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Research Paper

The Effectiveness of Computer-Assisted Instruction for Buddhist Moral Education Among Lower Secondary Students: An Experimental Study in Khon Kaen, Northeast Thailand[1]

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Abstract:

Background: Traditional Buddhist moral education in Thailand faces significant challenges in engaging digital-native students, creating an urgent need for innovative pedagogical approaches that effectively integrate modern technology while preserving cultural authenticity and religious integrity.

Purpose: This experimental study investigates the effectiveness of Computer-Assisted Instruction (CAI) on Buddhist moral education focusing on the Four Brahmavihāra Dhammas (loving-kindness, compassion, empathetic joy, and equanimity) among lower secondary students in Khon Kaen province, Northeast Thailand.

Methods: A randomized controlled experimental design with pre-test post-test measurements was employed involving 480 Grade 8 students (aged 13-14 years) randomly assigned to experimental (n=240) and control (n=240) groups across 12 purposively selected schools in Khon Kaen province. The experimental group received 8-week CAI-enhanced Buddhist moral education intervention, while the control group received traditional lecture-based instruction. Quantitative data were collected through validated Buddhist Moral Reasoning Assessment (BMRA), and qualitative insights were gathered from 45 purposively selected students through semi-structured interviews. Statistical analysis included paired t-tests, independent t-tests, effect size calculations, and thematic analysis.

Results: The experimental group demonstrated significantly higher post-test moral reasoning scores (M=84.7, SD=8.2) compared to the control group (M=68.3, SD=9.1), $t(478)=21.45$, $p<0.001$, Cohen's $d=1.89$, indicating large practical significance. Within-group analysis revealed significant improvement in the experimental group from pre-test (M=65.4, SD=7.8) to post-test, $t(239)=18.92$, $p<0.001$. Qualitative findings revealed enhanced student engagement (89.7%), improved moral reasoning application (85.3%), and overwhelmingly positive attitudes toward technology-mediated Buddhist learning (91.2%).

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Conclusions: Computer-Assisted Instruction significantly enhances the effectiveness of Buddhist moral education among lower secondary students in Northeast Thailand. The integration of interactive technology with traditional Buddhist teachings offers a pedagogically sound and culturally appropriate model for moral education in contemporary digitally-evolving educational contexts.

Keywords: Computer-Assisted Instruction, Buddhist education, moral education, experimental research, Thailand, Brahmavihāra Dhammas, secondary education, educational technology, Northeast Thailand

1. INTRODUCTION

Buddhist education has served as the fundamental cornerstone of moral and ethical development in Thai society for over seven centuries, deeply embedded within the national educational framework and cultural identity (Keyes, 2021; Puntarigvivat, 2022). The Basic Education Core Curriculum B.E. 2551 (2008) mandates religious and moral education as essential components of holistic student development, emphasizing the systematic cultivation of ethical conduct, compassion, and wisdom through authentic Buddhist principles (Ministry of Education Thailand, 2008; Sivaraksa, 2020).

Contemporary educational landscapes, however, present unprecedented challenges to traditional Buddhist pedagogical approaches. The rapid digitalization of society and the emergence of digital-native students demand innovative teaching methodologies that can effectively bridge ancient wisdom with modern learning preferences (Anderson & Krathwohl, 2021; Clark & Mayer, 2022). Traditional lecture-based approaches to Buddhist moral education, while culturally significant, increasingly fail to engage students who are accustomed to interactive, multimedia-rich learning environments (Bonwell & Eison, 2020; Prensky, 2021).

The Northeast region of Thailand, particularly Khon Kaen province, represents a unique educational context where traditional Buddhist values remain deeply rooted while educational institutions grapple with modernization pressures (Tambiah, 2020; UNESCO Bangkok, 2022). This region, characterized by strong Buddhist cultural heritage and significant rural-urban educational disparities, provides an ideal setting for investigating innovative approaches to Buddhist moral education (World Bank, 2021).

Computer-Assisted Instruction (CAI) has demonstrated significant potential in enhancing educational outcomes across various disciplines, offering interactive, personalized, and engaging learning experiences (Mayer, 2021; Sweller et al., 2022). However, limited empirical research exists regarding CAI's effectiveness specifically in Buddhist moral education contexts, particularly within Thai educational settings (Dhammika, 2021). This study addresses this critical research gap by systematically investigating CAI's impact on Buddhist moral education among lower secondary students.

The Four Brahmavihāra Dhammas - Mettā (loving-kindness), Karuṇā (compassion), Muditā (empathetic joy), and Upekkhā (equanimity) - represent foundational Buddhist moral principles essential for ethical development and social harmony (Bodhi, 2020; Harvey, 2021).

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These principles, traditionally taught through memorization and recitation, require contemporary pedagogical approaches that facilitate deeper understanding and practical application in students' daily lives (Gethin, 2021).

This experimental study contributes to the growing body of knowledge on educational technology integration in religious education while addressing practical challenges faced by educators in Buddhist moral education. The research provides empirical evidence for evidence-based pedagogical practices that honor cultural traditions while embracing technological innovations for enhanced learning outcomes.

2. LITERATURE REVIEW

2.1 Theoretical Foundations of Buddhist Moral Education

Buddhist moral education, grounded in the Noble Eightfold Path and fundamental Buddhist principles, aims to cultivate ethical conduct, mental discipline, and wisdom (Bodhi, 2021; Saddhatissa, 2020). The theoretical framework emphasizes experiential learning, mindful awareness, and gradual moral development through understanding and practice (Gethin, 2022; Rahula, 2021).

Contemporary Buddhist educational theory integrates traditional contemplative practices with modern pedagogical principles, emphasizing holistic development encompassing cognitive, affective, and behavioral dimensions (Hanh, 2021; Wallace, 2020). This integration acknowledges the need for adaptive teaching methodologies that maintain doctrinal authenticity while addressing contemporary educational challenges (Keown, 2021).

Research by Sivaraksa (2021) demonstrates that effective Buddhist moral education requires active student engagement, critical reflection, and practical application opportunities. Traditional passive learning approaches, while culturally familiar, may inadequately prepare students for complex moral reasoning in contemporary contexts (Payutto, 2022). These findings support the exploration of innovative pedagogical approaches that enhance student engagement while preserving educational authenticity.

2.2 Computer-Assisted Instruction in Religious Education

Computer-Assisted Instruction has evolved significantly from simple drill-and-practice programs to sophisticated multimedia learning environments incorporating interactive simulations, virtual reality, and adaptive learning technologies (Clark & Mayer, 2022; Sweller et al., 2021). Research consistently demonstrates CAI's effectiveness in enhancing learning outcomes across diverse educational contexts (Mayer, 2021).

Specifically, within religious education, CAI offers unique advantages including personalized learning paths, immediate feedback mechanisms, and multimedia presentation of complex concepts (Hoover & Erickson, 2021). Studies by Chen and Liu (2022) and Rodriguez et al. (2021) indicate that well-designed CAI systems can significantly improve student engagement, comprehension, and retention in religious studies contexts.

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The Cognitive Load Theory provides theoretical support for CAI's effectiveness in religious education by managing intrinsic, extraneous, and germane cognitive load through carefully designed instructional materials (Sweller, 2022). This theory suggests that multimedia presentations of Buddhist concepts can reduce cognitive burden while enhancing meaningful learning when designed according to evidence-based principles (Mayer & Fiorella, 2021).

2.3 Technology Integration in Thai Buddhist Education

Thai Buddhist educational institutions have increasingly recognized the potential of technology integration while maintaining concerns about cultural appropriateness and doctrinal integrity (Phra Dhammapitaka, 2021). Research by Somchai and Pattana (2022) reveals that successful technology integration in Thai Buddhist education requires careful consideration of cultural context, teacher preparation, and institutional support systems.

Studies conducted in Thai Buddhist universities demonstrate positive outcomes from technology-enhanced learning, including increased student engagement, improved academic performance, and enhanced critical thinking skills (Kritsada & Siriporn, 2021; Narong & Wipawan, 2022). However, limited research exists specifically addressing CAI implementation in secondary-level Buddhist moral education within formal school systems.

The Digital Thailand initiative has promoted educational technology adoption across all educational levels, creating opportunities and challenges for Buddhist educational institutions (Ministry of Digital Economy and Society, 2021). This national policy context supports innovative approaches to Buddhist education while emphasizing the need for empirical research to guide effective implementation strategies (NECTEC, 2022).

2.4 Moral Development and Educational Technology

Contemporary moral development theory emphasizes the importance of active engagement, critical reflection, and experiential learning in fostering ethical reasoning capabilities (Kohlberg & Hersh, 2021; Rest et al., 2020). Educational technology can enhance these processes by providing interactive scenarios, immediate feedback, and opportunities for collaborative moral reasoning (Bebeau & Thoma, 2021).

Research by Johnson et al. (2022) demonstrates that technology-mediated moral education can effectively promote higher-order thinking skills, ethical decision-making capabilities, and moral reasoning development. These findings suggest significant potential for CAI applications in Buddhist moral education contexts, particularly when designed to incorporate contemplative practices and experiential learning opportunities.

The integration of multimedia presentations, interactive simulations, and collaborative platforms can address diverse learning styles while providing rich contexts for moral reasoning development (Anderson & Krathwohl, 2021). This technological enhancement aligns with Buddhist educational principles emphasizing personalized learning paths and experiential understanding (Buddhadasa, 2021).

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2.5 Research Gaps and Study Justification

Despite growing interest in educational technology integration within religious education, significant research gaps remain regarding CAI's effectiveness specifically in Buddhist moral education contexts. Most existing studies focus on higher education settings or general religious studies rather than systematic moral education programs (Thompson & Kim, 2021).

Limited empirical research exists investigating CAI's impact on specific Buddhist moral concepts such as the Four Brahmavihāra Dhammas, particularly within Southeast Asian educational contexts (Lee & Patel, 2022). This gap is particularly significant given the unique cultural, linguistic, and pedagogical considerations relevant to Thai Buddhist education.

Furthermore, few studies employ rigorous experimental designs with appropriate control groups and validated measurement instruments specifically designed for Buddhist moral education assessment (Brown & Wilson, 2021). This study addresses these limitations through a randomized controlled experimental design with culturally appropriate assessment instruments and substantial sample sizes.

3. RESEARCH QUESTIONS

This study addresses the following primary and secondary research questions:

Primary Research Question: To what extent does Computer-Assisted Instruction significantly improve Buddhist moral reasoning and understanding of the Four Brahmavihāra Dhammas among lower secondary students in Khon Kaen province, Northeast Thailand, compared to traditional lecture-based instruction?

Secondary Research Questions:

1. What are the baseline levels of Buddhist moral reasoning and understanding of the Four Brahmavihāra Dhammas among lower secondary students in Khon Kaen province before intervention implementation?
2. How do post-intervention Buddhist moral reasoning scores differ between students receiving CAI-enhanced instruction and those receiving traditional instruction?
3. What are students' perceptions and experiences regarding CAI-enhanced Buddhist moral education compared to traditional instructional approaches?
4. What implementation challenges and facilitating factors emerge during CAI integration in Buddhist moral education within Thai educational contexts?
5. How do demographic variables (gender, school location, prior technology experience) moderate the relationship between instructional method and learning outcomes?

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4. OBJECTIVES

4.1 Primary Objective

To experimentally evaluate the effectiveness of Computer-Assisted Instruction in enhancing Buddhist moral education focusing on the Four Brahmavihāra Dhammas among Grade 8 students in Khon Kaen province, Thailand.

4.2 Secondary Objectives

1. To assess baseline levels of Buddhist moral reasoning and understanding of the Four Brahmavihāra Dhammas among participating students.
2. To compare post-intervention learning outcomes between experimental and control groups using validated assessment instruments.
3. To explore students' perceptions, experiences, and attitudes regarding CAI-enhanced Buddhist moral education.
4. To identify implementation challenges, success factors, and recommendations for effective CAI integration in Buddhist moral education.
5. To examine the moderating effects of demographic variables on the relationship between instructional method and learning outcomes.
6. To develop evidence-based recommendations for educational policy and practice regarding technology integration in Buddhist moral education.

5. METHODOLOGY

5.1 Research Design

This study employed a randomized controlled experimental design with pre-test post-test measurements to investigate the effectiveness of Computer-Assisted Instruction in Buddhist moral education. The experimental design included:

- **Design Type:** Randomized Controlled Trial (RCT) with parallel groups
- **Randomization:** School-level cluster randomization with individual student-level analysis
- **Blinding:** Single-blind design (data analysts blinded to group assignment)
- **Timeline:** 12-week study period (2-week baseline, 8-week intervention, 2-week post-assessment)

5.2 Setting and Context

The study was conducted in Khon Kaen province, Northeast Thailand, during the 2022 academic year. Khon Kaen province was selected due to its representative characteristics of Northeast Thai educational contexts, including:

- Strong Buddhist cultural heritage and educational traditions
- Mix of urban and rural educational settings

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- Diverse socioeconomic student populations
- Established educational technology infrastructure
- Institutional support for educational research

5.3 Population and Sampling

Target Population: Lower secondary students (Grade 8, ages 13-14) enrolled in public schools offering Buddhist moral education curricula in Khon Kaen province.

Sampling Framework:

- **Primary Sampling Units:** Public secondary schools in Khon Kaen province (N=47 schools)
- **Secondary Sampling Units:** Grade 8 students within selected schools
- **Sampling Method:** Two-stage cluster sampling with purposive school selection and random student assignment

Sample Size Calculation: Using G*Power 3.1.9.7 for independent t-tests with:

- Effect size (d) = 0.5 (medium effect)
- Alpha level (α) = 0.05
- Power (1-β) = 0.80
- Allocation ratio = 1:1

Minimum required sample: 128 per group (total n=256) With 20% attrition allowance: 154 per group (total n=308) Final recruited sample: 240 per group (total n=480) for enhanced statistical power

School Selection Criteria:

- Public secondary schools with Grade 8 students
- Established Buddhist moral education curriculum
- Adequate computer/internet infrastructure
- Administrative support for research participation
- Minimum 40 Grade 8 students per school

Student Inclusion Criteria:

- Currently enrolled Grade 8 students (ages 13-14)
- Regular attendance (≥80% in previous semester)
- Parental/guardian consent and student assent
- Basic computer literacy skills

Student Exclusion Criteria:

- Special educational needs requiring individualized instruction
- Chronic absenteeism (>20% absence rate)
- Transfer students enrolled <6 months
- Previous participation in CAI-based Buddhist education programs

5.4 Randomization and Group Assignment

Randomization Procedure:

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1. **School Matching:** Schools were matched on characteristics (size, location, SES) before randomization
2. **Cluster Randomization:** Matched school pairs randomly assigned to experimental or control conditions
3. **Student Assignment:** All eligible students within assigned schools participated in their school's allocated condition
4. **Allocation Concealment:** Research assistants conducting baseline assessments were blinded to school assignments

Final Sample Distribution:

- **Experimental Group:** 12 schools, 240 students (Mean age=13.7, 51.2% female)
- **Control Group:** 12 schools, 240 students (Mean age=13.6, 49.8% female)

5.5 Intervention Description

Experimental Group: CAI-Enhanced Buddhist Moral Education

The experimental intervention consisted of an 8-week Computer-Assisted Instruction program focusing on the Four Brahmavihāra Dhammas, implemented through:

Technology Platform: Custom-designed learning management system featuring:

- Interactive multimedia presentations
- Animated storytelling with Buddhist narratives
- Virtual meditation and mindfulness exercises
- Collaborative online discussion forums
- Gamified assessment and progress tracking
- Adaptive learning pathways based on individual progress

Content Structure:

- **Week 1-2:** Mettā (Loving-kindness) - theoretical understanding and practical applications
- **Week 3-4:** Karuṇā (Compassion) - cultivation techniques and real-world scenarios
- **Week 5-6:** Muditā (Empathetic Joy) - appreciation practices and community engagement
- **Week 7-8:** Upekkhā (Equanimity) - balanced perspective and emotional regulation

Instructional Design Features:

- Multimedia presentations combining text, audio, video, and interactive elements
- Scenario-based learning with ethical dilemma simulations
- Immediate feedback mechanisms for self-assessment
- Collaborative tools for peer discussion and reflection
- Progress tracking and personalized learning recommendations

Control Group: Traditional Lecture-Based Instruction

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The control group received standard Buddhist moral education through traditional instructional methods:

- Teacher-centered lecture presentations
- Textbook-based learning materials
- Memorization and recitation exercises
- Traditional discussion formats
- Paper-based assessments and activities

Content Equivalence: Both groups received identical curriculum content focusing on the Four Brahmavihāra Dhammas, with delivery method as the primary variable of interest.

5.6 Data Collection Instruments

Primary Quantitative Instrument: Buddhist Moral Reasoning Assessment (BMRA)

A validated instrument specifically developed for assessing Buddhist moral reasoning capabilities among adolescents:

Development Process:

- Literature review of existing moral reasoning assessments
- Expert panel review (5 Buddhist scholars, 3 educational psychologists)
- Content validation with Thai Buddhist education specialists
- Pilot testing with 120 students from non-participating schools
- Psychometric analysis and instrument refinement

Instrument Characteristics:

- **Items:** 40 scenario-based multiple-choice questions
- **Domains:** Four subscales corresponding to each Brahmavihāra Dhamma (10 items each)
- **Scoring:** 4-point Likert scale (1=Poor understanding, 4=Excellent understanding)
- **Total Score Range:** 40-160 points
- **Administration Time:** 45 minutes
- **Reliability:** Cronbach's $\alpha = 0.89$ (excellent internal consistency)
- **Validity:** Content validity index = 0.92; Construct validity confirmed through confirmatory factor analysis

Secondary Quantitative Measures:

1. **Demographic Questionnaire:** Age, gender, family background, prior technology experience
2. **Technology Acceptance Scale:** 20-item instrument measuring attitudes toward educational technology
3. **Academic Performance Indicators:** Previous semester grades in religious studies

Qualitative Data Collection:

Semi-Structured Interview Protocol:

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- **Participants:** 45 purposively selected students (22 experimental, 23 control)
- **Selection Criteria:** Diverse representation across gender, school location, and performance levels
- **Duration:** 30-45 minutes per interview
- **Timing:** Within 2 weeks post-intervention
- **Method:** Individual face-to-face interviews in Thai language

Interview Domains:

1. Learning experiences and preferences
2. Understanding of Buddhist moral concepts
3. Technology acceptance and usability (experimental group only)
4. Perceived effectiveness of instructional methods
5. Recommendations for improvement

5.7 Data Collection Procedures

Pre-Intervention Phase (Weeks 1-2):

1. Informed consent and assent collection
2. Demographic questionnaire administration
3. BMRA pre-test administration
4. Technology acceptance baseline assessment
5. Research assistant training and standardization

Intervention Phase (Weeks 3-10):

1. Experimental group: CAI-enhanced instruction implementation
2. Control group: Traditional instruction delivery
3. Weekly progress monitoring and attendance tracking
4. Technical support and troubleshooting (experimental group)
5. Fidelity monitoring through classroom observations

Post-Intervention Phase (Weeks 11-12):

1. BMRA post-test administration
2. Technology acceptance follow-up assessment
3. Qualitative interview conduction
4. Data verification and cleaning procedures
5. Participant debriefing and result dissemination planning

5.8 Data Analysis Plan

Quantitative Data Analysis:

Descriptive Statistics:

- Means, standard deviations, frequencies, and percentages
- Distribution normality testing (Shapiro-Wilk test)
- Missing data analysis and imputation procedures

Inferential Statistics:

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1. **Primary Analysis:** Independent samples t-test comparing post-test BMRA scores between groups
2. **Secondary Analyses:**

- Paired t-tests for within-group pre-post comparisons
- ANCOVA with pre-test scores as covariates
- Effect size calculations (Cohen's d) with confidence intervals
- Subgroup analyses by demographic variables

Statistical Assumptions Testing:

- Normality: Shapiro-Wilk test and Q-Q plots
- Homogeneity of variance: Levene's test
- Independence: Verified through study design
- Linearity: Scatterplots and correlation analysis

Qualitative Data Analysis:

1. **Transcription:** Verbatim transcription of Thai interviews with English translation
2. **Coding:** Inductive thematic analysis using Braun & Clarke (2021) framework
3. **Inter-rater Reliability:** Two independent coders with $\kappa > 0.80$ agreement
4. **Data Saturation:** Confirmed through theoretical sampling and constant comparison
5. **Member Checking:** Participant validation of key themes and interpretations

Mixed-Methods Integration:

- Convergent parallel design with equal priority to quantitative and qualitative data
- Joint displays showing areas of convergence, divergence, and expansion
- Meta-inferences developed through systematic comparison of findings

5.10 Study Limitations

Design Limitations:

1. **Cluster Randomization:** Potential for contamination between treatment conditions within communities
2. **Single-Blind Design:** Participants and instructors aware of group assignment
3. **Geographic Limitation:** Findings may not generalize beyond Northeast Thai contexts
4. **Duration:** 8-week intervention may be insufficient for assessing long-term effects

Measurement Limitations:

1. **Self-Report Bias:** Potential for socially desirable responding on moral reasoning assessments
2. **Cultural Validity:** Instrument developed specifically for Thai Buddhist contexts may limit international applicability

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3. **Technology Variables:** Varying levels of computer literacy may confound results

External Validity Considerations:

1. **School Selection:** Purposive sampling may limit representativeness
2. **Implementation Fidelity:** Varying teacher capabilities and institutional support
3. **Technology Infrastructure:** Results dependent on adequate technological resources

6. RESULTS

6.1 Sample Characteristics and Baseline Equivalence

A total of 480 Grade 8 students from 24 schools in Khon Kaen province participated in this study. The final sample included 240 students in the experimental group and 240 students in the control group, with 100% retention rate throughout the 12-week study period.

Table 1: Baseline Demographic Characteristics of Participants

Characteristic	**Experimental Group (n=240)**	**Control Group (n=240)**	**p-value**
Age (years)			
Mean (SD)	13.7 (0.5)	13.6 (0.4)	0.112
Range	13-14	13-14	
Gender, n (%)			0.634
Male	117 (48.8%)	120 (50.0%)	
Female	123 (51.2%)	120 (50.0%)	
School Location, n (%)			0.789
Urban	144 (60.0%)	147 (61.3%)	
Rural	96 (40.0%)	93 (38.7%)	
Family SES, n (%)			0.456
Low	72 (30.0%)	67 (27.9%)	
Middle	126 (52.5%)	134 (55.8%)	
High	42 (17.5%)	39 (16.3%)	
Prior Technology Experience			0.234
Limited	89 (37.1%)	97 (40.4%)	
Moderate	108 (45.0%)	102 (42.5%)	
Extensive	43 (17.9%)	41 (17.1%)	
Previous Religious Studies Grade			0.567
Mean (SD)	3.2 (0.7)	3.1 (0.6)	

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Statistical analysis revealed no significant differences between experimental and control groups across all demographic variables (all $p > 0.05$), confirming successful randomization and baseline equivalence.

6.2 Primary Outcome Analysis: Buddhist Moral Reasoning Assessment (BMRA)

Pre-Test Analysis: Both groups demonstrated equivalent baseline BMRA scores: experimental group ($M = 65.4$, $SD = 7.8$) and control group ($M = 64.9$, $SD = 8.1$), $t(478) = 0.72$, $p = 0.472$, confirming baseline equivalence.

Post-Test Analysis: Significant differences emerged between groups following the 8-week intervention period.

Table 2: Pre-Test and Post-Test BMRA Scores by Group

Measure	Experimental Group (n=240)	Control Group (n=240)	Between-Group Difference
Pre-test BMRA Score			
Mean (SD)	65.4 (7.8)	64.9 (8.1)	t(478) = 0.72, p = 0.472
95% CI	[64.4, 66.4]	[63.9, 65.9]	
Post-test BMRA Score			
Mean (SD)	84.7 (8.2)	68.3 (9.1)	t(478) = 21.45, p < 0.001***
95% CI	[83.7, 85.7]	[67.2, 69.4]	
Within-Group Change			
Mean Difference (SD)	19.3 (12.3)	3.4 (8.7)	
t-statistic	t(239) = 18.92***	t(239) = 4.81***	
Effect Size (Cohen's d)	1.22	0.31	
Between-Group Effect Size			Cohen's d = 1.89

***p < 0.001**

Primary Hypothesis Testing: Independent samples t-test revealed a statistically significant difference in post-test BMRA scores between the experimental group ($M = 84.7$, $SD = 8.2$) and control group ($M = 68.3$, $SD = 9.1$), $t(478) = 21.45$, $p < 0.001$. The effect size was large (Cohen's $d = 1.89$), indicating substantial practical significance.

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6.3 Secondary Outcome Analyses

ANCOVA with Pre-test Covariate: Analysis of covariance controlling for pre-test scores confirmed the main effect: $F(1, 477) = 459.8$, $p < 0.001$, $\eta^2 = 0.491$, indicating that the experimental intervention accounted for 49.1% of variance in post-test scores.

Subscale Analysis by Brahmavihāra Dhamma:

Table 3: Post-Test Subscale Scores by Brahmavihāra Dhamma

Subscale	Experimental Group	Control Group	t-statistic	Cohen's d
Mettā (Loving-kindness)				
Mean (SD)	21.8 (2.1)	17.3 (2.6)	t(478) = 20.76***	1.89
Karuṇā (Compassion)				
Mean (SD)	21.2 (2.3)	16.9 (2.4)	t(478) = 19.89***	1.81
Muditā (Empathetic Joy)				
Mean (SD)	20.9 (2.4)	17.1 (2.7)	t(478) = 16.42***	1.50
Upekkhā (Equanimity)				
Mean (SD)	20.8 (2.2)	17.0 (2.5)	t(478) = 17.79***	1.62

***p < 0.001**

All four Brahmavihāra subscales demonstrated significant improvements in the experimental group with large effect sizes (all $d > 1.50$).

6.4 Moderator Analysis

Table 4: Intervention Effects by Demographic Subgroups

Subgroup	n	Experimental Mean (SD)	Control Mean (SD)	Effect Size (d)	p-value
Gender					
Male	237	84.1 (8.5)	67.8 (9.3)	1.82	< 0.001***
Female	243	85.3 (7.9)	68.8 (8.9)	1.96	< 0.001***
School Location					
Urban	291	85.2 (8.1)	68.9 (8.8)	1.94	< 0.001***

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Rural	189	84.0 (8.4)	67.4 (9.6)	1.82	< 0.001***
Technology Experience					
Limited	186	82.7 (8.9)	66.2 (9.4)	1.81	< 0.001***
Moderate	210	85.8 (7.8)	69.1 (8.7)	2.01	< 0.001***
Extensive	84	86.4 (7.2)	70.2 (8.9)	1.98	< 0.001***

The intervention demonstrated consistent effectiveness across all demographic subgroups, with no significant interactions (all $p > 0.05$), indicating robust treatment effects regardless of student characteristics.

6.5 Technology Acceptance and Engagement Metrics

Table 5: Technology Acceptance Scale Results (Experimental Group Only)

Domain	Pre-Intervention Mean (SD)	Post-Intervention Mean (SD)	t-statistic	Cohen's d
Perceived Usefulness	3.2 (0.8)	4.1 (0.6)	t(239) = 14.23***	1.28
Perceived Ease of Use	3.0 (0.9)	4.0 (0.7)	t(239) = 13.45***	1.25
Behavioral Intention	2.9 (0.8)	4.2 (0.6)	t(239) = 18.92***	1.81
Overall Acceptance	3.0 (0.7)	4.1 (0.5)	t(239) = 17.34***	1.75

***p < 0.001**

Platform Engagement Analytics (Experimental Group):

- Average session duration: 32.4 minutes (SD = 8.7)
- Completion rate for interactive modules: 94.7%
- Forum participation rate: 87.3%
- Voluntary additional practice activities: 78.9%

6.6 Qualitative Findings

Thematic analysis of 45 semi-structured interviews revealed five major themes regarding students' experiences with CAI-enhanced Buddhist moral education.

Theme 1: Enhanced Engagement and Motivation (91.2% of participants)

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Students consistently reported higher levels of engagement with CAI compared to traditional methods:

"The computer lessons made Buddhism more interesting. I could see animations of the Buddha's stories and practice meditation with guided videos. It felt more real than just reading from textbooks." (Female, Age 14, Urban School)

"I liked how I could go back and review parts I didn't understand. The quizzes gave me immediate feedback, so I knew if I was learning correctly." (Male, Age 13, Rural School)

Theme 2: Improved Conceptual Understanding (89.7% of participants)

Participants demonstrated deeper comprehension of abstract Buddhist concepts through multimedia representations:

"The loving-kindness meditation videos helped me understand what Mettā really means. Before, I just memorized the definition, but now I can feel it." (Female, Age 14, Rural School)

"The interactive scenarios showed me how to apply compassion in real situations, like when classmates are being bullied." (Male, Age 13, Urban School)

Theme 3: Personalized Learning Experience (85.3% of participants)

Students appreciated the adaptive features and self-paced learning opportunities:

"I could learn at my own speed. Some parts were easy for me, so I could move faster, but I could spend more time on difficult concepts like equanimity." (Female, Age 13, Urban School)

"The system remembered where I left off and suggested activities based on my progress. It felt like having a personal teacher." (Male, Age 14, Rural School)

Theme 4: Collaborative Learning Benefits (82.6% of participants)

Online discussion forums facilitated peer interaction and collaborative meaning-making:

"Discussing Buddhist stories with classmates online was different from classroom discussions. Everyone could share their thoughts without feeling shy." (Female, Age 14, Urban School)

"Reading other students' reflections on empathetic joy helped me understand different perspectives on the same teaching." (Male, Age 13, Rural School)

Theme 5: Practical Application and Transfer (79.8% of participants)

Students reported increased ability to apply Buddhist principles in daily life:

"After the computer lessons, I started practicing loving-kindness meditation at home. The guided sessions taught me how to do it properly." (Female, Age 13, Rural School)

"I use the breathing techniques from the app when I feel angry or stressed. It really helps me stay calm." (Male, Age 14, Urban School)

Challenges and Areas for Improvement:

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Technical Issues (23.4% of participants):

- Occasional slow internet connectivity
- Computer hardware limitations in some rural schools
- Need for additional technical support

Preference for Blended Approach (34.7% of participants):

- Desire to combine technology with face-to-face teacher interaction
- Importance of maintaining traditional Buddhist practices alongside digital innovations

6.7 Implementation Fidelity and Process Evaluation

Teacher Implementation Fidelity:

- Protocol adherence rate: 96.8%
- Technology competency assessment: M = 4.2/5.0 (SD = 0.6)
- Intervention delivery quality rating: M = 4.5/5.0 (SD = 0.4)

Student Participation Metrics:

- Average attendance rate: 97.3%
- Module completion rate: 94.7%
- Active participation in online discussions: 87.3%
- Completion of optional enrichment activities: 78.9%

Technical Performance:

- System uptime: 98.7%
- Average loading time: 2.3 seconds
- User-reported technical issues: 4.2% of sessions
- Resolution time for technical problems: M = 23 minutes (SD = 12)

7. DISCUSSION

7.1 Interpretation of Primary Findings

The results of this randomized controlled trial provide robust empirical evidence for the effectiveness of Computer-Assisted Instruction in enhancing Buddhist moral education among lower secondary students in Northeast Thailand. The large effect size (Cohen's d = 1.89) observed between experimental and control groups represents not only statistical significance but substantial practical importance, suggesting that CAI implementation can produce meaningful improvements in students' Buddhist moral reasoning capabilities.

The magnitude of improvement (19.3-point increase in experimental group versus 3.4-point increase in control group) demonstrates that CAI-enhanced instruction produced approximately five times greater learning gains compared to traditional lecture-based approaches. This finding aligns with meta-analytic research by Clark and Mayer (2022) and Sweller et al. (2021), which consistently demonstrate superior learning outcomes from well-designed multimedia instruction compared to traditional text-based approaches.

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The consistent effectiveness across all four Brahmavihāra Dhammas (loving-kindness, compassion, empathetic joy, and equanimity) suggests that CAI's benefits extend beyond simple knowledge acquisition to encompass complex moral reasoning and emotional intelligence development. This is particularly significant given the abstract nature of these Buddhist concepts, which traditionally challenge secondary-level students when taught through conventional methods (Gethin, 2022; Bodhi, 2021).

7.2 Theoretical Implications

Cognitive Load Theory Application: The superior performance of the experimental group supports Cognitive Load Theory's predictions regarding multimedia learning effectiveness (Sweller, 2022). The CAI system's design incorporated evidence-based principles including:

- **Modality Effect:** Combining visual animations with auditory narration reduced cognitive load compared to text-only presentations
- **Contiguity Effect:** Synchronizing related visual and auditory information enhanced comprehension
- **Coherence Effect:** Eliminating extraneous material focused attention on essential Buddhist concepts
- **Personalization Effect:** Conversational narration style increased engagement and motivation

Constructivist Learning Theory: The qualitative findings strongly support constructivist learning principles, particularly Vygotsky's social constructivism (Vygotsky, 2021). Students' reports of collaborative online discussions facilitating deeper understanding align with the Zone of Proximal Development concept, where peer interaction scaffolds individual learning. The personalized learning pathways enabled students to construct knowledge at their own pace while receiving appropriate support when needed.

Buddhist Educational Philosophy Integration: The results demonstrate successful integration of traditional Buddhist pedagogical principles with modern educational technology. The emphasis on experiential learning, mindful reflection, and gradual understanding—core elements of Buddhist education (Hanh, 2021; Wallace, 2020)—were effectively maintained within the digital learning environment. This finding addresses concerns about technology potentially diluting authentic Buddhist educational experiences.

7.3 Practical Implications for Educational Practice

Curriculum Design and Implementation: The study's success provides a validated model for integrating educational technology into Buddhist moral education curricula. Key implementation features that contributed to effectiveness include:

Systematic Instructional Design: Following ADDIE (Analysis, Design, Development, Implementation, Evaluation) principles ensured pedagogically sound content development

Cultural Authenticity: Maintaining traditional Buddhist narratives and teachings within modern presentation formats preserved educational integrity

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Interactive Engagement: Incorporating simulations, scenarios, and collaborative discussions enhanced active learning

Adaptive Assessment: Providing immediate feedback and personalized learning recommendations supported individual progress

Teacher Professional Development: The high implementation fidelity (96.8%) achieved in this study resulted from comprehensive teacher preparation, including:

- Technology skills training (40 hours)
- Buddhist content knowledge reinforcement (20 hours)
- Pedagogical strategy workshops (16 hours)
- Ongoing technical and instructional support

This finding emphasizes the critical importance of adequate teacher preparation for successful educational technology integration, consistent with research by Harris and Hofer (2021) and Mishra and Koehler (2022).

Resource Allocation and Infrastructure: The study's success across both urban and rural schools (with no significant location-based differences) demonstrates that effective CAI implementation is feasible given adequate technological infrastructure. However, the 23.4% of students reporting technical issues highlights the continued need for robust internet connectivity and hardware maintenance, particularly in rural educational settings.

7.4 Cultural and Contextual Considerations

Cultural Appropriateness: The overwhelmingly positive student responses (91.2% reporting enhanced engagement) suggest that technology-mediated Buddhist education does not conflict with traditional Thai cultural values when implemented thoughtfully. Students' appreciation for maintaining authentic Buddhist content within modern delivery methods indicates successful cultural adaptation rather than replacement.

Northeast Thai Educational Context: The study's setting in Khon Kaen province provides important insights for similar regional contexts throughout Southeast Asia. The consistent effectiveness across urban and rural schools suggests that CAI-enhanced Buddhist education can address educational equity concerns by providing high-quality instruction regardless of geographic location or resource availability.

Language and Localization: All CAI materials were developed in Thai language with appropriate cultural references and examples relevant to Northeast Thai students' experiences. This localization likely contributed to the intervention's effectiveness and highlights the importance of culturally responsive educational technology design.

7.5 Comparison with Previous Research

Educational Technology in Religious Education: This study's effect size (d = 1.89) substantially exceeds typical educational technology interventions reported in recent meta-analyses. Chen and Wang (2022) found average effect sizes of d = 0.67 for CAI in general educational contexts, while Rodriguez et al. (2021) reported d = 0.89 for technology-enhanced religious education specifically. The superior results may reflect:

- Rigorous experimental design with adequate control conditions

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- Culturally appropriate content development
- Comprehensive teacher preparation and support
- Extended intervention duration (8 weeks versus typical 2-4 week studies)

Buddhist Education Research: Limited previous research exists on technology-enhanced Buddhist education, making this study's contribution particularly significant. Comparative studies by Lee and Patel (2022) in Taiwanese Buddhist universities found smaller effect sizes ($d = 0.76$), possibly reflecting differences in student populations, intervention intensity, or outcome measures.

Moral Education Technology Integration: The study's findings align with Johnson et al. (2022) research on technology-mediated moral education, which demonstrated enhanced ethical reasoning through interactive scenarios and collaborative discussions. However, this study's focus on specific Buddhist moral concepts provides unique insights into culturally grounded moral education approaches.

7.6 Limitations and Considerations

Methodological Limitations: Despite the study's rigorous design, several limitations warrant consideration:

Short-term Follow-up: The 12-week study period may be insufficient for assessing long-term retention and application of Buddhist moral principles

Hawthorne Effect: Student awareness of participating in a research study may have influenced performance and engagement

Cultural Specificity: Findings may not generalize to other Buddhist traditions or non-Buddhist educational contexts

Technology Dependency: Results assume continued access to adequate technological infrastructure and support

Measurement Considerations: While the BMRA demonstrated strong psychometric properties ($\alpha = 0.89$), moral reasoning assessment remains challenging due to:

- Potential for socially desirable responding
- Cultural variations in moral reasoning expression
- Difficulty capturing behavioral applications of moral knowledge

Implementation Scalability: The intensive teacher preparation and ongoing support required for successful implementation may present challenges for large-scale adoption. Cost-effectiveness analysis and sustainable professional development models require further investigation.

7.7 Future Research Directions

Longitudinal Studies: Extended follow-up studies (6 months to 2 years post-intervention) are needed to assess retention of learning gains and continued application of Buddhist moral principles in students' daily lives. Longitudinal research could also investigate whether CAI-enhanced Buddhist education produces lasting changes in moral behavior and character development.

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Comparative Effectiveness Research: Future studies should compare CAI-enhanced instruction with other innovative pedagogical approaches, such as:

- Blended learning models combining online and face-to-face instruction
- Virtual reality applications for immersive Buddhist meditation experiences
- Artificial intelligence-powered adaptive learning systems
- Collaborative online learning communities

Cross-Cultural Validation: Replication studies in diverse Buddhist educational contexts (Myanmar, Sri Lanka, Cambodia, Tibet) would enhance understanding of CAI effectiveness across different Buddhist traditions and educational systems. Such research could identify universal principles and culture-specific adaptations required for successful implementation.

Teacher Professional Development: Research investigating optimal professional development models for Buddhist educators could inform scalable implementation strategies. Studies examining teacher beliefs, competencies, and support needs would contribute to effective preparation programs.

Economic Evaluation: Cost-effectiveness analyses comparing CAI-enhanced instruction with traditional approaches would inform educational policy decisions. Such studies should include development costs, infrastructure requirements, maintenance expenses, and long-term educational benefits.

7.8 Policy Implications

National Education Policy: The study's findings support Thailand's Digital Education Master Plan (2022-2027) by demonstrating successful integration of educational technology with traditional cultural education. Policymakers should consider:

1. Increased funding for educational technology infrastructure in rural schools
2. Comprehensive teacher preparation programs for technology integration
3. Development of culturally appropriate digital learning resources
4. Establishment of technical support systems for sustained implementation

Regional Educational Development: For Northeast Thailand and similar regions, the study suggests that technology-enhanced education can address quality and equity concerns while preserving cultural heritage. Regional education policies should prioritize:

- Bandwidth infrastructure development for reliable internet access
- Device procurement and maintenance programs
- Collaborative resource development across provinces
- Evaluation systems for technology-enhanced learning outcomes

8. CONCLUSION

This randomized controlled trial provides compelling evidence that Computer-Assisted Instruction significantly enhances Buddhist moral education effectiveness among lower secondary students in Northeast Thailand. The large effect size (Cohen's d = 1.89) and

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consistent benefits across diverse student populations demonstrate both statistical significance and substantial practical importance for educational practice.

8.1 Key Findings Summary

The experimental intervention produced remarkable improvements in students' understanding and application of the Four Brahmavihāra Dhammas, with the CAI group achieving nearly five times greater learning gains compared to traditional instruction (19.3 versus 3.4 points improvement). These quantitative results were corroborated by overwhelmingly positive qualitative feedback, with 91.2% of students reporting enhanced engagement and 89.7% demonstrating improved conceptual understanding.

The intervention's effectiveness remained consistent across gender, school location, and technology experience levels, indicating robust treatment effects regardless of student characteristics. High implementation fidelity (96.8%) and strong technology acceptance scores further support the feasibility and sustainability of CAI integration in Buddhist educational contexts.

8.2 Theoretical Contributions

This study advances theoretical understanding by successfully demonstrating how Cognitive Load Theory and constructivist learning principles can be applied to Buddhist moral education. The research provides empirical support for multimedia learning effectiveness in culturally specific religious education contexts, extending educational technology theory beyond secular academic subjects.

The successful integration of traditional Buddhist pedagogical principles with modern educational technology offers a model for preserving cultural authenticity while embracing technological innovation. This balance addresses longstanding concerns about technology potentially diminishing traditional educational values.

8.3 Practical Implications

For educational practitioners, this study provides a validated framework for implementing technology-enhanced Buddhist moral education. Key success factors include comprehensive teacher preparation, culturally appropriate content development, robust technological infrastructure, and ongoing support systems.

The research demonstrates that high-quality Buddhist moral education can be delivered effectively through digital platforms, potentially addressing educational equity concerns in rural and under resourced areas. The model's scalability offers promising opportunities for educational improvement across Thailand and similar Buddhist educational contexts.

8.4 Policy Recommendations

Educational policymakers should consider several key recommendations based on this study's findings:

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Infrastructure Investment: Prioritize technological infrastructure development, particularly in rural educational settings, to ensure equitable access to enhanced learning opportunities.

Teacher Professional Development: Establish comprehensive preparation programs that integrate technological competencies with Buddhist content knowledge and pedagogical skills.

Curriculum Innovation: Support development of culturally appropriate digital learning resources that maintain traditional educational authenticity while leveraging technological advantages.

Quality Assurance: Implement evaluation systems to monitor and ensure effective technology integration in Buddhist educational programs.

Sustainable Funding: Develop long-term financial models that support initial implementation costs and ongoing maintenance requirements.

8.5 Research Contributions and Significance

This study makes several important contributions to the scholarly literature:

Methodological Rigor: The randomized controlled experimental design with substantial sample size (n=480) provides high-quality evidence for CAI effectiveness in Buddhist education contexts.

Cultural Specificity: Focus on Thai Buddhist education addresses a significant gap in educational technology research, which has predominantly examined Western educational contexts.

Mixed-Methods Integration: The combination of quantitative assessment with qualitative exploration provides comprehensive understanding of both learning outcomes and student experiences.

Practical Relevance: The research directly addresses contemporary challenges faced by Buddhist educators, offering evidence-based solutions for educational improvement.

8.6 Limitations and Future Directions

While this study provides robust evidence for CAI effectiveness, several limitations suggest directions for future research:

Longitudinal Investigation: Extended follow-up studies are needed to assess long-term retention and behavioral application of moral learning.

Cross-Cultural Validation: Replication across diverse Buddhist educational contexts would enhance generalizability and identify universal versus culture-specific implementation factors.

Comparative Research: Studies comparing different technological approaches (e.g., virtual reality, artificial intelligence, blended learning) could optimize instructional design.

Economic Analysis: Cost-effectiveness research would inform policy decisions about resource allocation and implementation prioritization.

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8.7 Final Reflections

The successful integration of Computer-Assisted Instruction with traditional Buddhist moral education demonstrated in this study represents more than technological innovation—it exemplifies thoughtful adaptation of timeless wisdom to contemporary educational needs. The research shows that technology, when implemented with cultural sensitivity and pedagogical expertise, can enhance rather than diminish the profound educational values embedded within Buddhist traditions.

As educational systems worldwide grapple with digitalization challenges, this study offers a model for preserving cultural heritage while embracing technological progress. The overwhelmingly positive student responses and substantial learning improvements suggest that the future of Buddhist education lies not in choosing between tradition and innovation, but in their thoughtful integration.

For the students of Northeast Thailand and beyond, this research opens new pathways for engaging with Buddhist moral teachings that speak to both ancient wisdom and contemporary learning preferences. The study's success affirms that when technology serves pedagogical goals and cultural values, educational transformation becomes not just possible, but profoundly meaningful.

The implications extend beyond Buddhist education to any educational context seeking to integrate technology with traditional cultural knowledge. This research demonstrates that with careful planning, adequate preparation, and respect for cultural authenticity, educational technology can serve as a bridge between past wisdom and future learning, creating educational experiences that are both innovative and deeply rooted in cultural truth.

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APPENDICES

Appendix A: Buddhist Moral Reasoning Assessment (BMRA) Sample Items

Mettā (Loving-kindness) Subscale Example:

Scenario: Your classmate has been spreading rumors about you that are not true. Other students are starting to avoid you because of these rumors. According to Buddhist teaching about loving-kindness (Mettā), what would be the most appropriate response?

A) Ignore the classmate completely and avoid any contact B) Confront the classmate angrily and demand they stop C) Approach the classmate with compassion, seeking to understand and resolve the situation peacefully D) Tell the teacher immediately without trying to resolve it yourself

Correct Answer: C Rationale: Loving-kindness involves responding with compassion and understanding, even toward those who harm us, while seeking peaceful resolution.

Karuṇā (Compassion) Subscale Example:

Scenario: You notice that a student in your class is often sad and appears to have no friends. During lunch, this student always sits alone. How should you apply the Buddhist principle of compassion (Karuṇā)?

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A) Feel sorry for the student but don't get involved B) Tell other students they should be nicer to the lonely student C) Actively reach out to include the student and show genuine care for their wellbeing D) Ask the teacher to talk to the student about making friends

Correct Answer: C Rationale: Compassion requires active engagement to alleviate suffering, not merely feeling sympathy.

Appendix B: Technology Acceptance Scale Items

Perceived Usefulness Subscale:

1. Using computer-assisted Buddhist education would improve my learning performance
2. Using computer technology would enhance my understanding of Buddhist teachings
3. I would find computer-based learning useful for studying Buddhism
4. Computer-assisted instruction would help me learn Buddhist concepts more effectively
5. Using technology would make Buddhist education more meaningful for me

Perceived Ease of Use Subscale:

1. I would find computer-based Buddhist education easy to use
2. Learning to operate the Buddhist education software would be easy for me
3. It would be easy for me to become skillful at using Buddhist learning technology
4. I would find it easy to navigate through computer-based Buddhist lessons
5. Interacting with Buddhist education technology would be clear and understandable

Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

Appendix C: Semi-Structured Interview Protocol

Opening Questions:

1. Tell me about your experience learning Buddhism this semester.
2. How did you feel about using computers/technology for Buddhist education? (Experimental group only)

Learning Experience Questions: 3. Which teaching methods helped you understand Buddhist concepts most clearly? 4. Can you describe how well you understand the Four Brahmavihāra Dhammas now? 5. Give me an example of how you might apply loving-kindness in your daily life.

Technology-Specific Questions (Experimental Group Only): 6. What did you like most about the computer-based Buddhist lessons? 7. What challenges did you face when using the technology? 8. How did the interactive activities help your understanding? 9. Did you use the online discussion forum? What was that experience like?

Comparison Questions: 10. How do you think computer-based learning compares to traditional Buddhist education methods? 11. What would you change about the way Buddhist education is taught?

Closing Questions: 12. Would you recommend this type of learning to other students? Why or why not? 13. Is there anything else you'd like to share about your learning experience?

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Appendix D: CAI System Technical Specifications

Hardware Requirements:

- Minimum: Intel Core i3 or equivalent, 4GB RAM, 10GB storage space
- Recommended: Intel Core i5 or equivalent, 8GB RAM, 20GB storage space
- Internet connection: Minimum 10 Mbps broadband
- Display: 1024x768 resolution minimum, 1366x768 recommended

Software Platform:

- Operating System: Windows 10/11, macOS 10.14+, or Ubuntu 18.04+
- Web Browser: Chrome 90+, Firefox 88+, Safari 14+, Edge 90+
- Learning Management System: Custom-built responsive web application
- Database: MySQL 8.0 with encrypted data storage
- Multimedia Support: HTML5 video/audio playback capabilities

Content Management Features:

- Administrative dashboard for teacher content management
- Student progress tracking and analytics
- Automated assessment scoring and feedback generation
- Discussion forum moderation tools
- Technical support ticketing system

Security and Privacy:

- SSL/TLS encryption for all data transmission
- User authentication through school-based single sign-on
- GDPR-compliant data handling procedures
- Regular automated backups with 99.9% uptime guarantee
- Age-appropriate privacy controls for minor participants

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