

RESEARCH ARTICLE

Ubiquitous Collaborative Learning Applications: Driving Gender-Inclusive Success in Computer Education

Krittawaya Thongkoo¹  and Kannika Daungcharone^{1,*} 

¹College of Arts, Media and Technology, Chiang Mai University, Chiang Mai 50200, Thailand

*Corresponding author: Kannika Daungcharone, kannika.d@cmu.ac.th

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Abstract

This study explores the transformative potential of ubiquitous collaborative learning applications in fostering gender-inclusive success in computer education. Persistent gender disparities in STEM fields, particularly in computing, highlight the need for innovative educational approaches that ensure equitable access and engagement. This research evaluates how these applications enhance learning achievement and perceptions equitably across genders, providing a promising pathway to address longstanding challenges in education. A mixed-methods approach was employed, involving 226 undergraduate computing students from northern Thailand. Data collected through pre- and post-tests and surveys revealed significant improvements in learning achievement for the experimental group, with no notable gender differences in outcomes. Additionally, students in the experimental group reported higher satisfaction with the application's user interface, perceived usefulness, ease of use, and overall learning experience than those in the control group. The findings underscore the capacity of ubiquitous collaborative learning applications to support inclusive and equitable education, addressing gender disparities while improving educational outcomes. The implications of this study are significant, highlighting the importance of leveraging innovative educational technologies to foster engagement, reduce inequities, and prepare students for the demands of the digital era.

1. Introduction

The integration of ubiquitous collaborative applications into computer education offers significant potential to foster sustainable development and address enduring gender disparities in learning achievement and perceptions. Despite advancements in educational technology, gender gaps in STEM fields persist, particularly in computer education, limiting diversity and innovation in the workforce (Silva et al., 2021; Bairoh, 2023; Costa et al., 2024). These disparities often lead to a less diverse talent pool, which can hinder innovation and limit the full potential of technological advancements. Traditional educational strategies have frequently proven insufficient in effectively engaging and retaining female students in computing, thereby perpetuating this imbalance in representation (MIT Professional Education, 2023; Pavlov, 2024). These challenges often stem from pervasive societal stereotypes, a

lack of visible female role models, and pedagogical approaches that may inadvertently alienate female learners, leading to lower self-efficacy and reduced interest in the field (Chan, 2022). Consequently, female students frequently report a lack of belonging and confidence within male-dominated computing environments, contributing to higher attrition rates from these programs (Yates and Plagnol, 2022). Understanding how these disparities can be mitigated through inclusive and adaptive learning tools is essential to promoting equity and preparing diverse learners for success in the digital age. While skepticism exists regarding the focus on gender differences in technological learning environments, the persistence of these inequities highlights the urgency of such investigations.

Ubiquitous learning, characterized by seamless access to educational resources at any time and place, has emerged as a cornerstone of contemporary education. It provides flexibility and accessibility, enabling

students to learn at their own pace while revisiting content as needed. Recent studies suggest that integrating sustainable software development concepts and emphasizing mathematical logic in computer education curricula can make the field more attractive to female students, addressing gender imbalances (Silva et al., 2021). Additionally, the rapid evolution of educational technologies has created dynamic, interactive, and personalized learning environments that significantly enhance student engagement and academic outcomes (Zabolotska et al., 2021; Schmid and Petko, 2019; Kaur, 2018; Pavlov, 2024). These advancements not only transform learning environments but also necessitate the development of innovative methodological and theoretical frameworks to critically analyze the role of technology in education. As Castaneda and Williamson (2021) argue, new research toolboxes are required to better understand the sociotechnical and political dynamics of educational technologies and their broader implications.

When combined with collaborative methods, ubiquitous learning fosters interactive and engaging educational experiences that are critical to modern education (Srivastava et al., 2021; Aithal and Aithal, 2023). Ubiquitous learning applications, leveraging mobile and internet technology, not only offer immediate access to instructional content but also promote collaboration and personalization (Tham and Verhulsdonck, 2023; Elsafi, 2020). These tools enable continuous interaction between real-world and digital environments, offering situation-specific resources and opportunities for active participation in problem-solving projects (Virtanen et al., 2018; Chin et al., 2018; Pimmer et al., 2016). Rooted in social constructivism, collaborative learning emphasizes social interactions and teamwork as essential for knowledge acquisition, further enhancing its educational benefits (Ho et al., 2017; Saleem et al., 2021). Research demonstrates that integrating collaborative learning into ubiquitous learning environments significantly improves academic performance and critical thinking skills (Wu, 2020; Lin and Wang, 2024). The COVID-19 pandemic further accelerated the adoption of these technologies, highlighting the need for adaptable and intuitive platforms to overcome challenges posed by physical distance and cater to diverse learning preferences (Liao et al., 2015; Abdullah et al., 2024; Parthasarathy et al., 2025). Despite these advances, limited research has explored how ubiquitous collaborative applications address gender disparities in educational outcomes, particularly in computer education.

The primary objective of this study is to examine the differences in learning achievement and perceptions between male and female students using a collaborative learning application in computer education. Employing a mixed-methods approach, this research evaluates the application's effectiveness among undergraduate computing students across three universities in northern Thailand. Assessment techniques, including pre- and

post-tests, grading rubrics, and surveys, were utilized to provide a comprehensive understanding of the application's impact (Garlinska et al., 2023). This investigation aims to contribute to the growing body of knowledge on educational technology by exploring how collaborative learning tools can reduce gender disparities and improve student outcomes in computer education (Haleem et al., 2022). Ultimately, this study underscores the transformative potential of ubiquitous collaborative learning applications to create inclusive and equitable educational environments. By addressing persistent gender gaps and enhancing teaching and learning methods, these tools can play a pivotal role in preparing students for the challenges and opportunities of the digital age (Borgonovi et al., 2023).

2. Related Work

2.1 Ubiquitous Learning in Higher Education

Ubiquitous learning, or u-learning, is characterized by its flexibility and accessibility, allowing learners to engage with educational content anytime and anywhere via mobile devices and internet connectivity. This approach integrates seamlessly into daily life, ensuring that students can access context-aware and personalized learning experiences that cater to their unique needs and schedules (Qurat-ul-Ain et al., 2019; Cárdenas-Robledo and Peña-Ayala, 2018). As mobile technologies, cloud computing, and the Internet of Things (IoT) have evolved, u-learning environments have become more sophisticated, offering real-time adaptive content delivery and interaction (Hwang, 2014; Aljawarneh, 2020).

The benefits of u-learning are significant, ranging from improved engagement to enhanced knowledge retention. By enabling learners to revisit materials at their own pace, u-learning promotes deeper understanding and supports students with diverse learning styles (Matthew et al., 2021; Chen and Huang, 2012). Interactive technologies, such as multimedia platforms and social media, further enhance this approach by fostering collaboration and peer interaction, which are essential for sustained engagement and knowledge sharing (Gómez et al., 2014).

However, implementing u-learning environments presents challenges. Technological limitations, particularly in remote or underserved regions, exacerbate the digital divide and impede equitable access to these tools. Additionally, designing effective u-learning environments requires specialized skills and considerable effort, particularly when adapting content for mobile platforms (Matthew et al., 2021). Addressing these challenges is critical to maximizing the potential of u-learning for creating inclusive educational environments.

2.2 Collaborative Learning Theories and Models

Collaborative learning is a transformative educational approach that emphasizes the social aspects of learning by fostering a sense of community. In this model, students work together to solve problems, complete tasks, or create products, promoting active engagement and shared knowledge construction. The foundation of collaborative learning is rooted in several influential learning theories, including Vygotsky's Social Constructivism, Piaget's Constructivist Learning Theory, and Bandura's Social Learning Theory (Ullah and Anwar, 2020).

Vygotsky's concept of the Zone of Proximal Development (ZPD) highlights the space between what learners can achieve independently and what they can accomplish with guidance from more knowledgeable peers or instructors. In collaborative settings, peer support bridges this gap, allowing for shared exploration and understanding (Zajda, 2021). Additionally, Vygotsky emphasized the role of dialogue and social interaction in fostering cognitive development, where learners internalize knowledge through cooperative processes. Similarly, Piaget's constructivist theory focuses on active engagement, where learners construct knowledge through interaction with their environment. Collaborative environments facilitate this process by enabling hands-on activities and discussions, which deepen understanding and refine problem-solving skills (McPeake et al., 2019). Bandura's Social Learning Theory adds another layer, emphasizing observational learning, where learners acquire skills and strategies by observing and modeling the behavior of their peers. This dynamic interplay of guidance and imitation creates an enriching collaborative learning environment.

Collaborative learning can take both structured and unstructured forms. Cooperative learning, a subset of collaborative learning, involves structured group activities in which each member has a defined role, promoting accountability and interdependence. Examples include Jigsaw, Think-Pair-Share, and Group Investigation. These activities are designed to enhance group cohesion, foster positive social interaction, and ensure that every member contributes to the group's success. On the other hand, collaborative learning often emphasizes less structured approaches that focus on exploring meaningful questions and solving complex problems together. Examples include problem-based learning (PBL), collaborative writing, and online discussion forums. Both models encourage shared goals, mutual engagement, and the critical negotiation of meaning, making them effective tools for fostering a deeper understanding of concepts.

The benefits of collaborative learning are multifaceted. It significantly enhances critical thinking and problem-solving skills by engaging students in rigorous discussions and negotiations, helping them refine

their analytical abilities (Pardjono, 2002). Communication skills, such as active listening, articulation, and constructive feedback, are also improved, preparing students for both academic and professional challenges. Furthermore, collaborative learning promotes knowledge retention by encouraging active participation and providing opportunities for students to explain concepts and address misconceptions (Loes and Pascarella, 2017).

Despite its numerous benefits, implementing collaborative learning effectively requires addressing several challenges. Group dynamics, such as managing conflicts or balancing participation, can affect the success of collaborative activities. Additionally, assessing individual contributions and group performance can be complex, requiring well-designed evaluation methods. Technology plays a pivotal role in overcoming these challenges by providing tools to facilitate communication, manage resources, and ensure equitable participation (Erkens and Bodemer, 2019). However, educators must ensure that all students have access to these tools and possess the necessary proficiency to use them effectively.

Supported by robust theoretical frameworks and practical models, collaborative learning remains a powerful approach for fostering critical thinking, communication skills, and knowledge retention. To maximize its effectiveness, educators must engage in careful planning, provide facilitation, and implement assessments that address the unique challenges of group work and technology integration. These efforts can ensure that collaborative learning becomes a cornerstone of inclusive and effective education.

2.3 Integration of Ubiquitous and Collaborative Learning

The integration of ubiquitous and collaborative learning combines two transformative educational paradigms, creating dynamic, flexible, and inclusive learning environments that cater to diverse student needs. By blending the continuous, context-aware access of ubiquitous learning with the interactive, social nature of collaborative learning, this approach significantly enhances educational experiences and outcomes. Ubiquitous learning ensures that students can access resources anytime and anywhere, supporting participation in group activities and discussions among diverse and dispersed teams (Jeong and Hmelo-Silver, 2016). Collaborative learning, in turn, fosters social interaction and teamwork, amplifying engagement and motivation in digital learning spaces (Thongkoo et al., 2019). This integration is particularly effective in enabling real-time collaboration, such as problem-based learning (PBL), where students tackle complex, real-world problems using a combination of data, tools, and group dynamics. Research by Vallejo-Correa et al. (2021) and Barbosa et al. (2014) highlights how decentralized collaborative platforms enhance student engagement and per-

formance in higher education by facilitating flexible and continuous interaction regardless of location. Similarly, Karakaya and Bozkurt (2022) demonstrated that combining mobile and ubiquitous learning with collaborative approaches significantly enhances learning outcomes by offering personalized and interactive experiences.

For successful integration, robust technological infrastructure is critical, including reliable internet access and user-friendly platforms that ensure equitable participation (Farhan et al., 2019). Instructional design plays an equally vital role, as activities must be tailored for mobile platforms to promote meaningful interaction and provide personalized feedback. Educators must also navigate challenges such as ensuring consistent participation, managing group dynamics, and designing assessment strategies that account for both individual and group contributions (Grant, 2019). By leveraging the strengths of both ubiquitous and collaborative learning, educators can create learning environments that are flexible, interactive, and inclusive, particularly in computer education. These approaches not only foster personalized learning and real-world problem-solving skills but also address equity concerns by providing access and engagement opportunities for diverse student populations. However, addressing infrastructure and instructional challenges is essential to fully unlock the potential of these integrated methodologies.

2.4 Gender Differences in Learning Achievement and Perceptions

Despite efforts to promote inclusivity, gender disparities in STEM education, particularly in computer education, persist, making it imperative to explore innovative solutions. Evidence indicates that male students often outperform female students in computer education courses due to factors such as prior exposure, higher self-efficacy, and societal expectations (El-Hamamsy et al., 2023). Male students typically have more experience with programming and technology before entering formal education, giving them a distinct advantage in related subjects (Chan, 2022). The integration of ubiquitous collaborative learning applications has shown promise in mitigating these disparities. By creating flexible, accessible, and engaging learning environments, these applications cater to the diverse needs of students, allowing them to learn at their own pace while promoting active collaboration. These tools support equitable participation by fostering inclusive teamwork and providing personalized feedback, thereby helping reduce barriers faced by underrepresented groups.

Research also suggests that strategies such as incorporating sustainable software development and logical reasoning into computer education courses can make the field more appealing to female students (Alamri et al., 2021). Additionally, the use of interactive and adaptive learning technologies helps improve both the per-

ceptions and achievements of female students, offering opportunities for real-time engagement and peer collaboration (Alamri et al., 2021). Addressing gender disparities requires a holistic approach, encompassing the design of inclusive educational environments, targeted interventions, and the effective use of technology to personalize learning experiences. Ubiquitous collaborative learning applications provide a powerful framework for reducing inequities by combining the accessibility of ubiquitous learning with the social benefits of collaboration. These applications empower students of all genders to succeed by promoting teamwork, critical thinking, and self-directed learning, which are essential for thriving in STEM fields (Castaneda and Williamson, 2021). This research underscores the transformative potential of ubiquitous collaborative learning applications in addressing gender gaps in computer education. By fostering equitable access and engagement, these tools can play a pivotal role in reshaping perceptions and improving outcomes for all students, preparing them to excel in the digital era.

3. Novelty and Key Contribution

This study makes significant contributions to the field of educational technology by addressing gender disparities in computer education through the lens of ubiquitous collaborative learning applications. Unlike previous research that has largely examined the benefits of ubiquitous and collaborative learning in isolation, this study uniquely integrates these approaches and investigates their combined impact on gender differences in learning outcomes and perceptions. This focus bridges an important gap in the literature, particularly in STEM education, where gender inequities remain a critical issue. By examining how a ubiquitous collaborative learning application influences academic performance, engagement, and perceptions, this research offers a transformative perspective on the role of technology in promoting equity in education. The study explores whether these tools can mitigate or exacerbate gender disparities, providing empirical evidence to guide educators and policymakers in designing inclusive learning environments that cater to diverse learners.

Grounded in social constructivist theories, the study emphasizes the importance of collaboration and interaction in knowledge acquisition. This theoretical foundation is combined with the advancements of ubiquitous learning technologies, which provide personalized, flexible, and context-aware learning experiences. By merging these paradigms, the research highlights the potential of educational technologies to create dynamic and inclusive environments that address gender-specific challenges in STEM fields. The findings from this study have the potential to transform computer education by offering actionable insights into how gender differences manifest and can be addressed in technology-enhanced

learning environments. By demonstrating the effectiveness of ubiquitous collaborative learning applications in fostering equitable learning outcomes, this research contributes to the ongoing discourse on gender inclusivity in computer education. It also underscores the broader societal benefits of reducing gender gaps in STEM, where increased diversity has been linked to innovation and productivity gains.

This research not only extends the theoretical understanding of ubiquitous collaborative learning but also offers practical implications for implementing these technologies in ways that promote gender-inclusive success. By addressing critical challenges in computer education, the study highlights the transformative potential of educational technology to foster equity and empower diverse learners in the digital age.

In summary, the burgeoning fields of ubiquitous and collaborative learning offer transformative avenues for modern education by providing flexible, engaging, and socially interactive environments. While individually effective, their integration presents a powerful framework for enhancing learning experiences, particularly in computer education (Lin and Wang, 2024). However, despite these technological and pedagogical advancements, persistent gender disparities in computer education continue to limit diversity and innovation in the workforce. This body of literature highlights a critical need to explore how integrated learning applications can effectively mitigate long-standing gender inequities, paving the way for more inclusive and equitable educational outcomes for all students (Borgonovi et al., 2023).

4. Research Methodology

4.1 Participants

Participants were selected from three universities in northern Thailand. All were enrolled in computer education-related courses and had no prior experience with HTML or PHP programming. A total of 226 students participated in the study. These students were drawn from Maejo University ($n = 43$, comprising 14 female and 29 male students), Mae Fah Luang University ($n = 88$, with 52 female and 36 male students), and Chiang Mai University ($n = 95$, consisting of 45 female and 50 male students). To ensure an unbiased distribution, participants were randomly assigned to either the experimental group (EG) or the control group (CG) using a computerized randomization method. The EG, comprising 116 students, learned through the novel approach of the ubiquitous collaborative learning (UCL) application. Meanwhile, the CG, consisting of 110 students, used an online support system combined with traditional learning methods (OSTL).

The sample size was determined through a power analysis to ensure sufficient statistical power for detecting meaningful differences between the groups. Random assignment controlled for potential confounding

variables, thereby enhancing the internal validity and reliability of the study. Moreover, the demographic and baseline characteristics of both groups were analyzed to confirm that the groups had comparable starting points.

4.2 Measuring Tools

The study employed various instruments to assess knowledge acquisition and perceptions. To evaluate students' understanding of PHP programming, pre-test and post-test knowledge tests were developed by three programming experts. These tests, comprising 15 multiple-choice questions on user-defined and built-in functions, awarded one point for each correct answer, with a maximum score of 15. To minimize test-related biases, the pre-test and post-test covered identical content areas but used different questions. The tests demonstrated acceptable internal reliability, with a Kuder-Richardson Formula 20 (KR-20) coefficient of 0.75, and content validity was ensured through expert review to align the test items with the intended learning objectives.

Additionally, a perception questionnaire adapted from Liaw's model (Liaw, 2008) was utilized to gather demographic data and evaluate students' perceptions of the learning activities. The 19-item questionnaire employed a five-point Likert scale (1 = "strongly disagree" to 5 = "strongly agree") and covered five dimensions: User Interface Design (3 items, Cronbach's alpha = 0.81), Perceived Usefulness (6 items, Cronbach's alpha = 0.88), Perceived Ease of Use (5 items, Cronbach's alpha = 0.70), Attitudes toward Learning (3 items, Cronbach's alpha = 0.86), and Intention to Use (2 items, Cronbach's alpha = 0.89). With an overall Cronbach's alpha of 0.89, the questionnaire exhibited strong internal consistency, ensuring a reliable evaluation of students' perceptions.

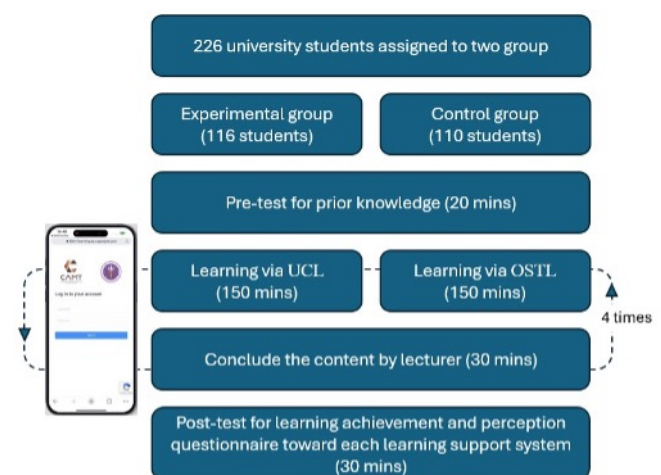


Figure 1. Outlines the experimental procedure and the sequence of activities.

4.3 Experimental Procedure

The study employed a structured experimental procedure, illustrated in Fig. 1, to compare the effectiveness of the learning approaches. Initially, all participants completed a demographic survey and a 30-minute pre-test to assess their baseline knowledge of HTML and PHP programming, ensuring that any improvements observed could be attributed to the instructional intervention. Following the pre-test, all students received a 20-minute interactive introductory lesson, which laid the groundwork for the subsequent learning phases.

The main instructional phase of the study comprised four distinct sessions. Each session consisted of approximately 150 minutes of primary learning activities, followed by a 30-minute instructor-led conclusion and review of the content covered. The experimental group (EG) utilized the ubiquitous collaborative learning (UCL) application, which included features such as real-time individual and group code editors, annotation tools, and live chat functionalities designed to promote dynamic collaboration and engagement. Conversely, the control group (CG) followed traditional learning methods supplemented by an online support system offering static resources and asynchronous communication tools. The same instructor delivered all sessions to both groups to ensure consistency and minimize instructor-related biases. The specific learning activities and content delivery for each session were as follows:

Session 1: Introduction to Basic Concepts (HTML Structure and PHP Syntax)

UCL Group: Students accessed foundational modules on HTML structures and basic PHP syntax through the UCL application. Activities included interactive tutorials, short quizzes, and initial collaborative exercises focused on simple code snippets, allowing real-time peer feedback within the application's shared workspace.

OSTL Group: Learning commenced with instructor-led lectures covering HTML basics and introductory PHP concepts. In-class exercises were completed individually, with the online support system (OSTL) providing supplementary reading materials and a basic discussion forum for questions, but offering limited collaborative functionality.

Session 2: Intermediate Programming and Logic (HTML Forms and PHP Conditionals)

UCL Group: The UCL application guided students through more advanced HTML forms, data handling using PHP, and an introduction to conditional statements. Collaborative tasks involved pair-programming challenges and group problem-solving activities using the application's integrated code editor and communication features.

OSTL Group: This session involved lectures on intermediate HTML and PHP concepts, followed by individual practice exercises. The OSTL primarily served as a repository for additional examples and a submission portal for assignments, with instructor feedback

provided after class.

Session 3: Dynamic Content and Database Interaction (PHP and MySQL Basics)

UCL Group: Students explored dynamic content generation and fundamental database interaction using PHP and MySQL directly within the UCL environment. Collaborative projects focused on developing small interactive web pages that retrieved or stored data, with continuous peer and instructor interaction facilitated through the application.

OSTL Group: Lectures covered dynamic web content and the theoretical aspects of database connectivity. Practical activities involved instructor-led examples and individual assignments requiring students to configure their local development environments without integrated collaborative tools, relying on the OSTL for resource access and assignment submission.

Session 4: Project-Based Application and Debugging (Comprehensive Web Application)

UCL Group: The final session centered on a comprehensive project in which groups developed a simple web application integrating all previously learned concepts. The UCL platform supported all stages of development, from planning and coding to debugging and peer review, fostering a highly interactive and adaptive learning process.

OSTL Group: Students completed a larger individual project that required the application of HTML and PHP concepts learned throughout the course. The OSTL provided project specifications and facilitated assignment submission; however, debugging and problem-solving activities were conducted primarily on an individual basis, with limited real-time collaborative support.

Following the completion of all four learning sessions, students participated in a 30-minute post-test to assess knowledge acquisition across the entire curriculum. Subsequently, they completed a 40-minute perception survey designed to evaluate their experiences with the learning activities and to provide insights into the effectiveness of the UCL application compared with traditional learning methods.

5. Experimental Results

5.1 Gender Differences in Learning Achievement

Pre-test and post-test results for the experimental group (EG) and control group (CG) were analyzed. Pre-test scores indicated comparable baseline knowledge across genders and groups, with no statistically significant differences ($p > 0.05$), as shown in Table 1. However, post-test results revealed significant improvement in both groups, with the EG outperforming the CG.

Table 1. Summarizes the results for pre-test and post-test scores across genders and groups (mean $\pm$ SD).

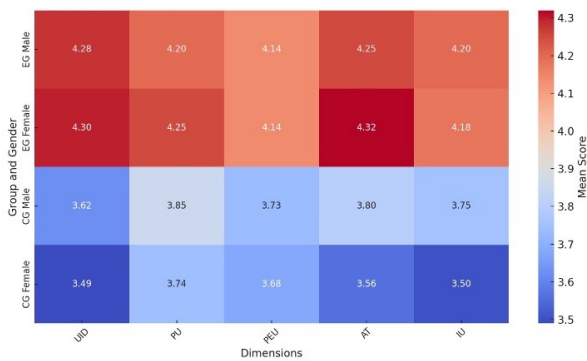
Gender	Group	Pre-Test	Post-Test	Diff.	<i>p</i> -value
Male	EG	6.03 $\pm$ 1.87	10.25 $\pm$ 2.40	+4.22	< 0.001
Female	EG	6.12 $\pm$ 1.75	10.07 $\pm$ 2.07	+3.95	< 0.001
Male	CG	6.02 $\pm$ 1.90	7.88 $\pm$ 2.29	+1.86	< 0.001
Female	CG	6.48 $\pm$ 2.01	8.07 $\pm$ 1.93	+1.59	< 0.001

An independent-samples t-test comparing post-test scores between the EG and CG revealed a significant difference ($p < 0.001$), with an effect size (Cohen's d) of 1.02, indicating a large practical impact.

A two-way MANOVA examining the effects of gender, group membership, and their interaction revealed that group membership significantly influenced learning achievement ($p < 0.001$), with the experimental group (EG) consistently outperforming the control group (CG). Gender did not have a significant effect on learning achievement ($p = 0.44$), indicating no gender-based differences in outcomes. Furthermore, the interaction between gender and group was also non-significant ($p = 0.73$), suggesting that the effectiveness of the intervention was consistent across genders. These findings highlight the effectiveness of the ubiquitous collaborative learning application in enhancing learning outcomes for all students, regardless of gender.

5.2 Gender Differences in Learning Perceptions

Students' perceptions of the learning experience were evaluated using a questionnaire comprising five dimensions: User Interface Design (UID), Perceived Usefulness (PU), Perceived Ease of Use (PEU), Attitude Toward Learning (AT), and Intention to Use (IU).

**Figure 2.** Heat map of perception scores across dimensions, emphasizing differences between EG and CG.

A heat map Fig. 2 illustrates higher scores across all perception dimensions for the EG than for the CG. Within the EG, female students reported slightly higher mean scores than male students across most dimensions.

Table 2. Summarizes mean scores across dimensions by gender and group (mean $\pm$ SD).

Dimension	Group	Gender	Mean $\pm$ SD
UID	EG	Male	4.28 $\pm$ 0.75
	EG	Female	4.30 $\pm$ 0.75
	CG	Male	3.62 $\pm$ 0.55
	CG	Female	3.49 $\pm$ 0.68
PU	EG	Male	4.20 $\pm$ 0.67
	EG	Female	4.25 $\pm$ 0.67
	CG	Male	3.85 $\pm$ 0.58
	CG	Female	3.74 $\pm$ 0.58
PEU	EG	Male	4.14 $\pm$ 0.70
	EG	Female	4.14 $\pm$ 0.70
	CG	Male	3.73 $\pm$ 0.55
	CG	Female	3.68 $\pm$ 0.65
AT	EG	Male	4.25 $\pm$ 0.78
	EG	Female	4.32 $\pm$ 0.77
	CG	Male	3.80 $\pm$ 0.60
	CG	Female	3.56 $\pm$ 0.62
IU	EG	Male	4.20 $\pm$ 0.70
	EG	Female	4.18 $\pm$ 0.70
	CG	Male	3.75 $\pm$ 0.62
	CG	Female	3.50 $\pm$ 0.69

Table 2 summarizes the mean perception scores across the five evaluated dimensions by group and gender. Students in the experimental group (EG) reported higher mean scores than those in the control group (CG) for all dimensions. Female students in the EG showed slightly higher mean scores than male students in most dimensions; however, these differences were small.

The two-way MANOVA results revealed that group membership significantly influenced perception scores across all dimensions ($p < 0.001$), whereas gender did not have a significant effect on perceptions ($p = 0.71$), nor was there a significant interaction between gender and group ($p = 0.58$). These findings indicate that the learning application was positively received by all students, regardless of gender, demonstrating its inclusivity and gender-neutral user experience.

5.3 Summary of Findings

The findings demonstrate that the ubiquitous collaborative learning application significantly enhanced learning achievement and perceptions, with a large effect size indicating substantial practical significance. Importantly, no significant gender-based differences were observed in either learning outcomes or perceptions, supporting the inclusivity of the tool and its potential to promote equity in computer education.

6. Discussion

The findings from this study provide valuable insights into the role of ubiquitous collaborative learning applications in computer education, particularly in enhancing learning achievement, perceptions, and engagement

while addressing gender differences. The results demonstrate that the application significantly improved learning achievement in the experimental group compared to the control group, with no significant gender-based differences in outcomes. This finding is particularly significant as it validates UCL applications as highly effective pedagogical tools, surpassing traditional methods, consistent with previous research on technology-enhanced collaborative learning environments (e.g., Lin and Wang (2024); Karakaya and Bozkurt (2022)). More critically, the absence of gender-based disparities in learning outcomes directly addresses a vital challenge in STEM education, aligning with the aspirational goals of gender equity and showing a promising divergence from studies that often report persistent gender gaps in computing achievement (e.g., Chan (2022)). This suggests that the UCL application successfully creates an equitable learning playing field. This highlights the application's ability to bridge gender gaps in learning achievement, making it an inclusive tool that supports the academic success of all students, irrespective of gender.

Furthermore, students in the experimental group reported higher perceptions across all dimensions—User Interface Design (UID), Perceived Usefulness (PU), Perceived Ease of Use (PEU), Attitude Toward Learning (AT), and Intention to Use (IU)—than those in the control group. These uniformly higher perceptions are significant as they indicate strong user acceptance and satisfaction, which are crucial for the sustainable adoption and long-term effectiveness of any educational technology, resonating with the principles of technology acceptance models. While male and female students expressed similar overall perceptions, female students in the experimental group consistently rated dimensions such as UI and PU slightly higher, suggesting a particular appreciation for the application's supportive and interactive features, such as real-time collaboration and instant feedback. This subtle but important nuance aligns with qualitative findings suggesting that female learners often value supportive, interactive, and collaborative learning environments more intensely in computing contexts (e.g., Yates and Plagnol (2022)). These findings suggest that the application fostered an engaging and motivating learning environment for all students, with no evidence of gender bias.

Theoretically, the results align with Vygotsky's Zone of Proximal Development (ZPD) ((Yousif, 2025; Rahman, 2024), demonstrating how technology-enhanced collaborative learning environments can provide scaffolding that supports equitable knowledge acquisition. This alignment is further supported by research highlighting how interactive and collaborative platforms facilitate deeper learning and skill development through social interaction (e.g., (Wu, 2020; Srivastava et al., 2021)). The lack of significant interaction effects between gender and group in the MANOVA reinforces the inclusivity of the tool, affirming its potential to create a welcoming and supportive learning space that promotes

equitable participation and outcomes. This finding is especially crucial as it challenges the pervasive notion of inherent gender biases in technological learning, providing empirical evidence that well-designed ubiquitous collaborative applications can effectively neutralize such disparities (Borgonovi et al., 2023; El-Hamamsy et al., 2023). In conclusion, the findings highlight the effectiveness of ubiquitous collaborative learning applications in enhancing learning achievement and perceptions without introducing gender bias. By catering equally to the diverse needs of male and female students, these tools offer a balanced and inclusive approach to computer education. This underscores their potential to foster equitable and effective learning experiences, making them valuable assets in addressing persistent disparities in STEM education.

7. Conclusion

Integrating ubiquitous collaborative learning applications into computer education has demonstrated significant potential to enhance learning outcomes and improve student perceptions, particularly in addressing gender disparities. Statistical analysis highlights these applications as inclusive tools that cater to diverse student needs, fostering equity in education. By creating engaging, flexible, and context-aware learning environments, these tools empower educators to support students across genders effectively. However, their full potential depends on overcoming challenges such as ensuring equitable access to infrastructure and equipping educators with the necessary training.

Policymakers and educational leaders should prioritize the adoption of these applications, especially in underserved areas, by investing in reliable technological infrastructure and professional development for educators. Future research should expand beyond gender to explore demographic factors such as socioeconomic status, cultural diversity, and educational backgrounds. Longitudinal studies are needed to evaluate long-term impacts and explore how emerging technologies such as AI and augmented reality can further personalize learning experiences. Researchers should also examine innovative pedagogical strategies—such as collaboration, gamification, and adaptive learning—and their integration with ubiquitous technologies to maximize educational outcomes. Addressing these areas will help advance inclusive and equitable education systems that meet the diverse needs of students in the digital age.

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CRediT Authorship Contribution Statement

Krittawaya Thongkoo: Conceptualization, Methodology, Software, Validation, Investigation, Resources, Data curation, Visualization, Funding acquisition, Writing – original draft. **Kannika Daungcharone:** Conceptualization, Methodology, Formal analysis, Validation, Investigation, Resources, Writing – review & editing.

Declaration of Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- Abdullah, W. D., Afikah, A., Apino, E., Supahar, and Jumadi (2024). Moderator effect of mobile learning on students' achievement in physics: A meta-analysis. *Journal of Baltic Science Education*, 23(2):187–207. DOI: 10.33225/jbse/24.23.187.
- Aithal, P. S. and Aithal, S. (2023). Stakeholders' analysis of the effect of ubiquitous education technologies on higher education. *International Journal of Applied Engineering and Management Letters*, 7(2):102–133. DOI: 10.47992/IJAEML.2581.7000.0177.
- Alamri, H. A., Watson, S., and Watson, W. (2021). Learning technology models that support personalization within blended learning environments in higher education. *TechTrends*, 65(1):62–78. DOI: 10.1007/s11528-020-00530-3.
- Aljawarneh, S. A. (2020). Reviewing and exploring innovative ubiquitous learning tools in higher education. *Journal of Computing in Higher Education*, 32(1):57–73. DOI: 10.1007/s12528-019-09207-0.
- Bairoh, S. (2023). *The gender(ed) gap(s) in STEM: Explaining the persistent underrepresentation of women in STEM careers*. PhD thesis, Hanken School of Economics. Doctoral thesis, <https://helda.helsinki.fi/items/f7d00e3c-db5b-4686-9a16-ebacca064ed5>.
- Barbosa, J. L. V., Barbosa, D. N. F., Rigo, S. J., de Oliveira, J. M., and Rabello, S. A. J. (2014). Integrating collaborative and decentralized models to support ubiquitous learning. *International Journal of Information and Communication Technology Education*, 10(3):77–86. DOI: 10.4018/ijicte.2014070106.
- Borgonovi, F., Han, S. W., and Greiff, S. (2023). Gender differences in collaborative problem-solving skills in a cross-country perspective. *Journal of Educational Psychology*, 115(5):747–766. DOI: 10.1037/edu0000788.
- Cárdenas-Robledo, L. A. and Peña-Ayala, A. (2018). Ubiquitous learning: A systematic review. *Telematics and Informatics*, 35(1):1097–1132. DOI: 10.1016/j.tele.2018.01.009.
- Casta neda, L. and Williamson, B. (2021). Assembling new toolboxes of methods and theories for innovative critical research on educational technology. *Journal of New Approaches in Educational Research*, 10(1):1–14. DOI: 10.7821/naer.2021.1.703.
- Chan, R. C. H. (2022). A social cognitive perspective on gender disparities in self-efficacy, interest, and aspirations in science, technology, engineering, and mathematics (STEM): the influence of cultural and gender norms. *International Journal of STEM Education*, 9:37. DOI: 10.1186/s40594-022-00352-0.
- Chen, C.-C. and Huang, T.-C. (2012). Learning in a u-Museum: Developing a context-aware ubiquitous learning environment. *Computers & Education*, 59(3):873–883. DOI: 10.1016/j.compedu.2012.04.003.
- Chin, K.-Y., Lee, K.-F., and Chen, Y.-L. (2018). Using an interactive ubiquitous learning system to enhance authentic learning experiences in a cultural heritage course. *Interactive Learning Environments*, 26(4):444–459. DOI: 10.1080/10494820.2017.1341939.
- Costa, L. F. C., Nascimento, L. M. A., de Lima, Y. O., Santos, A. M., Barbosa, C. E., Xexéo, G., and de Souza, J. M. (2024). Women's journey in stem education in Brazil: A rapid review on engineering and computer science. *IEEE Access*, 12:112576–112593. DOI: 10.1109/ACCESS.2024.3442879.
- El-Hamamsy, L., Bruno, B., Audrin, C., Chevalier, M., Avry, S., Zufferey, J. D., and Mondada, F. (2023). How are primary school computer science curricular reforms contributing to equity? Impact on student learning, perception of the discipline, and gender gaps. *International Journal of STEM Education*, 10:60. DOI: 10.1186/s40594-023-00438-3.
- Elsafi, A. (2020). Augmented strategies for mobile and ubiquitous learning technologies. In Yu, S., Ally, M., and Tsinakos, A., editors, *Emerging Technologies and Pedagogies in the Curriculum*, pages 245–260. Springer Singapore. DOI: 10.1007/978-981-15-0618-5_15.
- Erkens, M. and Bodemer, D. (2019). Improving collaborative learning: Guiding knowledge exchange through the provision of information about learning partners and learning contents. *Computers & Education*, 128:452–472. DOI: 10.1016/j.compedu.2018.10.009.

- Farhan, W., Razmak, J., Demers, S., and Laflamme, S. (2019). E-learning systems versus instructional communication tools: Developing and testing a new e-learning user interface from the perspectives of teachers and students. *Technology in Society*, 59:101192. DOI: 10.1016/j.techsoc.2019.101192.
- Garlinska, M., Osial, M., Proniewska, K., and Pre-gowska, A. (2023). The influence of emerging technologies on distance education. *Electronics*, 12(7):1550. DOI: 10.3390/electronics12071550.
- Gómez, S., Zervas, P., Sampson, D. G., and Fab-regat, R. (2014). Context-aware adaptive and personalized mobile learning delivery supported by uolmp. *Journal of King Saud University - Computer and Information Sciences*, 26(1):47–61. DOI: 10.1016/j.jksuci.2013.10.008.
- Grant, M. M. (2019). Difficulties in defining mobile learning: Analysis, design characteristics, and implications. *Educational Technology Research and Development*, 67:361–388. DOI: 10.1007/s11423-018-09641-4.
- Haleem, A., Javaid, M., Qadri, M. A., and Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, 3:275–285. DOI: 10.1016/j.susoc.2022.05.004.
- Ho, S.-C., Hsieh, S.-W., Sun, P.-C., and Chen, C.-M. (2017). To activate English learning: Listen and speak in real life context with an AR featured U-learning system. *Educational Technology & Society*, 20(2):176–187. <https://psycnet.apa.org/record/2017-17491-015>.
- Hwang, G.-J. (2014). Definition, framework and research issues of smart learning environments: A context-aware ubiquitous learning perspective. *Smart Learning Environments*, 1(1):4. DOI: 10.1186/s40561-014-0004-5.
- Jeong, H. and Hmelo-Silver, C. E. (2016). Seven affordances of computer-supported collaborative learning: How to support collaborative learning? How can technologies help? *Educational Psychologist*, 51(2):247–265. DOI: 10.1080/00461520.2016.1158654.
- Karakaya, K. and Bozkurt, A. (2022). Mobile-assisted language learning (MALL) research trends and patterns through bibliometric analysis: Empowering language learners through ubiquitous educational technologies. *System*, 110:102925. DOI: 10.1016/j.system.2022.102925.
- Kaur, M. (2018). Tools of ICT in open and distance learning for inclusive education in developing world. In Anjana, editor, *Technology for Efficient Learner Support Services in Distance Education*. Springer, Singapore. DOI: 10.1007/978-981-13-2300-3_2.
- Liao, Y.-W., Huang, Y.-M., Chen, H.-C., and Huang, S.-H. (2015). Exploring the antecedents of collaborative learning performance over social networking sites in a ubiquitous learning context. *Computers in Human Behavior*, 43:313–323. DOI: 10.1016/j.chb.2014.10.028.
- Liaw, S.-S. (2008). Investigating students' perceived satisfaction, behavioral intention, and effectiveness of e-learning: A case study of the blackboard system. *Computers & Education*, 51(2):864–873. DOI: 10.1016/j.compedu.2007.09.005.
- Lin, Y.-L. and Wang, W.-T. (2024). Enhancing students' online collaborative PBL learning performance in the context of coauthoring-based technologies: A case of wiki technologies. *Education and Information Technologies*, 29:2303–2328. DOI: 10.1007/s10639-023-11907-1.
- Loes, C. N. and Pascarella, E. T. (2017). Collaborative learning and critical thinking: Testing the link. *The Journal of Higher Education*, 88(5):726–753. DOI: 10.1080/00221546.2017.1291257.
- Matthew, U. O., Kazaure, J. S., and Okafor, N. U. (2021). Contemporary development in e-learning education, cloud computing technology & internet of things. *EAI Endorsed Transactions on Cloud Systems*, 7(20):e3. DOI: 10.4108/eai.31-3-2021.169173.
- McPeake, J., Hirshberg, E. L., Christie, L. M., Drum-right, K., Haines, K., Hough, C. L., Meyer, J., Wade, D., Andrews, A., Bakhrui, R., Bates, S., Barwise, J. A., Bastarache, J., Beesley, S. J., Boehm, L. M., Brown, S., Clay, A. S., Firshman, P., Greenberg, S., Harris, W., Hill, C., Hodgson, C., Holdsworth, C., Hope, A. A., Hopkins, R. O., Howell, D. C. J., Janssen, A., Jackson, J. C., Johnson, A., Kross, E. K., Lamas, D., MacLeod-Smith, B., Mandel, R., Marshall, J., Mikkelsen, M. E., Nackino, M., Quasim, T., Sevin, C. M., Slack, A., Spurr, R., Still, M., Thompson, C., Weinhouse, G., Wilcox, M. E., and Iwashyna, T. J. (2019). Models of peer support to remediate post-intensive care syndrome: A report developed by the society of critical care medicine thrive international peer support collaborative*. *Critical Care Medicine*, 47(1):e21–e27. DOI: 10.1097/ccm.0000000000003497.
- MIT Professional Education (2023). The gender gap in STEM: Still gaping in 2023. Accessed June 22, 2025, <https://professionalprograms.mit.edu/blog/leadership/the-gender-gap-in-stem/>.
- Pardjono (2002). Active learning: The Dewey, Piaget, Vygotsky, and constructivist theory perspectives. *Jurnal Ilmu Pendidikan Universitas Negeri*

- Malang, 9(3):163–178. <https://journal.um.ac.id/index.php/jip/article/view/487/1599>.
- Parthasarathy, P., Mittal, A., Aggarwal, A., Mantri, A., and Singh, N. (2025). The COVID-19 fighter: An interactive learning platform. *Information Discovery and Delivery*, 53(2):161–180. DOI: 10.1108/IDD-11-2022-0111.
- Pavlov, V. (2024). Higher education policies for female retention in computer science. Delft University of Technology Repository. Accessed June 22, 2025. <https://resolver.tudelft.nl/uuid:aae5145a-4748-4339-b60e-ffdf9ab5f26a>.
- Pimmer, C., Mateescu, M., and Gröbner, U. (2016). Mobile and ubiquitous learning in higher education settings: A systematic review of empirical studies. *Computers in Human Behavior*, 63:490–501. DOI: 10.1016/j.chb.2016.03.045.
- Qurat-ul-Ain, Shahid, F., Aleem, M., Islam, M. A., Iqbal, M. A., and Yousaf, M. M. (2019). A review of technological tools in teaching and learning computer science. *Eurasia Journal of Mathematics, Science and Technology Education*, 15(11). DOI: 10.29333/ejmste/109611.
- Rahman, L. (2024). Vygotsky's zone of proximal development of teaching and learning in STEM education. *International Journal of Engineering Research and Technology*, 13(8):389–394. DOI: 10.5281/zenodo.18137951.
- Saleem, A., Kausar, H., and Deeba, F. (2021). Social constructivism: A new paradigm in teaching and learning environment. *Perennial Journal of History*, 2(2):403–421. DOI: 10.52700/pjh.v2i2.86.
- Schmid, R. and Petko, D. (2019). Does the use of educational technology in personalized learning environments correlate with self-reported digital skills and beliefs of secondary-school students? *Computers and Education*, 136:75–86. DOI: 10.1016/j.compedu.2019.03.006.
- Silva, D. C., Salati, L. R., Villas-Bôas, A. P., Schwarz, K., Fontanari, A. M., Soll, B., Costa, A. B., Hirakata, V., Schneider, M., and Lobato, M. I. R. (2021). Factors associated with ruminative thinking in individuals with gender dysphoria. *Frontiers in Psychiatry*, 12:602293. DOI: 10.3389/fpsy.2021.602293.
- Srivastava, S., Varshney, A., Katyal, S., Kaur, R., and Gaur, V. (2021). A smart learning assistance tool for inclusive education. *Journal of Intelligent & Fuzzy Systems*, 40(6):11981–11994. DOI: 10.3233/JIFS-210075.
- Tham, J. C. K. and Verhulsdonck, G. (2023). Smart education in smart cities: Layered implications for networked and ubiquitous learning. *IEEE Transactions on Technology and Society*, 4(1):87–95. DOI: 10.1109/TTS.2023.3239586.
- Thongkoo, K., Panjaburee, P., and Daungcharone, K. (2019). A development of ubiquitous learning support system based on an enhanced inquiry-based learning approach. *International Journal of Mobile Learning and Organisation*, 13(2):129–151. DOI: 10.1504/IJMLO.2019.098179.
- Ullah, A. and Anwar, S. (2020). The effective use of information technology and interactive activities to improve learner engagement. *Education Sciences*, 10(12):349. DOI: 10.3390/educsci10120349.
- Vallejo-Correa, P., Monsalve-Pulido, J., and Tabares-Betancur, M. (2021). A systematic mapping review of context-aware analysis and its approach to mobile learning and ubiquitous learning processes. *Computer Science Review*, 39:100335. DOI: 10.1016/j.cosrev.2020.100335.
- Virtanen, M. A., Haavisto, E., Liikanen, E., and Kääriäinen, M. (2018). Ubiquitous learning environments in higher education: A scoping literature review. *Education and Information Technologies*, 23:985–998. DOI: 10.1007/s10639-017-9646-6.
- Wu, S.-Y. (2020). Incorporation of collaborative problem solving and cognitive tools to improve higher cognitive processing in online discussion environments. *Journal of Educational Computing Research*, 58(1):249–272. DOI: 10.1177/0735633119828044.
- Yates, J. and Plagnol, A. C. (2022). Female computer science students: A qualitative exploration of women's experiences studying computer science at university in the uk. *Education and Information Technologies*, 27(3):3079–3105. DOI: 10.1007/s10639-021-10743-5.
- Yousif, J. H. (2025). Artificial intelligence revolution for enhancing modern education using zone of proximal development approach. *Applied Computing Journal*, 5(2):386–398. DOI: 10.52098/acj.20255239.
- Zabolotska, O., Zhyliak, N., Hevchuk, N., Petrenko, N., and Alieko, O. (2021). Digital competencies of teachers in the transformation of the educational environment. *Journal of Optimization in Industrial Engineering*, 14(Special Issue):25–32. <https://sanad.iau.ir/Journal/jie/Article/951385>.
- Zajda, J. (2021). Constructivist learning theory and creating effective learning environments. In *Globalisation and Education Reforms. Creating Effective Learning Environments*, volume 25, pages 35–50. Springer, Cham. DOI: 10.1007/978-3-030-71575-5_3.