidentiality of their experimental responses and the complete anonymity of their identities outside the immediate research team. Participants were explicitly reminded that they retained the right to withdraw from the study at any assessment interval without negative repercussions, and that they were not obligated to complete all assessment items. Because immersive technologies carry distinct physiological risks, participants were continuously monitored for symptoms of motion sickness. To proactively mitigate cybersickness, participants were advised to eat a light meal before their scheduled sessions and to have chewing gum readily available, as chewing gum can reduce motion sickness symptoms (Kaufeld et al., 2022). A strict distress protocol was embedded directly into the delivery of the active intervention, with the principal investigator operating as a counsellor.

The participant qualitative feedback framework further enabled users to report any adverse psychological or somatic reactions immediately. Additionally, the debriefing forms provided to all individuals included a list of counselling services. All responses generated by the participants were encrypted and stored securely on a password-protected computer in strict accordance with the General Data Protection Regulation and the Data Protection Act (Official Journal of the European Union, 2018).

2.5. Statistical analyses

A series of 2 × 3 split-plot repeated-measures analyses of variance (ANOVAs) were conducted across the five primary academic and psychological outcome measures. For each model, the within-subjects repeated factor was Time (Week 0, Week 4, and Week 12), and the between-subjects factor was Group (active vs. delayed intervention). All inferential analyses were conducted using cumulative summed scores rather than item-level means. As part of the feasibility testing, item-level responses were examined, and internal consistency was assessed using Cronbach's alpha due to the psychometric adaptations made to the questionnaires for this study. Prior to hypothesis testing, all underlying statistical assumptions were rigorously evaluated. Normality was assessed using the Shapiro–Wilk test and visual inspection of Q–Q plots. Homogeneity of variance between the groups was assessed using Levene's test, where appropriate. For the repeated-measures models, the assumption of sphericity was evaluated using Mauchly's test, with Greenhouse–Geisser corrections applied to the degrees of freedom whenever violations were detected. In most cases, statistical assumptions were not violated ($p > 0.05$). There were no missing data within the final dataset; consequently, no data imputation procedures were required.

To control the family-wise error rate at 5% and minimise the risk of Type I inflation, Bonferroni adjustments were systematically applied to all post hoc pairwise comparisons. Precision of the estimates was evaluated using 95% confidence intervals (CIs). Partial eta-squared served as the primary measure of effect size for the mixed-design analyses, whereas Cohen's d was calculated to estimate effect sizes for follow-up and exploratory contrasts. Specifically, a series of paired-samples t-tests was used to compare pre- and post-session heart rate measurements, and a nonparametric Quade's rank-based analysis of covariance (ANCOVA) was conducted to examine whether intervention effects remained after controlling for the frequency of Kokua app use and the duration of procrastination. Qualitative participant feedback was analysed using inductive content analysis. Emergent categories were summarised descriptively using code frequencies and percentages.

3. Results: Repeated-measures analyses of variance (ANOVAs)

3.1. Active group

3.1.1. Academic procrastination

With reference to **Table 2**, there was a significant effect of time (Weeks 0–12) on academic procrastination, $F(2, 28) = 12.27$, $p = 0.004$, $\eta p^2 = 0.47$, 95% CI [16.91, 30.72]. Bonferroni-adjusted pairwise comparisons indicated a significant improvement from Week 0 to Week 12 ($p < 0.001$).

Table 2. Means and standard deviations for study outcomes across assessment points ($N = 30$).

Outcome variable	Group	Week 0 M (SD)	Week 4 M (SD)	Week 12 M (SD)
Academic Procrastination	Active	27.20 (6.35)	19.40 (5.46)	19.33 (4.37)**
	Delayed	24.13 (4.88)	20.40 (4.59)	19.67 (4.60)*
Perceived Academic Stress	Active	19.20 (3.83)	19.27 (3.80)	11.53 (3.93)**
	Delayed	18.67 (2.69)	17.87 (1.64)	12.00 (4.11)*
Academic Engagement	Active	21.13 (2.50)	24.13 (2.67)	26.07 (2.89)**
	Delayed	20.26 (2.84)	23.07 (4.18)	24.20 (3.41)*
Academic Self-Efficacy	Active	18.07 (2.89)	22.47 (4.17)	22.87 (3.70)**
	Delayed	18.73 (2.93)	21.93 (3.83)	23.40 (2.69)*
Cognitive Mindfulness	Active	22.80 (4.35)	28.80 (2.57)	28.13 (2.67)*
	Delayed	21.53 (2.38)	22.87 (1.73)	27.07 (4.68)**

Note: Values are presented as means (M) and standard deviations (SD). Active group ($n = 15$); Delayed group ($n = 15$). Higher scores indicate greater levels of academic procrastination, perceived academic stress, academic engagement, academic self-efficacy, and cognitive mindfulness. ** $p < 0.05$; * $p < 0.001$.

3.1.2. Perceived academic stress

There was a significant effect of time (Weeks 0–12) on perceived academic stress, $F(2, 28) = 17.01$, $p < 0.001$, $\eta p^2 = 0.47$, 95% CI [9.36, 21.33]. Pairwise comparisons using Bonferroni adjustments indicated a significant improvement from Week 0 to Week 12 ($p < 0.001$).

3.1.3. Academic engagement

There was a significant effect of time (Weeks 0–12) on academic engagement, $F(2, 28) = 14.04$, $p < 0.001$, $\eta p^2 = 0.68$, 95% CI [19.75, 27.67]. Pairwise comparisons using Bonferroni adjustments indicated a significant improvement from Week 0 to Week 12 ($p < 0.001$).

3.1.4. Academic self-efficacy

There was a significant effect of time (Weeks 0–12) on academic self-efficacy, $F(2, 28) = 17.97$, $p < 0.001$, 0.73, 95% CI [16.47, 24.92]. Pairwise comparisons using Bonferroni adjustments indicated a significant improvement from Week 0 to Week 12 ($p < 0.001$).

3.1.5. Cognitive mindfulness

There was a significant effect of time (Weeks 0–12) on cognitive mindfulness, $F(2, 28) = 10.64$, $p = 0.002$, $\eta p^2 = 0.62$, 95% CI [20.39, 29.61]. Pairwise comparisons using Bonferroni adjustments indicated a significant improvement from Week 0 to Week 12 ($p = 0.009$).

3.2. Delayed group

3.2.1. Academic procrastination

With reference to **Table 2**, there was a significant effect of time (Weeks 0–12) on academic procrastination, $F(2, 28) = 7.78$, $p = 0.006$, $\eta p^2 = 0.55$, 95% CI [17.12, 26.84]. Pairwise comparisons using Bonferroni adjustments indicated a significant improvement from Week 0 to Week 12 ($p = 0.012$).

3.2.2. Perceived academic stress

There was a significant effect of time (Weeks 0–12) on perceived academic stress, $F(2, 28) = 9.86$, $p = .002$, $\eta p^2 = 0.60$, 95% CI [9.73, 20.16]. Pairwise comparisons using Bonferroni adjustments indicated a significant improvement from Week 0 to Week 12 ($p = 0.003$).

3.2.3. Academic engagement

There was a significant effect of time (Weeks 0–12) on academic engagement, $F(2, 28) = 8.29$, $p = 0.005$, $\eta p^2 = 0.56$, 95% CI [18.65, 26.09]. Pairwise comparisons using Bonferroni adjustments indicated a significant improvement from Week 0 to Week 12 ($p = 0.007$).

3.2.4. Academic self-efficacy

There was a significant effect of time (Weeks 0–12) on academic self-efficacy, $F(2, 28) = 13.52$, $p < 0.001$, $\eta p^2 = 0.68$, 95% CI [17.11, 24.89]. Pairwise comparisons using Bonferroni adjustments indicated a significant improvement from Week 0 to Week 12 ($p < 0.001$).

3.2.5. Cognitive mindfulness

There was a significant effect of time (Weeks 0–12) on cognitive mindfulness, $F(2, 28) = 13.46$, $p < 0.001$, $\eta p^2 = 67$, 95% CI [20.21, 29.66]. Pairwise comparisons using Bonferroni adjustments indicated a significant improvement from Week 0 to Week 12

($p < 0.001$).

3.3. Two-way mixed-design ANOVA outcomes

A series of 3 (Time: Week 0, Week 4, Week 12) × 2 (Group: active, delayed) mixed-design ANOVAs were conducted to evaluate the impact of the intervention across five academic and psychological outcome measures.

For cognitive mindfulness, the mixed ANOVA revealed a statistically significant Time × Group interaction effect, indicating that the trajectory of mindfulness scores over the 12 weeks differed significantly between the two conditions. Decomposition of this interaction via independent-samples t-tests showed no baseline differences between the Active ($M = 22.80$, $SD = 4.35$) and Delayed ($M = 21.53$, $SD = 2.38$) groups at Week 0 ($p > 0.05$). However, a large between-group difference emerged at Week 4, $t(28) = 7.41$, $p < 0.001$, $d = 2.80$, driven by a sharp increase in the Active group ($M = 28.80$, $SD = 2.57$) while the Delayed group showed little change during this period ($M = 22.87$, $SD = 1.73$). By Week 12, the difference in cognitive mindfulness was no longer statistically significant ($p = 0.454$), suggesting the Delayed group reached a similar level following receipt of the intervention.

For the remaining four variables—academic procrastination, perceived academic stress, academic engagement, and academic self-efficacy—the mixed-design ANOVAs yielded a highly consistent pattern characterised by a significant main effect of time, but no statistically significant Time × Group interaction effects ($p > 0.05$). These findings indicate that the intervention accelerated improvements in cognitive mindfulness relative to the delayed group, whereas changes in the remaining outcomes occurred similarly across both groups once each had received the intervention.

3.4. Comparing heart rate pre- and post-session

A series of paired-samples t-tests evaluated pre- and post-session pulse rates at Weeks 0, 4, and 12 for both the active and delayed groups. In the active group, post-session pulse rates were significantly lower than pre-session rates at Week 0, $t(14) = 4.04$, $p = 0.001$, $d = 0.70$; Week 4, $t(14) = 2.78$, $p = 0.015$, $d = 0.72$; and Week 12, $t(14) = 6.21$, $p < 0.001$, $d = 1.60$. Similarly, the delayed group demonstrated significantly lower post-session pulse rates at Week 0, $t(14) = 6.20$, $p < 0.001$, $d = 1.60$; Week 4, $t(14) = 14.00$, $p < 0.001$, $d = 3.61$; and Week 12, $t(14) = 7.88$, $p < 0.001$, $d = 2.03$.

The large effect sizes observed for the within-session pulse rate reductions (ranging from $d = 0.70$ to $d = 3.61$) may reflect the immediate physiological response to the mindfulness sessions; however, they should be interpreted cautiously given the small sample size and repeated within-subjects design.

3.5. AI app use and duration of procrastination

Prior to the main analyses, participants' baseline procrastination profiles and independent engagement with the Kokua TRIPP application outside of scheduled VR sessions were evaluated. These analyses were undertaken to determine whether intervention effects remained after accounting for individual differences in baseline procrastination history and independent use of the Kokua TRIPP application.

Regarding baseline procrastination frequency, most of the sample reported experiencing daily procrastination for less than one hour (n = 12, 40.0%) or daily for more than one hour (n = 8, 26.7%). The remaining participants reported experiencing procrastination for most of the day (n = 6, 20.0%) or every other day for most of the day (n = 4, 13.3%). In terms of intervention adherence outside of laboratory sessions, 60.0% of participants (n = 18) reported using the Kokua TRIPP app daily. An additional 26.7% (n = 8) used the application every other day, while 13.3% (n = 4) reported engagement every three days.

Including procrastination duration and Kokua TRIPP app use frequency as covariates did not alter the pattern or significance of the primary intervention outcomes across any of the five dependent variables ($p > 0.05$ for both covariates). The main effect of time on academic procrastination, perceived academic stress, academic engagement, and academic self-efficacy remained statistically significant ($p < 0.05$). Furthermore, the unique Time × Group interaction effect for cognitive mindfulness remained robust ($p < 0.05$).

3.6. Qualitative content analysis of participant feedback

To supplement the quantitative outcomes, an inductive content analysis was performed on written feedback collected from participants (N = 30) at the final follow-up assessment. Responses were organised into thematic clusters, with response frequencies capturing intervention utility, platform feasibility, and perceived impacts on academic behaviour.

3.6.1. Perceived utility and areas for improvement

When evaluating the helpful aspects of the VR mindfulness, participants highlighted several core benefits. Over a quarter of the sample pointed to the high-quality digital graphics and visual architecture (n = 8, 26.7%), described the immersive laboratory experience as uniquely engaging or "hypnotic" (n = 8, 26.7%), or noted that it directly helped them gain deeper psychological insight (n = 8, 26.7%). The remaining participants explicitly characterised the sessions as relaxing (n = 6, 20.0%).

Conversely, when prompted to identify limitations or areas requiring improvement, the feedback centred heavily on logistical availability. Forty per cent of the sample (n = 12) expressed a desire for the intervention to be more widely available for regular, long-term use. Additionally, a third of the cohort (n = 10, 33.3%) suggested that the duration of the VR intervention sessions should be lengthened, while some noted that the mindfulness exercise structures required an initial acclimation period to engage with effectively (n = 8, 26.7%).

3.6.2. Comparative evaluation of VR and app modalities

Participants expressed highly positive evaluations regarding their interaction with the immersive virtual reality hardware. The majority described their overall VR experience as highly engaging (n = 18, 60.0%), with the remaining proportion explicitly characterising the platform as amazing (n = 12, 40.0%).

In contrast, assessments of the accompanying Kokua AI mobile application were mixed. More than half of the sample reported that the VR headset and mobile AI application operated synergistically and worked well together (n = 16, 53.3%). However, a substantial minority noted that the mobile application interface was fundamentally less impactful or engaging than the fully immersive VR environment (n = 14, 46.7%). Reflecting this preference, the entire sample unanimously asserted that the immersive VR component should be made readily accessible on an ongoing, institutional basis (n = 30, 100.0%).

3.6.3. Perceived behavioural and academic impacts

The qualitative feedback aligned with the quantitative improvements observed across student behavioural tracks. Regarding academic procrastination, the participants reported that the intervention successfully enhanced their overall academic confidence and rendered their procrastination habits more manageable (n = 30, 100.0%). Similarly, the intervention was perceived as highly supportive of student stress management; the vast majority of participants found that their perceived academic stress became more manageable (n = 24, 80.0%), while the remaining cohort reported a meaningful reduction in intrusive, stress-induced thoughts (n = 6, 20.0%).

Finally, the VR mindfulness demonstrated a subjective impact on institutional engagement. The majority of the sample reported that the training increased their reflective awareness of their internal problems (n = 18, 60.0%), while others felt a heightened sense of intrinsic motivation to actively engage with their formal academic studies (n = 12, 40.0%). Concluding the feedback loop, a clear majority suggested that the intervention framework should be made accessible for longer durations (n = 20, 66.7%), and a final third recommended that VR mindfulness tools should be formally integrated into university curriculum teaching models and student well-being support services (n = 10, 33.3%).

4. Discussion

The findings from this split-plot repeated-measures design provided preliminary support for the pilot study's primary hypotheses. As anticipated, there was a statistically significant main effect of time across the 12-week intervention framework. For both the active and delayed groups, academic engagement, cognitive mindfulness, and academic self-efficacy significantly increased from baseline to Week 12. Concurrently, academic procrastination and perceived academic stress demonstrated significant post-intervention reductions. The intervention's positive effects persisted even after accounting for participants' varied histories of procrastination and the frequency of their independent use of the Kokua TRIPP app. This analysis suggests that improvements in psychological outcomes were independent of app usage frequency or the duration of participants' procrastination. Support was also observed for physiological stress regulation, with both the active and delayed groups showing a reduction in average heart rate following VR cognitive mindfulness sessions.

Concerning cognitive mindfulness, participants' levels increased post-intervention in this study. Mindfulness appears to support individuals in relinquishing efforts to reduce negative thoughts and instead acknowledging their presence (Gkintoni et al., 2025). Mindfulness can increase awareness of the transience of negative thoughts, emotions, and bodily sensations, leading to more flexible, objective responses rather than automatic reactions. This contrasts with habitual judgments and interpretations of stimuli that enter awareness, which trigger strong emotions and reactions that can contribute to poor mental health, including procrastination (Marchand, 2012). Part of VR and cognitive mindfulness, including TRIPP activities such as focus and calm, involves reducing external distractions. VR has been shown to reduce anxiety in distraction-free environments that support focus and presence (McGarry et al., 2023). Indeed, participant feedback in this study commonly described the VR experience as engaging and supportive in reducing perceived academic stress and increasing awareness of procrastination. The findings align with previous research demonstrating the beneficial effects of mindfulness on procrastination among student populations (Franco et al., 2026). The observed interaction effect for cognitive mindfulness and its cascading relationship with procrastination may reflect mechanisms consistent with experiential learning theory (Kolb, 2014). Immersive VR encourages active engagement, reflection, and present-moment awareness, potentially supporting meaningful learning experiences that enhance academic engagement and goal-setting. This could support teaching and learning, for example, through goal setting and the use of immersive technologies to foster reflective awareness.

Kim et al. (2024) studied the effects of VR-based mindfulness and a mindfulness app on well-being among 60 student participants. While both mindfulness applications improved students' well-being, the mobile app showed lower anxiety levels than the VR mindfulness application, as indicated by electroencephalogram (EEG) recordings. However, the mechanism by which VR mindfulness promotes mindfulness and well-being, regardless of arousal level, remains unclear. Indeed, in this study, participants acknowledged the importance of both VR and app mindfulness. While the sample size in the current study was insufficient to fully randomise participants to separate app-only and VR-only conditions, participants reported that the modalities worked well together and expressed a general preference for immersive VR. This preference may stem from the greater sense of awe and visual immersion provided by VR. Participants were encouraged to log their Kokua AI app use by utilising a mobile app calendar reminder. Because this relies heavily on human input and notification compliance, it may be open to human error, meaning these outcomes should be interpreted with caution. Structurally, the frequency of Kokua AI app use was not independently associated with any study outcomes. Furthermore, intervention effects remained significant after statistically controlling for app use and reported procrastination duration. This implies that improvements were not solely attributable to the frequency of AI app use. Future research employing objective, in-app usage metrics may better clarify the independent role of AI-supported behavioural prompting. The small sample size necessitated the use of a waitlist-controlled framework.

While these outcomes are informative, they are insufficient to generalise these behavioural trajectories across cognitive mindfulness, perceived academic stress, academic engagement, self-efficacy, and procrastination to a larger student population. The present findings should be interpreted within the context of a pilot waitlist-controlled trial involving university students and therefore may not generalise to other educational settings, age groups, or clinical populations. Waitlist randomised controlled trials are useful for acquiring preliminary data in under-researched areas and are frequently utilised in counselling and psychotherapy-based interventions. However, within this framework, observed effect sizes are often artificially inflated, compromising internal validity (Laws et al., 2022). Additionally, it is common in waitlist-controlled designs for positive or negative anticipatory effects to influence study outcomes (Laws et al., 2022). Indeed, the large effect size observed for cognitive mindfulness at Week 4 (d = 2.80) should be interpreted with caution. The fact that the statistical difference between groups disappeared by Week 12 suggests the Delayed group reached a similar level following receipt of the intervention. Introducing randomised groups with varied experimental conditions (e.g., voice guidance versus non-voice guidance, or non-immersive VR versus app-only groups) alongside an active control group might provide a more robust evaluation of the intervention's distinct impact on academic procrastination. This could be extended to include physiological measures, such as electroencephalogram (EEG).

Similarly, there was an apparent reduction in heart rate observed across the active and delayed intervention groups. Although preliminary, this finding may indicate that the intervention influenced physiological markers associated with relaxation and autonomic stress regulation. Given that heart rate represents an objective physiological measure, the observed reduction provides tentative support for the possibility that the intervention produced physiological effects beyond self-reported psychological outcomes. However, this study used an overall average rather than continuous heart rate monitoring, which may have obscured temporary fluctuations, peak stress responses, and specific recovery patterns that could have affected the data.

The timing of the intervention may also have influenced the findings, as many participants had completed their major academic assessments by the final follow-up period. Consequently, reductions in perceived academic stress and academic procrastination may have been attributable, in part, to naturally reduced academic demands rather than to the therapeutic intervention alone. Future research should consider controlling for assessment schedules and academic workloads when evaluating mindfulness-based interventions for student procrastination. Nevertheless, sustained improvements in cognitive mindfulness, academic engagement, and academic self-efficacy were observed, suggesting that the intervention contributed to positive academic and psychological development beyond changes associated with the academic calendar.

Finally, the questionnaires were shortened following participant feedback during intervention development to minimise participant burden, reduce redundancy, and optimise engagement while maintaining conceptual coverage (Kilmen and Bulut, 2025). While the internal reliability of the adjusted assessment tools in this study was good, it was not ideal, as direct comparisons of research outcomes with existing literature using non-adapted questionnaires were compromised. Future research focusing on developing and psychometrically validating standardised, shorter versions of the specific academic questionnaires used in this study is warranted. Targeting a diverse group of students at different stages of their academic journeys, particularly during the critical transition to university, may provide an ideal opportunity for future longitudinal research to examine whether VR-based mindfulness interventions can systematically mitigate academic procrastination and enhance long-term student success.

5. Conclusion

This preliminary study evaluated the effectiveness of an immersive VR cognitive mindfulness intervention and an AI-based mindfulness application in reducing student academic procrastination and perceived academic stress, while improving academic self-efficacy and academic engagement. Overall, the dual-modality intervention appeared feasible, suggesting associations with positive psychological developments and preliminary physiological improvements. Outcomes suggested reductions in perceived academic stress and academic procrastination, alongside increases in cognitive mindfulness, academic engagement, and academic self-efficacy over the 12-week study period. Methodologically, a significant Time × Group interaction was observed only for cognitive mindfulness, capturing the active cohort's accelerated growth at Week 4 and the delayed cohort's subsequent "catch-up" at Week 12. For the remaining outcomes—procrastination, perceived academic stress, academic engagement, and self-efficacy—no significant Time × Group interaction effects were observed. Rather than indicating an intervention deficit, this lack of interaction may reflect a parallel main effect of time, suggesting that both the active and delayed groups achieved statistically comparable, positive improvements by the conclusion of the trial. While these preliminary findings provide encouraging support for integrating immersive VR cognitive mindfulness and AI-based tools within higher education frameworks, the precise mechanisms driving these concurrent changes require further investigation. Future large-scale randomised trials should investigate these timelines using mediation analyses or structural equation modelling (SEM) to map the exact pathways linking immersive VR engagement to downstream self-efficacy, stress regulation, and procrastination outcomes. Ultimately, a more comprehensive understanding of these psychological and physiological processes, achieved through larger and more diverse student samples, may inform the development of scalable, targeted interventions designed to maximise academic engagement, mitigate chronic procrastination, and bolster long-term student retention.

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