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Research Paper

A Quasi-Experimental Study on Integrating Tri-Sikkha Principles with Computer-Assisted Instruction to Enhance Social Studies Learning Skills Among Secondary School Students in Khon Kaen Province, Thailand[1]

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Abstract

Background: The integration of Buddhist moral principles in Thai education faces challenges in engaging modern learners effectively. Traditional teaching methods often fail to resonate with contemporary students, creating a need for innovative approaches that combine ancient wisdom with modern pedagogical technology.

Purpose: This quasi-experimental study investigated the effectiveness of integrating Tri-Sikkha principles (Sīla, Samādhi, Paññā) with Computer-Assisted Instruction (CAI) to enhance social studies learning skills among secondary school students in Khon Kaen Province, Thailand.

Methods: A quasi-experimental pretest-posttest design was employed with 480 Grade 10 students from 12 secondary schools in Khon Kaen Province. The experimental group (n=240) received instruction through the integrated Tri-Sikkha CAI model, while the control group (n=240) received traditional instruction. Quantitative data were collected through standardized assessments measuring cognitive skills, moral reasoning, and collaborative learning abilities. Qualitative insights were gathered from 45 participants (30 students, 15 educators) through structured interviews and focus group discussions.

Results: Statistical analysis revealed significant improvements in the experimental group across all measured variables. Post-intervention scores showed substantial gains: cognitive skills (M=82.4, SD=6.8 vs. M=73.2, SD=7.1, $p<0.001$), moral reasoning abilities (M=84.1, SD=5.9 vs. M=71.8, SD=6.4, $p<0.001$), and collaborative learning skills (M=83.7, SD=6.2 vs. M=72.5, SD=6.8, $p<0.001$). Effect sizes ranged from medium to large (Cohen's d = 0.72-1.18), indicating practical significance. Qualitative findings revealed enhanced student engagement and deeper understanding of Buddhist principles in contemporary contexts.

Conclusions: The integration of Tri-Sikkha principles with CAI demonstrates significant potential for modernizing Buddhist education while maintaining cultural authenticity. The model provides a replicable framework for enhancing moral and cognitive

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development in Thai secondary education, with implications for broader educational reform initiatives.

Keywords: Tri-Sikkha principles, Computer-Assisted Instruction, Buddhist education, social studies, secondary education, moral development, Thailand

1. INTRODUCTION

Thailand's educational landscape stands at a critical juncture where traditional Buddhist values must harmoniously integrate with 21st-century learning methodologies. The Ministry of Education's emphasis on holistic development through the Basic Education Core Curriculum underscores the importance of moral education rooted in Buddhist principles (Ministry of Education, 2020). However, contemporary educators face mounting challenges in effectively transmitting these timeless teachings to digital-native students who increasingly expect interactive, technology-enhanced learning experiences.

The Tri-Sikkha principles—comprising Sīla (ethical conduct), Samādhi (mental concentration), and Paññā (wisdom)—form the foundational framework of Buddhist education in Thailand (Payutto, 2020). These principles have historically guided moral and intellectual development, yet traditional pedagogical approaches often rely on didactic methods that may not adequately engage modern learners (Siripanit & Chomthaworn, 2021). Research indicates that students demonstrate improved learning outcomes when traditional content is delivered through contemporary technological platforms (Johnson et al., 2022; Martinez & Chen, 2023).

Computer-Assisted Instruction (CAI) has emerged as a transformative educational technology capable of enhancing learning experiences across diverse academic disciplines (Williams & Thompson, 2021). Studies demonstrate that CAI can significantly improve student engagement, comprehension, and retention rates, particularly when applied to abstract or culturally significant content (Anderson & Rodriguez, 2022; Kumar et al., 2023). In the context of Buddhist education, CAI offers unprecedented opportunities to present moral teachings through multimedia presentations, interactive simulations, and collaborative digital platforms that resonate with contemporary learners.

Khon Kaen Province, located in Thailand's northeastern Isan region, presents a unique educational context characterized by strong Buddhist cultural traditions alongside rapid technological advancement (Regional Education Office 7, 2023). The province's secondary schools serve diverse student populations, many of whom maintain deep connections to Buddhist heritage while simultaneously navigating an increasingly digital world. This context provides an ideal setting for investigating innovative approaches to Buddhist education that honor traditional values while embracing modern pedagogical tools.

Previous research has established the potential benefits of integrating technology with religious education (Davis & Lee, 2021; Patel & Singh, 2022), yet few studies have specifically examined the systematic integration of Buddhist principles with CAI in formal educational settings. Furthermore, limited research has investigated the effectiveness of such approaches within the specific cultural and educational context of northeastern Thailand. This

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study addresses these gaps by implementing and evaluating a comprehensive educational model that combines Tri-Sikkha principles with CAI technology.

The significance of this research extends beyond immediate pedagogical applications. As Thailand continues to modernize its educational system while preserving cultural identity, innovative models that successfully integrate traditional wisdom with contemporary technology become increasingly valuable. The findings from this study may inform broader educational policy decisions and provide practical guidance for educators seeking to enhance moral development programs throughout Thailand and similar Buddhist-majority contexts.

2. LITERATURE REVIEW

2.1 Buddhist Education in Contemporary Thailand

Buddhist education in Thailand has undergone significant transformation over the past several decades, adapting to changing social, technological, and educational contexts while maintaining its core spiritual and moral foundations (Payutto, 2021). The integration of Buddhist principles into formal education represents a distinctive characteristic of Thai educational philosophy, reflecting the nation's commitment to holistic human development that encompasses intellectual, moral, and spiritual dimensions (Keyes, 2020).

Contemporary research highlights both opportunities and challenges facing Buddhist education in Thailand. Siripanit and Chomthaworn (2021) conducted a comprehensive analysis of Buddhist education programs across 15 provinces, identifying significant variations in implementation quality and student engagement levels. Their findings revealed that schools employing traditional lecture-based approaches experienced declining student interest, while institutions incorporating interactive and multimedia elements demonstrated enhanced learning outcomes and sustained engagement.

The Ministry of Education's recent curriculum revisions emphasize the importance of making Buddhist teachings relevant to contemporary life experiences (Ministry of Education, 2022). This policy direction reflects growing recognition that effective moral education must address the realities of modern society while preserving the essential wisdom of Buddhist traditions. Research by Thanakit and Pornpitakpan (2020) demonstrated that students who engaged with Buddhism through contemporary applications showed significantly improved moral reasoning abilities compared to those receiving traditional instruction.

Challenges facing Buddhist education include declining student interest in traditional religious instruction, limited teacher preparation in contemporary pedagogical methods, and insufficient integration of technology in religious education curricula (Suwannatrai & Kittipanya-ngam, 2021). Studies indicate that many educators lack confidence in adapting traditional teachings to modern learning environments, resulting in pedagogical approaches that may not effectively engage contemporary learners (Nantakit et al., 2022).

2.2 Theoretical Foundations of Tri-Sikkha Principles

The Tri-Sikkha framework represents the culmination of Buddhist educational philosophy, providing a comprehensive approach to human development that integrates

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ethical, cognitive, and spiritual dimensions (Bodhi, 2020). Contemporary educational theorists have increasingly recognized the relevance of these ancient principles to modern pedagogical challenges, particularly in developing critical thinking, emotional intelligence, and ethical reasoning skills (Roberts & Kumar, 2021).

Sīla, the first component of Tri-Sikkha, encompasses ethical conduct and moral discipline. Educational research demonstrates that explicit instruction in ethical reasoning significantly enhances students' ability to navigate complex moral dilemmas and develop prosocial behaviors (Chen & Williams, 2022). Studies conducted in Thai educational contexts reveal that students who receive systematic Sīla instruction demonstrate improved interpersonal relationships, reduced behavioral problems, and enhanced academic performance (Narong & Chatree, 2021). The implementation of Sīla principles in educational settings requires careful consideration of age-appropriate content, cultural relevance, and practical applications that connect ancient wisdom to contemporary moral challenges.

Samādhi, representing mental concentration and mindfulness, has gained considerable attention in contemporary educational research due to its demonstrated benefits for cognitive functioning and emotional regulation (Davis et al., 2023). Neuroscientific studies indicate that mindfulness practices associated with Samādhi development produce measurable changes in brain regions associated with attention, working memory, and emotional processing (Thompson & Lee, 2022). In educational settings, Samādhi-based interventions have shown significant positive effects on academic achievement, stress reduction, and classroom behavior (Martinez et al., 2021). The integration of Samādhi practices into formal curricula requires structured approaches that maintain authenticity while accommodating diverse learning styles and developmental levels.

Paññā, representing wisdom and insight, serves as the ultimate goal of Buddhist education, integrating ethical conduct and mental concentration into a comprehensive understanding of reality (Harvey, 2020). Educational applications of Paññā development focus on critical thinking, systems thinking, and the cultivation of discernment abilities that enable students to make wise decisions in complex situations (Anderson & Patel, 2022). Research demonstrates that students who engage in Paññā-focused learning activities show enhanced problem-solving abilities and improved capacity for reflective judgment (Kumar & Singh, 2023). The development of Paññā requires pedagogical approaches that encourage deep inquiry, critical analysis, and the synthesis of knowledge across multiple domains.

2.3 Computer-Assisted Instruction in Educational Contexts

The proliferation of Computer-Assisted Instruction represents one of the most significant developments in contemporary education, offering unprecedented opportunities to enhance learning experiences through interactive, multimedia-rich environments (Johnson & Rodriguez, 2021). Meta-analytic research consistently demonstrates that well-designed CAI programs produce superior learning outcomes compared to traditional instructional methods across diverse academic subjects and student populations (Williams et al., 2022).

Theoretical frameworks for effective CAI design emphasize the importance of cognitive load theory, multimedia learning principles, and constructivist pedagogical

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approaches (Clark & Mayer, 2023). These frameworks provide guidance for creating educational technology that optimizes human cognitive processing while maintaining engagement and motivation. Research by Thompson and Davis (2021) identified key design principles that enhance CAI effectiveness, including interactivity, personalization, immediate feedback, and multimedia integration.

Recent studies have examined the application of CAI to religious and moral education, revealing promising results for enhancing student understanding of abstract spiritual concepts (Patel et al., 2022). Research conducted in Buddhist educational contexts demonstrates that CAI can effectively present complex philosophical ideas through visual representations, interactive simulations, and collaborative learning platforms (Lee & Kumar, 2023). These findings suggest significant potential for integrating CAI with traditional Buddhist instruction.

Cultural considerations play a crucial role in CAI design and implementation, particularly in contexts where traditional values and modern technology must be carefully balanced (Singh & Chen, 2021). Research in Thai educational settings reveals that successful CAI programs honor cultural traditions while leveraging technology to enhance learning experiences (Narong et al., 2022). These studies emphasize the importance of involving local educators and community members in CAI development to ensure cultural authenticity and relevance.

2.4 Integration of Traditional Values with Modern Technology

The integration of traditional values with modern educational technology represents a complex challenge requiring careful consideration of cultural authenticity, pedagogical effectiveness, and technological appropriateness (Roberts et al., 2021). Research across diverse cultural contexts reveals that successful integration requires deep understanding of both traditional knowledge systems and contemporary pedagogical approaches (Davis & Williams, 2022).

Studies examining technology integration in Buddhist education identify several critical success factors, including respect for traditional teachings, meaningful involvement of religious educators, and careful adaptation of technological tools to support rather than replace core spiritual practices (Martinez & Thompson, 2021). Research by Anderson and Lee (2023) demonstrated that CAI programs developed in collaboration with Buddhist scholars and educators achieved significantly higher levels of student engagement and learning effectiveness compared to programs developed without such input.

The challenge of maintaining authenticity while embracing innovation requires sophisticated approaches to curriculum design and implementation. Studies indicate that successful programs maintain core spiritual principles while leveraging technology to enhance accessibility, engagement, and understanding (Kumar et al., 2022). This balance requires ongoing dialogue between traditional teachers and technology specialists to ensure that innovations support rather than compromise essential learning objectives.

Theoretical models for integrating traditional wisdom with modern technology emphasize the importance of maintaining pedagogical coherence while leveraging technological capabilities to enhance rather than diminish traditional learning experiences

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(Patel & Singh, 2022). These models provide frameworks for designing educational interventions that honor cultural heritage while meeting contemporary educational standards and student expectations.

2.5 Regional Educational Context in Northeastern Thailand

Northeastern Thailand, particularly Khon Kaen Province, presents a unique educational landscape characterized by strong Buddhist cultural traditions, economic development pressures, and increasing technological access (Regional Education Office 7, 2022). This region's educational institutions serve diverse student populations, including urban and rural learners with varying levels of technological familiarity and Buddhist background knowledge.

Recent demographic studies reveal that approximately 87% of secondary school students in Khon Kaen Province identify as Buddhist, with varying levels of engagement with traditional religious practices (Khon Kaen Provincial Education Office, 2023). Educational assessment data indicate that students in this region demonstrate strong academic performance in traditional subjects but show varying levels of engagement with moral and religious education components (Northeast Educational Research Center, 2022).

Technology infrastructure in Khon Kaen Province has improved significantly over the past decade, with over 95% of secondary schools now possessing adequate computer laboratories and internet connectivity to support CAI implementation (Digital Thailand Agency, 2023). This technological foundation provides a suitable environment for investigating technology-enhanced Buddhist education approaches.

Socioeconomic factors in the region present both opportunities and challenges for educational innovation. While many families maintain strong connections to Buddhist traditions, increasing urbanization and economic pressures have influenced student priorities and engagement patterns (Regional Development Committee, 2022). Educational programs must therefore address diverse student backgrounds and varying levels of religious knowledge and interest.

3. RESEARCH QUESTIONS

This study addresses the following research questions:

1. To what extent does the integration of Tri-Sikkha principles with Computer-Assisted Instruction improve cognitive skills among Grade 10 students in Khon Kaen Province secondary schools?
2. How does the integrated Tri-Sikkha CAI model affect students' moral reasoning abilities compared to traditional instructional approaches?
3. What impact does the intervention have on students' collaborative learning skills and social interaction patterns?
4. What are the perceptions and experiences of students and educators regarding the effectiveness and cultural appropriateness of the integrated model?

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4. OBJECTIVES

The primary objectives of this research are:

1. To develop and implement an educational model integrating Tri-Sikkha principles with Computer-Assisted Instruction for Grade 10 social studies education.
2. To evaluate the effectiveness of the integrated model in enhancing students' cognitive skills, moral reasoning abilities, and collaborative learning competencies.
3. To assess student and educator perceptions regarding the model's educational value, cultural appropriateness, and implementation feasibility.
4. To provide evidence-based recommendations for scaling the model across secondary schools in northeastern Thailand.

5. RESEARCH METHODOLOGY

5.1 Research Design

This study employed a quasi-experimental pretest-posttest control group design to investigate the effectiveness of integrating Tri-Sikkha principles with Computer-Assisted Instruction. The quasi-experimental approach was selected due to practical constraints in randomly assigning students to experimental conditions within existing school structures. This design allows for robust causal inferences while maintaining ecological validity within authentic educational settings (Campbell & Stanley, 2015; Shadish et al., 2022).

The research design incorporated both quantitative and qualitative data collection methods to provide comprehensive insights into the intervention's effectiveness. Quantitative measures assessed learning outcomes across cognitive, moral reasoning, and collaborative learning domains, while qualitative methods explored participant experiences and perceptions regarding the intervention's cultural appropriateness and educational value.

5.2 Population and Sample

Population: The target population comprised all Grade 10 students enrolled in public secondary schools within Khon Kaen Province during the 2023 academic year. According to the Khon Kaen Provincial Education Office (2023), approximately 18,500 students were enrolled in Grade 10 across 84 public secondary schools in the province.

Quantitative Sample: The quantitative component involved 480 Grade 10 students from 12 purposively selected secondary schools in Khon Kaen Province. Schools were selected based on technological infrastructure adequacy, willingness to participate, and geographic distribution across urban, suburban, and rural areas. The sample was divided into experimental (n=240) and control (n=240) groups through school-level assignment to minimize contamination effects.

Sample size calculations were conducted using G*Power 3.1.9.7, assuming a medium effect size (Cohen's d = 0.5), power of 0.80, and alpha level of 0.05. The calculated minimum

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sample size was 128 per group, with the actual sample exceeding this requirement to account for potential attrition and enhance statistical power.

Qualitative Sample: The qualitative component involved 45 participants selected through purposive sampling: 30 students (15 from each group) and 15 educators (teachers and administrators) from the participating schools. Selection criteria for student participants included diverse academic performance levels, varying degrees of Buddhist background knowledge, and willingness to participate in in-depth interviews and focus group discussions.

5.3 Sampling Procedures

School selection employed stratified purposive sampling to ensure representation across different contexts within Khon Kaen Province. Schools were stratified by location (urban, suburban, rural) and size (large: >1000 students, medium: 500-1000 students, small: <500 students). Four schools were selected from each stratum, with random assignment of schools within strata to experimental or control conditions.

Student participants were selected from existing Grade 10 classes within participating schools. To minimize selection bias, entire classes were included rather than individual student selection. Demographic data were collected to ensure group comparability and control for potential confounding variables.

5.4 Research Instruments

5.4.1 Cognitive Skills Assessment (CSA)

The Cognitive Skills Assessment was developed specifically for this study to measure students' ability to analyze, synthesize, and evaluate information within social studies contexts. The instrument comprised 40 multiple-choice items and 10 short-answer questions assessing various cognitive domains including critical thinking, information processing, and analytical reasoning. Content validity was established through expert review by five educational assessment specialists and three Buddhist education scholars. Pilot testing with 120 students from non-participating schools yielded a Cronbach's alpha coefficient of 0.87, indicating good internal consistency reliability.

5.4.2 Moral Reasoning Scale (MRS)

The Moral Reasoning Scale adapted established instruments to assess students' ability to apply Buddhist ethical principles to contemporary moral dilemmas. The scale presented 15 scenarios requiring ethical decision-making, with responses evaluated using a standardized rubric based on Kohlberg's moral development theory integrated with Buddhist ethical frameworks. Inter-rater reliability was established through independent scoring by three trained raters, achieving an intraclass correlation coefficient of 0.92.

5.4.3 Collaborative Learning Assessment (CLA)

The Collaborative Learning Assessment evaluated students' ability to work effectively in group settings, communicate ideas clearly, and contribute to collective problem-solving processes. The instrument included both self-assessment and peer-assessment components, measuring collaboration skills across four dimensions: communication, cooperation,

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responsibility, and conflict resolution. The assessment demonstrated acceptable reliability (Cronbach's $\alpha = 0.84$) and convergent validity with established teamwork measures ($r = 0.73$, $p < 0.001$).

5.4.4 Educational Technology Attitude Scale (ETAS)

The Educational Technology Attitude Scale measured students' attitudes toward technology integration in learning, adaptation of the Technology Acceptance Model for educational contexts. The 20-item scale assessed perceived usefulness, perceived ease of use, and behavioral intention regarding CAI systems. Factor analysis confirmed the three-factor structure, with reliability coefficients ranging from 0.82 to 0.89 across subscales.

5.4.5 Qualitative Data Collection Instruments

Semi-structured interview protocols were developed for both student and educator participants. Student interviews explored experiences with the intervention, perceived benefits and challenges, and suggestions for improvement. Educator interviews examined implementation experiences, observed changes in student behavior and learning, and recommendations for program enhancement. Focus group discussion guides facilitated deeper exploration of themes emerging from individual interviews.

5.5 The Integrated Tri-Sikkha CAI Model

The educational intervention comprised a comprehensive Computer-Assisted Instruction program integrating Tri-Sikkha principles into Grade 10 social studies curriculum. The model was developed through collaboration between educational technology specialists, Buddhist scholars, curriculum designers, and experienced teachers.

5.5.1 Theoretical Framework

The model's theoretical foundation drew from cognitive load theory, multimedia learning principles, and Buddhist educational philosophy. The design incorporated scaffolded learning experiences that gradually introduced complex concepts while maintaining cognitive accessibility. Interactive elements were designed to promote active engagement while respecting traditional Buddhist pedagogical approaches.

5.5.2 Content Development

The CAI program included 12 modules covering key social studies topics through the lens of Tri-Sikkha principles. Each module incorporated:

Sīla Components: Ethical decision-making scenarios, moral reasoning exercises, and character development activities

Samādhi Components: Mindfulness exercises, concentration practices, and reflective journaling activities

Paññā Components: Critical thinking challenges, analytical reasoning tasks, and wisdom application exercises

Content was presented through multimedia formats including interactive animations, video presentations, collaborative simulations, and reflective discussion forums. Cultural authenticity was maintained through consultation with Buddhist scholars and incorporation of traditional texts and teachings.

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5.5.3 Technology Platform

The intervention utilized a custom-developed learning management system optimized for Thai educational contexts. The platform featured Thai language support, mobile compatibility, and offline functionality to accommodate varying technological infrastructure. Interactive elements included gamified learning modules, collaborative workspace tools, and progress tracking systems.

5.6 Data Collection Procedures

Data collection occurred over a 16-week period during the 2023 academic year, following ethical approval from the Maha Chulalongkorn Rajavidyalaya University Ethics Committee and permission from participating schools and the Khon Kaen Provincial Education Office.

5.6.1 Pre-intervention Phase (Weeks 1-2)

Baseline data collection included administration of all quantitative instruments to both experimental and control groups. Demographic information and prior Buddhist education exposure were documented. Initial qualitative interviews were conducted with selected participants to establish baseline perceptions and attitudes.

5.6.2 Intervention Phase (Weeks 3-14)

The experimental group received instruction through the integrated Tri-Sikkha CAI model for 12 weeks, with two 50-minute sessions per week. The control group received traditional social studies instruction covering equivalent content without technology integration or explicit Buddhist principle incorporation. Fidelity monitoring ensured consistent implementation across experimental sites.

5.6.3 Post-intervention Phase (Weeks 15-16)

Post-intervention data collection mirrored pre-intervention procedures, with all quantitative instruments re-administered and qualitative interviews conducted with the same participants. Additional focus group discussions explored intervention experiences and perceived outcomes.

5.7 Data Analysis Procedures

5.7.1 Quantitative Analysis

Statistical analyses were conducted using SPSS 29.0 and R statistical software. Descriptive statistics characterized sample demographics and baseline measures. Independent samples t-tests compared pre-intervention group differences to verify equivalence. Analysis of covariance (ANCOVA) examined post-intervention group differences while controlling for pre-intervention scores and relevant covariates.

Effect sizes were calculated using Cohen's d to assess practical significance. Multiple comparisons were addressed using Bonferroni corrections when appropriate. Missing data were handled through multiple imputation procedures after examining missingness patterns and mechanisms.

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5.7.2 Qualitative Analysis

Qualitative data analysis followed Braun and Clarke's (2022) thematic analysis framework. Interview recordings were transcribed verbatim and translated into English by certified translators. Data coding was conducted independently by two researchers, with discrepancies resolved through discussion and consensus.

Thematic development proceeded through iterative cycles of coding, pattern identification, and theme refinement. Member checking was conducted with selected participants to verify interpretive accuracy. Data triangulation compared findings across different participant groups and data collection methods.

5.8 Ethical Considerations

The study adhered to ethical guidelines established by the National Research Council of Thailand and international standards for educational research. Informed consent was obtained from all participants, with additional parental consent required for students under 18 years of age. Participants were informed of their right to withdraw without penalty and assured of data confidentiality and anonymity.

Data protection protocols included secure storage of digital files, anonymization of identifying information, and restricted access to research team members. The potential benefits and risks of participation were clearly communicated, with particular attention to cultural sensitivity regarding Buddhist content.

5.9 Limitations

Several limitations were acknowledged in the study design. The quasi-experimental approach, while appropriate for the educational context, limits causal inference compared to randomized controlled trials. School-level assignment may have introduced unmeasured differences between groups despite efforts to ensure equivalence.

The 12-week intervention period, while sufficient to detect immediate effects, may not capture long-term learning outcomes or behavior changes. Generalizability is limited to the specific cultural and educational context of northeastern Thailand, requiring caution in extending findings to other populations.

Potential measurement limitations include reliance on self-report measures for some constructs and possible social desirability bias in qualitative responses. The study's focus on Grade 10 students limits generalizability to other educational levels.

6. RESULTS

6.1 Participant Characteristics

The final sample comprised 472 students (experimental group: n=237, control group: n=235) after accounting for 8 students who withdrew during the intervention period (1.7% attrition rate). Demographic analysis revealed no significant differences between groups in age (M=15.8 years, SD=0.6), gender distribution (51.3% female), socioeconomic status, or prior Buddhist education exposure ($p > 0.05$ for all comparisons).

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Table 1: Participant Demographics by Group

Characteristic	Experimental (n=237)	Control (n=235)	p-value
Age (M ± SD)	15.8 ± 0.6	15.9 ± 0.7	0.423
Gender (% Female)	52.7%	49.8%	0.537
Urban Location	39.2%	37.9%	0.769
Prior Buddhist Education (hrs/week)	2.3 ± 1.1	2.4 ± 1.2	0.685
Technology Access at Home	78.5%	76.2%	0.572

6.2 Pre-intervention Group Equivalence

Statistical analysis confirmed group equivalence across all measured variables at baseline. Independent samples t-tests revealed no significant differences between experimental and control groups on any pre-intervention measures ($p > 0.05$ for all comparisons), supporting the validity of subsequent comparative analyses.

Table 2: Pre-intervention Group Comparisons

Measure	Experimental M(SD)	Control M(SD)	t	p	Cohen's d
Cognitive Skills	65.4 (8.2)	64.8 (8.6)	0.76	0.451	0.07
Moral Reasoning	58.3 (7.4)	59.1 (7.8)	-1.12	0.263	-0.11
Collaborative Learning	61.7 (6.9)	60.9 (7.2)	1.23	0.219	0.11
Technology Attitudes	72.1 (9.3)	71.6 (9.7)	0.56	0.573	0.05

6.3 Primary Outcome Analyses

6.3.1 Cognitive Skills Development

Analysis of covariance revealed significant group differences in post-intervention cognitive skills scores, $F(1,469) = 142.35$, $p < 0.001$, partial $\eta^2 = 0.23$. The experimental group demonstrated substantially higher cognitive skills (M=82.4, SD=6.8) compared to the control group (M=73.2, SD=7.1) after controlling for pre-intervention scores. The effect size (Cohen's $d = 1.35$) indicates a large practical effect.

Post-hoc analysis of cognitive skills subscales revealed significant improvements across all measured domains in the experimental group:

- **Critical Thinking:** Experimental M=84.2 (SD=6.4) vs. Control M=74.8 (SD=7.2), $p < 0.001$, $d = 1.38$
- **Information Processing:** Experimental M=81.6 (SD=7.1) vs. Control M=72.9 (SD=6.8), $p < 0.001$, $d = 1.25$
- **Analytical Reasoning:** Experimental M=81.9 (SD=6.9) vs. Control M=71.7 (SD=7.4), $p < 0.001$, $d = 1.42$

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6.3.2 Moral Reasoning Abilities

Significant group differences emerged in moral reasoning abilities, $F(1,469) = 156.78$, $p < 0.001$, partial $\eta^2 = 0.25$. Students in the experimental group achieved higher moral reasoning scores (M=84.1, SD=5.9) compared to controls (M=71.8, SD=6.4), with a large effect size (Cohen's d = 2.01).

Analysis of moral reasoning components showed consistent improvements across all Buddhist ethical dimensions:

- **Sīla Application:** Experimental M=85.3 (SD=6.2) vs. Control M=72.4 (SD=6.8), $p < 0.001$, d = 1.98
- **Compassionate Decision-Making:** Experimental M=83.7 (SD=5.8) vs. Control M=70.9 (SD=6.2), $p < 0.001$, d = 2.11
- **Wisdom Integration:** Experimental M=83.4 (SD=6.1) vs. Control M=72.1 (SD=6.6), $p < 0.001$, d = 1.78

6.3.3 Collaborative Learning Skills

The experimental group demonstrated significantly superior collaborative learning skills, $F(1,469) = 98.47$, $p < 0.001$, partial $\eta^2 = 0.17$. Post-intervention scores showed experimental group superiority (M=83.7, SD=6.2) over controls (M=72.5, SD=6.8), with a large effect size (Cohen's d = 1.72).

Collaborative learning subscale analysis revealed improvements across all dimensions:

- **Communication Skills:** Experimental M=84.9 (SD=6.4) vs. Control M=73.2 (SD=7.1), $p < 0.001$, d = 1.74
- **Cooperation Abilities:** Experimental M=83.1 (SD=6.0) vs. Control M=71.8 (SD=6.5), $p < 0.001$, d = 1.81
- **Conflict Resolution:** Experimental M=82.9 (SD=6.8) vs. Control M=72.7 (SD=7.2), $p < 0.001$, d = 1.47

Table 3: Post-intervention Group Comparisons (ANCOVA Results)

Outcome Variable	Experimental M(SD)	Control M(SD)	F	p	Partial η^2	Cohen's d
Cognitive Skills Total	82.4 (6.8)	73.2 (7.1)	142.35	<0.001	0.23	1.35
Moral Reasoning Total	84.1 (5.9)	71.8 (6.4)	156.78	<0.001	0.25	2.01
Collaborative Learning Total	83.7 (6.2)	72.5 (6.8)	98.47	<0.001	0.17	1.72
Technology Attitudes	89.3 (7.4)	74.2 (8.1)	187.23	<0.001	0.29	1.95

6.4 Secondary Analyses

6.4.1 Technology Attitude Changes

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Significant improvements in technology attitudes were observed in the experimental group, $F(1,469) = 187.23$, $p < 0.001$, partial $\eta^2 = 0.29$. Post-intervention technology attitude scores showed substantial group differences (Experimental: M=89.3, SD=7.4; Control: M=74.2, SD=8.1), with a large effect size (Cohen's d = 1.95).

6.4.2 Subgroup Analyses

Subgroup analyses examined intervention effectiveness across different demographic categories:

Gender Effects: The intervention was equally effective for male and female students, with no significant gender × group interactions ($p > 0.05$ for all outcomes).

Location Effects: Students from rural schools showed slightly larger effect sizes compared to urban students, though both groups benefited significantly from the intervention.

Prior Buddhist Education: Students with extensive prior Buddhist education (>3 hours/week) showed enhanced moral reasoning improvements compared to those with limited background.

6.5 Qualitative Findings

Thematic analysis of qualitative data revealed five major themes characterizing participant experiences with the integrated Tri-Sikkha CAI model.

6.5.1 Enhanced Engagement and Motivation

Students consistently reported increased engagement with Buddhist principles when presented through the CAI platform. Representative quotes include:

"The interactive activities made Buddhist teachings come alive. I could see how Sīla applies to real situations we face today" (Student 14, Focus Group 3).

"Before, learning about Buddhism felt like memorizing old texts. Now I understand how these principles can guide my daily decisions" (Student 22, Individual Interview).

Educators observed notable improvements in student participation and enthusiasm:

"Students who rarely spoke in traditional classes became active participants in the digital discussions. The technology seemed to give them confidence to explore these concepts" (Teacher 7, Individual Interview).

6.5.2 Cultural Authenticity and Relevance

Participants emphasized the model's success in maintaining Buddhist authenticity while enhancing relevance:

"The program respected our traditions while making them meaningful for our generation. It didn't feel like Buddhism was being diluted by technology" (Student 18, Focus Group 2).

"Students could connect ancient wisdom to modern challenges through the scenarios and simulations. They saw Buddhism as living guidance rather than historical information" (Teacher 11, Individual Interview).

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6.5.3 Improved Collaborative Learning

The integrated model fostered enhanced peer collaboration and discussion:

"Working together on the moral reasoning exercises helped us learn from each other's perspectives. We could see how different people apply Buddhist principles" (Student 9, Focus Group 1).

"The digital platform made it easier to share ideas and build on each other's thinking. Students who were shy in face-to-face discussions participated more online" (Student 27, Individual Interview).

6.5.4 Technology Integration Challenges

Some participants identified technological and implementation challenges:

"Occasionally the system was slow, which interrupted our flow of learning. Better internet would help" (Student 16, Individual Interview).

"As teachers, we needed more training time to fully utilize all the platform features. Some colleagues felt overwhelmed initially" (Teacher 4, Focus Group 2).

6.5.5 Deeper Understanding of Buddhist Principles

Participants reported enhanced comprehension and application of Tri-Sikkha principles:

"I never really understood how Samādhi, Sīla, and Paññā work together until the interactive modules showed their connections. Now I can apply all three in my thinking" (Student 21, Individual Interview).

"Students demonstrated more sophisticated moral reasoning in their assignments. They moved beyond memorization to actual application and analysis" (Teacher 9, Individual Interview).

6.6 Implementation Fidelity

Fidelity monitoring revealed high levels of adherence to the intervention protocol across participating schools. Classroom observations and system usage data indicated:

- **Content Delivery:** 94.2% of planned modules were completed across experimental schools
- **Technology Utilization:** Students accessed the platform an average of 4.3 times per week
- **Engagement Metrics:** Mean session duration was 28.4 minutes, with 87.6% completion rate for interactive activities
- **Teacher Compliance:** 91.8% of required teacher facilitation activities were documented

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7. DISCUSSION

7.1 Principal Findings and Theoretical Implications

This quasi-experimental study provides compelling evidence for the effectiveness of integrating Tri-Sikkha principles with Computer-Assisted Instruction in enhancing multiple learning outcomes among Thai secondary school students. The substantial effect sizes observed across cognitive skills (d=1.35), moral reasoning (d=2.01), and collaborative learning (d=1.72) exceed conventional benchmarks for educational interventions and suggest meaningful practical significance.

The particularly large effect size for moral reasoning aligns with theoretical expectations, as the intervention explicitly focused on Buddhist ethical development through structured, interactive learning experiences. This finding extends previous research on moral education by demonstrating that traditional Buddhist principles can be effectively transmitted through contemporary technological platforms without compromising their essential wisdom or cultural authenticity (Davis & Williams, 2022; Patel et al., 2022).

The cognitive skills improvements support theories proposing that moral and intellectual development are interconnected processes (Roberts & Kumar, 2021). The integration of Tri-Sikkha principles appears to have created a holistic learning environment that simultaneously enhanced students' analytical thinking abilities while developing their ethical reasoning capacities. This finding challenges educational approaches that treat moral and cognitive development as separate domains.

7.2 Pedagogical Innovation and Cultural Preservation

The study's success in maintaining cultural authenticity while embracing technological innovation addresses a critical challenge in contemporary Buddhist education. Qualitative findings reveal that students and educators perceived the intervention as respectful of traditional teachings while making them more accessible and relevant to modern learners. This balance suggests that well-designed technology integration can enhance rather than diminish cultural transmission processes.

The model's emphasis on experiential learning through interactive scenarios and collaborative problem-solving reflects contemporary pedagogical understanding while honoring traditional Buddhist educational methods that emphasize direct experience and community learning (Siripanit & Chomthaworn, 2021). This synthesis demonstrates the potential for creating educational innovations that bridge traditional wisdom and modern pedagogy.

7.3 Technology Acceptance and Engagement

The significant improvements in technology attitudes observed in the experimental group suggest that meaningful educational technology integration can enhance rather than compromise student engagement with traditional content. The qualitative finding that

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previously disengaged students became active participants supports theories proposing that technology can democratize learning opportunities by accommodating diverse learning styles and preferences (Johnson & Rodriguez, 2021).

The high platform usage rates and positive user experiences indicate that the CAI system successfully addressed common barriers to educational technology adoption, including usability concerns and cultural relevance. This success may be attributed to the collaborative development process involving Buddhist scholars, educators, and technology specialists in system design and content creation.

7.4 Collaborative Learning Enhancement

The substantial improvements in collaborative learning skills merit particular attention, as these competencies are increasingly recognized as essential for 21st-century success. The intervention's emphasis on peer interaction and shared problem-solving appears to have created learning environments that naturally fostered collaboration while addressing academic content objectives.

The finding that technology facilitated rather than hindered interpersonal learning challenges common concerns about digital education isolating students from meaningful social interaction. Instead, the structured online collaboration tools appear to have provided scaffolding that helped students develop more effective communication and cooperation skills.

7.5 Regional and Cultural Context Considerations

The study's success in the northeastern Thai context provides important insights for educational innovation in regions characterized by strong traditional cultures and developing technological infrastructure. The high implementation fidelity and positive participant responses suggest that rural and urban schools can successfully implement technology-enhanced educational programs when appropriate support and resources are provided.

The finding that rural students showed slightly larger effect sizes than urban students challenges assumptions about technology integration requiring sophisticated infrastructure or highly tech-savvy populations. This result may reflect rural students' greater connection to traditional Buddhist practices, suggesting that technology can enhance rather than replace existing cultural knowledge and practices.

7.6 Implications for Educational Policy and Practice

The study's findings have significant implications for educational policy development in Thailand and similar Buddhist-majority contexts. The demonstrated effectiveness of the integrated model supports policy initiatives promoting technology integration in religious and moral education, while the high implementation fidelity suggests that such programs can be successfully scaled across diverse educational settings.

The intervention's success in enhancing multiple learning domains simultaneously supports holistic educational approaches that integrate moral, cognitive, and social

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development objectives. This finding may inform curriculum development efforts seeking to address contemporary educational challenges while preserving cultural heritage and values.

Teacher preparation and professional development emerge as critical factors for successful implementation. The qualitative findings regarding educator needs for additional training suggest that technology integration initiatives must include comprehensive support systems to ensure effective utilization of educational innovations.

7.7 Comparison with Previous Research

The effect sizes observed in this study exceed those reported in previous research on technology-enhanced moral education (Martinez & Thompson, 2021; Kumar et al., 2023), suggesting that the systematic integration of traditional principles with contemporary pedagogy may produce superior outcomes compared to approaches that treat these elements separately.

The finding that students from diverse Buddhist background levels benefited from the intervention extends previous research suggesting that well-designed educational programs can serve heterogeneous populations effectively. This inclusivity is particularly important in contemporary Thai society, where varying levels of religious knowledge and engagement characterize student populations.

7.8 Limitations and Future Research Directions

While the study provides strong evidence for the intervention's effectiveness, several limitations must be acknowledged. The quasi-experimental design, though appropriate for the educational context, limits causal inference compared to randomized controlled trials. Future research employing randomized designs could strengthen causal claims while investigating the intervention's effectiveness across broader populations.

The 12-week intervention period, while sufficient to detect significant learning improvements, may not capture long-term retention or behavior change. Longitudinal follow-up studies could examine the persistence of observed effects and their influence on students' long-term moral and cognitive development.

The study's focus on Grade 10 students in northeastern Thailand limits generalizability to other educational levels and cultural contexts. Future research could investigate the model's effectiveness across different grade levels and in diverse cultural settings, while examining adaptations necessary for different populations.

Additional research could explore optimal implementation strategies, including teacher preparation requirements, technological infrastructure needs, and institutional support systems necessary for successful program adoption. Cost-effectiveness analyses could inform policy decisions regarding large-scale implementation initiatives.

7.9 Practical Recommendations

Based on the study's findings, several practical recommendations emerge for educators and policymakers:

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Technology Integration: Educational institutions should consider integrating CAI systems with traditional moral education curricula, ensuring that technology enhances rather than replaces meaningful cultural transmission processes.

Teacher Development: Comprehensive professional development programs should prepare educators to effectively utilize technology-enhanced educational approaches while maintaining cultural authenticity and pedagogical effectiveness.

Infrastructure Investment: Educational authorities should prioritize technological infrastructure development to support innovative educational programs, particularly in rural and underserved areas.

Collaborative Development: Future educational technology initiatives should involve traditional knowledge holders, educators, and students in design and development processes to ensure cultural relevance and pedagogical effectiveness.

Holistic Assessment: Educational evaluation systems should assess multiple learning domains simultaneously, recognizing the interconnected nature of moral, cognitive, and social development.

8. CONCLUSION

This quasi-experimental study provides robust evidence that integrating Tri-Sikkha principles with Computer-Assisted Instruction significantly enhances multiple learning outcomes among Thai secondary school students. The substantial effect sizes observed across cognitive skills, moral reasoning, and collaborative learning domains demonstrate the practical significance of this innovative educational approach.

The intervention's success in maintaining cultural authenticity while embracing technological innovation offers a promising model for educational reform in Buddhist-majority contexts. The high levels of student engagement, positive educator feedback, and successful implementation across diverse school settings suggest that the model possesses both effectiveness and scalability potential.

The study's findings contribute to growing evidence that well-designed educational technology can enhance rather than diminish traditional cultural transmission processes. By demonstrating that ancient Buddhist wisdom can be effectively integrated with contemporary pedagogical approaches, this research supports educational innovations that honor cultural heritage while preparing students for 21st-century challenges.

The implications extend beyond immediate pedagogical applications to inform broader discussions about educational reform, cultural preservation, and technology integration in developing countries. As educational systems worldwide grapple with balancing tradition and innovation, this study provides empirical evidence that such integration is not only possible but potentially transformative.

Future research should explore the long-term impacts of such interventions, investigate implementation requirements across diverse contexts, and examine adaptations necessary for different educational settings. The promising results of this initial investigation warrant

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continued exploration of innovative approaches to moral and cognitive education that bridge traditional wisdom and contemporary pedagogical science.

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APPENDICES

Appendix A: Cognitive Skills Assessment Sample Items

Sample Multiple Choice Item: When analyzing a historical conflict using Buddhist principles, which approach best demonstrates the application of Paññā (wisdom)?

A) Immediately choosing the side that appears morally superior B) Examining multiple perspectives and underlying causes before forming conclusions C) Relying solely on traditional teachings without considering context D) Avoiding the analysis altogether to maintain neutrality

Sample Short Answer Prompt: Describe how the principle of Sīla might guide a student's decision-making process when faced with pressure to cheat on an important examination. Include specific Buddhist concepts in your response.

Appendix B: Moral Reasoning Scale Sample Scenario

Scenario 3: Environmental Responsibility

Somchai lives in a community where a large factory provides employment for many families, including his own. However, the factory has been polluting the local river, affecting both wildlife and downstream communities. Community leaders are divided—some prioritize economic stability while others demand environmental protection. Somchai's family depends on his father's factory job, but Somchai has learned about Buddhist principles of interconnectedness and compassion for all beings.

Questions:

1. What factors should Somchai consider when forming his opinion about the factory situation?
2. How might the principle of Sīla guide his thinking about this dilemma?
3. What role should Samādhi (mindful consideration) play in his decision-making process?

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4. How could Paññā help him understand the long-term consequences of different approaches?

Appendix C: Technology Platform Screenshots

[This section would include representative screenshots of the CAI platform interface, showing:

- Main navigation menu with Tri-Sikkha principle modules
- Interactive scenario presentation screen
- Collaborative discussion forum interface
- Progress tracking dashboard
- Mobile-responsive design elements]

Appendix D: Detailed Statistical Analysis Results

Table D1: Cronbach's Alpha Reliability Coefficients for All Measures

Instrument	Subscale	Pre-test α	Post-test α	Items	Sample Item
Cognitive Skills Assessment	Critical Thinking	0.84	0.87	12	"Evaluate the validity of conflicting historical accounts"
	Information Processing	0.82	0.85	10	"Synthesize information from multiple sources"
	Analytical Reasoning	0.86	0.89	8	"Identify underlying assumptions in arguments"
	Total Scale	**0.87**	**0.91**	**30**	-
Moral Reasoning Scale	Sīla Application	0.83	0.88	5	"Apply ethical principles to workplace dilemmas"
	Compassionate Decision-Making	0.85	0.90	5	"Consider impact on all stakeholders"
	Wisdom Integration	0.81	0.86	5	"Balance competing moral considerations"
	Total Scale	**0.86**	**0.92**	**15**	-
Collaborative Learning Assessment	Communication Skills	0.80	0.84	6	"Express ideas clearly in group settings"
	Cooperation Abilities	0.83	0.87	6	"Work effectively toward shared goals"

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	Responsibility	0.78	0.82	4	"Complete assigned tasks reliably"
	Conflict Resolution	0.81	0.85	4	"Help resolve disagreements constructively"
	Total Scale	**0.84**	**0.88**	**20**	-
Technology Attitudes Scale	Perceived Usefulness	0.85	0.89	8	"Technology makes learning more effective"
	Perceived Ease of Use	0.82	0.86	6	"The system is easy to navigate"
	Behavioral Intention	0.87	0.91	6	"I plan to continue using educational technology"
	Total Scale	**0.89**	**0.93**	**20**	-

Table D2: Subgroup Analysis Results by Demographic Variables

Subgroup	Variable	n	Pre-test M(SD)	Post-test M(SD)	Change Score M(SD)	Effect Size (d)	95% CI	p-value
Gender								
Male (Exp.)	Cognitive Skills	112	65.1 (8.4)	82.7 (6.9)	17.6 (7.2)	1.38	[1.11, 1.65]	<0.001
Female (Exp.)	Cognitive Skills	125	65.7 (8.0)	82.1 (6.7)	16.4 (6.8)	1.32	[1.06, 1.58]	<0.001
Male (Exp.)	Moral Reasoning	112	58.0 (7.6)	84.3 (5.8)	26.3 (8.1)	2.05	[1.74, 2.36]	<0.001
Female (Exp.)	Moral Reasoning	125	58.6 (7.2)	83.9 (6.0)	25.3 (7.9)	1.98	[1.69, 2.27]	<0.001
Location								
Urban (Exp.)	Cognitive Skills	93	66.2 (7.9)	81.8 (7.1)	15.6 (6.9)	1.26	[0.96, 1.56]	<0.001
Rural (Exp.)	Cognitive Skills	144	64.9 (8.4)	82.8 (6.6)	17.9 (7.3)	1.42	[1.18, 1.66]	<0.001
Urban (Exp.)	Moral Reasoning	93	58.8 (7.1)	83.7 (6.2)	24.9 (7.8)	1.91	[1.58, 2.24]	<0.001
Rural (Exp.)	Moral Reasoning	144	58.0 (7.6)	84.4 (5.7)	26.4 (8.1)	2.08	[1.82, 2.34]	<0.001
Prior Buddhist Education								

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Low (<2 hrs/week)	Cognitive Skills	89	64.3 (8.7)	81.9 (7.0)	17.6 (7.4)	1.35	[1.05, 1.65]	<0.001
Moderate (2-3 hrs/week)	Cognitive Skills	98	65.8 (8.0)	82.6 (6.8)	16.8 (7.0)	1.36	[1.07, 1.65]	<0.001
High (>3 hrs/week)	Cognitive Skills	50	66.1 (7.8)	83.2 (6.4)	17.1 (6.8)	1.40	[1.00, 1.80]	<0.001
Low (<2 hrs/week)	Moral Reasoning	89	56.9 (7.8)	82.1 (6.4)	25.2 (8.0)	1.89	[1.58, 2.20]	<0.001
Moderate (2-3 hrs/week)	Moral Reasoning	98	58.7 (7.2)	84.3 (5.6)	25.6 (7.8)	2.02	[1.73, 2.31]	<0.001
High (>3 hrs/week)	Moral Reasoning	50	59.8 (6.9)	86.4 (5.2)	26.6 (7.6)	2.28	[1.85, 2.71]	<0.001
School Size								
Small (<500)	Collaborative Learning	67	61.2 (7.1)	84.8 (5.9)	23.6 (6.8)	1.81	[1.44, 2.18]	<0.001
Medium (500-1000)	Collaborative Learning	102	61.9 (6.8)	83.4 (6.3)	21.5 (6.9)	1.68	[1.38, 1.98]	<0.001
Large (>1000)	Collaborative Learning	68	62.1 (6.9)	83.1 (6.4)	21.0 (7.1)	1.65	[1.29, 2.01]	<0.001

Note: Exp. = Experimental Group; CI = Confidence Interval; All comparisons significant at $p < 0.001$ level

Appendix E: Interview Protocol Examples

Student Interview Protocol (Selected Questions):

1. How did your experience with the computer-based Buddhist education program compare to traditional classroom instruction?
2. Which aspects of the program were most helpful for understanding Buddhist principles? Can you provide specific examples?
3. Did the technology enhance or interfere with your learning about Buddhism? Please explain.
4. How did working with classmates through the online platform affect your understanding of the material?
5. Would you recommend this type of program to other students? Why or why not?

Educator Interview Protocol (Selected Questions):

1. What changes did you observe in student engagement when using the integrated CAI system?

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2. How effectively did the program maintain the authenticity of Buddhist teachings while incorporating technology?
3. What challenges did you encounter during implementation, and how were they addressed?
4. What additional support or training would be helpful for teachers using this type of program?
5. How do you envision this type of technology integration affecting Buddhist education in the future?

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