

Article

Enhancing ICT Literacy and Achievement: A TPACK-Based Blended Learning Model for Thai Business Administration Students

Cherisa Nantha ¹, Kobchai Siripongdee ^{2,*}, Surapong Siripongdee ², Paitoon Pimdee ²,
Thiyaporn Kantathanawat ² and Kanitphan Boonsomchuae ³

¹ Department of Digital Technology for Education, Faculty of Technical Education, Rajamangala University of Technology Thanyaburi, Pathum Thani 12110, Thailand; cherisa_n@rmutt.ac.th

² School of Industrial Education and Technology, King Mongkut Institute of Technology Ladkrabang, Bangkok 10520, Thailand; surapong.si@kmitl.ac.th (S.S.); paitoon.pi@kmitl.ac.th (P.P.); thiyaporn.ka@kmitl.ac.th (T.K.)

³ Department of Technical Education, Faculty of Technical Education, Rajamangala University of Technology Thanyaburi, Pathum Thani 12110, Thailand; kanitphan_b@rmutt.ac.th

* Correspondence: dr.kobchais@gmail.com; Tel.: +66-081-496-8642

Abstract: The COVID-19 pandemic has heightened the need for 21st century skills, particularly computer and ICT literacy (CICT) in Thailand. This study aimed to develop a TPACK (Technological Pedagogical and Content Knowledge)-based blended learning model (BLM) to enhance CICT skills and academic performance among 179 Business Administration (BA) undergraduates in the 2022 academic year Computer and Information Applications course. Research instruments were designed and evaluated by experts. Over 18 weeks, qualitative and quantitative data were collected, with the qualitative data undergoing content analysis. Descriptive statistics were used to analyze quantitative data, comparing pretests, post-tests, and 2-week retests using a repeated measure ANOVA. One-sample t-tests were used to assess the model's impact on CICT skills. The results showed a significant score improvement between tests, with the highest mean being seen in the 2-week retest. The BA-TPACK model significantly enhanced CICT skills, exceeding 80%. The students expressed high satisfaction, with the BA-TPACK model effectively enhancing CICT skills and academic achievement, recommending its integration into future computer and information courses. This study's contribution lies in addressing the pressing need for CICT skills in the 'new normal'. By developing and implementing a BLM grounded in the TPACK framework, this study not only enhances students' CICT proficiency but also fills a crucial gap in the literature regarding effective pedagogical approaches to foster 21st century skills.

Keywords: achievement; blended learning; ICT literacy skills; Thailand; TPACK



Citation: Nantha, C.; Siripongdee, K.; Siripongdee, S.; Pimdee, P.; Kantathanawat, T.; Boonsomchuae, K. Enhancing ICT Literacy and Achievement: A TPACK-Based Blended Learning Model for Thai Business Administration Students. *Educ. Sci.* **2024**, *14*, 455. <https://doi.org/10.3390/educsci14050455>

Academic Editors: Soonja Yeom, Nicole Herbert, Matthew Springer and Soo-Hyung Kim

Received: 20 December 2023

Revised: 18 April 2024

Accepted: 22 April 2024

Published: 25 April 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

In the aftermath of the global COVID-19 pandemic, educational institutions across Thailand have undergone a paradigm shift, adapting their curricula to meet the demands of the 'new normal' era of globalization. In this context, the integration of 21st century skills has emerged as a central focus, with particular emphasis placed on computer and ICT literacy (CICT) skills among the 3Rs (reading, writing, arithmetic) and 7Cs (critical thinking, creativity, collaboration, communication, etc.) soft skills. The prioritization of CICT skills stems from the ubiquitous need for computer and information applications in various professions amidst the post-pandemic landscape [1].

However, reports from the Thailand Professional Qualification Institute (TPQI) highlight a concerning lack of digital literacy competency among ICT stakeholders, including students, faculty, and teachers, with only 40.09 percent meeting standard criteria [2]. This deficit is particularly significant for Business Administration (BA) undergraduates, who

require both knowledge and proficiency in CICT to excel in their academic pursuits and future careers. Indeed, CICT skills have become indispensable for success in the BA field, serving as a gateway to realizing students' aspirations and professional goals. Recognizing the critical role of digital technology and literacy in higher education, Thailand's Ministry of Higher Education, Science, Research, and Innovation (MHESI) has underscored the importance of CICT skills for undergraduates and educators alike in this new era [3].

Furthermore, the transition period following the COVID-19 pandemic has had a profound impact on teaching and learning methodologies in Thailand. Blended learning (BL) strategies have emerged as a cornerstone of the 'new normal' educational landscape, offering a dynamic approach that combines both online and offline modalities with promising outcomes. Numerous studies have demonstrated the efficacy of BL in enhancing learning outcomes and fostering digital skills development, particularly among undergraduate students [4]. By incorporating various educational technologies, BL facilitates a seamless integration of offline, in-class, online, and out-of-class activities, thereby significantly influencing the learning experience [5]. Importantly, the BL model promotes interaction and collaboration among students, even while adhering to physical distancing measures [6]. Thus, given its adaptability and effectiveness in integrating technology into the learning environment, the BL model stands out as the most viable solution for navigating the challenges posed by the 'new normal'.

While the adoption of blended learning (BL) has been widely embraced across various disciplines, some studies have indicated no significant performance differences between BL and traditional instructional methods [7]. Additionally, research on learning outcomes in BL environments suggests that the complexity of planning is greater compared to previous studies. Particularly in the fields of educational management and psychology, studies have highlighted the need for specific design and analysis tailored to each BL environment to address this disparity. Recommendations include promoting flexibility and interaction within BL environments, while also considering learners' cognitive characteristics [7]. Consequently, as the instructional designer for the Computer and Information Applications (CIAs) course within the Business Economics and Management program, it is imperative to prioritize understanding the context and characteristics of the learners before implementing BL.

The CIA course, offered by the Business Economics and Management program within the BA faculty of KMITL, aims to equip undergraduates with a comprehensive understanding of the essential principles in computers and ICT relevant to the business field. This includes topics such as historical backgrounds, digital literacy, data communications and networks, ethics, legal aspects, and business applications. To address these objectives, this study adhered to the ten stages of the systematic instructional design outlined in the Dick and Carey model [8].

Before implementing blended learning (BL), the researchers conducted a thorough examination of the background and expectations of the students enrolled in the course during the 2022 semester. This involved administering questionnaires and need assessment forms to gauge their preferences and requirements [9–15]. The findings revealed a strong preference among students for utilizing online technologies to support their learning, including social networks, collaborative tools, and online information-sharing services. Interestingly, despite half of the students not owning a personal computer, all of them possessed smartphones. Additionally, the majority of Business Administration (BA) undergraduates expressed expectations of achieving learning outcomes encompassing both academic achievement and essential digital literacy skills within the classroom setting.

Consequently, as the instructional designers, it was essential to prioritize the selection of educational technology platforms and materials that would cater to the specific needs of the learners and align with the course syllabus. Additionally, dynamic activities within both in-class and out-of-class sessions were categorized into pre-class, during-class, and post-class activities, enabling effective monitoring and evaluation of student learning processes through the implementation of the flipped classroom concept [16].

The TPACK concept is a widely embraced instructional framework utilized by educators and researchers for effective technology integration in teaching and learning [17]. This framework builds on Lee Shulman's (1986, 1987) construct of pedagogical content knowledge (PCK) to include technology knowledge [18]. Later, it was enhanced and renamed to TPCK or TPACK in 2008 for easier communication within the educational research community [19].

TPACK consists of three main domains: technological knowledge (TK), content knowledge (CK), and pedagogical knowledge (PK). Within these domains, there are sub-domains such as technological pedagogical knowledge (TPK), technological content knowledge (TCK), and pedagogical content knowledge (PCK), which illustrate the intersections of the main domains [20]. These concepts are crucial for training teachers to effectively integrate technology into their teaching practices [18]. These domains and sub-domains provide a comprehensive framework for analyzing and designing instruction, particularly in contemporary learning environments enriched with various educational technologies [21].

Phase 1 of this study involved an extensive review of the relevant literature about the BLM based on the TPACK concept, with a specific focus on enhancing CICT skills and academic achievement among undergraduate students within the Business Administration (BA) faculty. This phase also included an analysis of content and learners' contextual factors to inform the design and implementation of the instructional approach.

Subsequently, Phase 2 commenced upon the qualification of all research instruments, marking the transition to the implementation stage of this study.

2. Literature Review

The researchers conducted a comprehensive review of the relevant theories, literature, and research to identify the most suitable learning model for BA undergraduates in the digital era, with a focus on the BLM and the TPACK concept for enhancing students' achievement and requisite skills.

2.1. Blended Learning Model (BLM)

The concept of blended learning (BL) emerged around the turn of the millennium, with Graham [22] defining it as a model that integrates face-to-face (F2F) teaching with computer-mediated instruction. Over time, BL has evolved to encompass a variety of learning methods that leverage the internet and digital media within the traditional classroom setting, requiring active engagement from both teachers and students [23]. Additionally, Driscoll [24,25] has delineated four key concepts within BL:

1. Combining F2F instruction with web-based technologies, such as live virtual classrooms, self-paced instruction, and multimedia resources.
2. Integrating various pedagogical approaches, including constructivism, behaviorism, and cognitivism, with or without instructional technology.
3. Utilizing instructional technologies, such as DVDs, web-based learning platforms, and multimedia materials.
4. Incorporating instructional technology into real-world job tasks to achieve learning objectives.

As such, BL operates across three main dimensions: blending instructional media, blending pedagogical approaches, and combining F2F instruction with online teaching [26]. It is important to note that BL does not adhere to any specific theory [27], making it a highly adaptable and flexible concept for integrating technology into instructional design processes [28]. BL also offers numerous advantages in the digital age, including:

1. Higher learner achievement compared to purely face-to-face (F2F) or online teaching [29,30].
2. Self-paced learning facilitated through digital media enables individualized progress [31].
3. Opportunities for all learners to reach their maximum potential [32].
4. Exposure to both independent and teamwork experiences [33].
5. Use of ICT technologies to cultivate learners' attitudes and skills [34].

6. Enhanced communication between teachers and students through qualitative and quantitative evaluation via computers [35].
7. Reduction in practice and training costs through online spaces and electronic media [36].
8. Increased opportunities for teacher improvement and evaluation of instruction [37].
9. Reallocation of resources by faculties to support student achievement [38].
10. Provision of additional opportunities for talented learners to pursue further skills or exceed grade restrictions [39].
11. Support for individualized learning, moving away from traditional lecture-based instruction [40].
12. Facilitation of self-pacing to ensure understanding for each learner [41].
13. Creation of a virtual learning environment that connects all stakeholders without physical presence [42].

Despite its advantages, BL also presents several challenges, including [43].

1. Technical difficulties may arise without proper planning and implementation [44].
2. Potential barriers posed by students lacking computer and IT literacy [43].
3. Challenges in managing teamwork or group work in an online environment.
4. Risk of students becoming fatigued with learning through recorded media technology.
5. Longer time and higher costs are associated with effective feedback mechanisms.
6. Consideration of supportive network infrastructure.
7. Risk of wasting resources through ineffective use of expensive tools [45].
8. Requirement for students and teachers to possess basic technology knowledge and willingness to learn [44].
9. Costs associated with high technology installation and maintenance [43].

Potential issues stemming from lacking motivation among stakeholders [37,46].

In the 21st century, the rapid advancement of internet speed and facilities has significantly influenced the widespread adoption and implementation of BL, particularly during the COVID-19 pandemic period. Valiathan [47] categorized BL teaching drivers into three modes: skill-driven, attitude-driven, and competency-driven models. Additionally, Siripongdee [28] identified four characteristics of BL in educational approaches, including face-to-face, self-paced, tele-D, and ubiquitous, which intersect with time and place dimensions.

Information and Communication Technology (ICT) has emerged as a critical driver of national development across all sectors in the modern era. Alvin Toffler's seminal 1980 work, 'The Third Wave', prophesized that ICT would supplant mechanical technology as the primary force propelling industrial societies forward [48]. Indeed, in the 21st century, the globalization of education has propelled ICT to the forefront, transforming teaching methods, integrating pedagogies, and establishing itself as a potent educational tool across all levels of academia, particularly in higher education.

Researchers have increasingly incorporated ICT into their BLMs, leveraging it to enhance content delivery, facilitate activities, conduct evaluations, and utilize technology for specific learning outcomes. This integration of ICT represents a true revolution, fundamentally reshaping the educational landscape of contemporary society and nurturing key competencies essential for lifelong learning [49].

2.2. Technological Pedagogical and Content Knowledge (TPACK)

TPACK has been extensively studied over the past 20 years, with over 1300 publications exploring its development, application, and assessment across different educational contexts and subjects [19]. This framework has significantly influenced faculty practices and educational administrators, highlighting the potential of technology in education [19]. However, its widespread adoption has led to various interpretations and challenges, particularly regarding its measurement and validation [50].

Educators are required to seamlessly incorporate teaching technologies into different teaching methods and subjects, a practice that has evolved since the early 20th century [51]. With the rapid advancement of digital technologies, educators must continuously evaluate

and adapt their instructional designs to align with changing technological landscapes. Consequently, various learning models have been developed to enhance educators' TPACK abilities, with collaborative strategies being particularly popular [52]. Overall, educators' development of TPACK is vital for effective technology-enhanced teaching, underscoring the importance of ongoing professional development in this area [18].

2.3. Statement of the Problem and Research Objectives

The rapid advancement of technology in the 21st century has brought about significant changes in educational practices, necessitating a shift towards innovative instructional approaches to meet the evolving needs of learners. In the context of higher education, particularly in Thailand, the emergence of the 'new normal' educational landscape following the global pandemic has underscored the importance of equipping undergraduate students with essential 21st century skills, particularly in Computer and Information and Communication Technology (CICT) literacy.

However, despite the growing recognition of the importance of CICT skills for undergraduate students, there remains a need to develop effective instructional models that can enhance both academic achievement and CICT proficiency in this demographic. Furthermore, the diverse technological backgrounds and learning preferences of students pose unique challenges for educators in designing and implementing instructional strategies that can cater to their individual needs and maximize learning outcomes.

Against this backdrop, the present study aims to address the following research objectives:

RO1. To assess the impact of the BA-TPACK blended learning model on the academic achievement of BA undergraduate students in the CIA course by comparing pretest, post-test, and 2w-retest scores.

RO2. To evaluate the effectiveness of the blended learning model in enhancing CICT skills among BA undergraduate students through comprehensive needs assessment measures.

RO3. To investigate students' perceptions of the BA-TPACK blended learning model's effectiveness and utility in improving their learning experiences and outcomes in the CIA course, as indicated by satisfaction levels and feedback.

By addressing these research objectives, this study seeks to answer the following research questions.

2.4. Research Questions

RQ1. How does the implementation of a blended learning model based on the Technological Pedagogical and Content Knowledge (TPACK) framework impact the academic achievement of Business Administration (BA) undergraduate students enrolled in the Computer and Information Applications (CIAs) course?

RQ2. What are the effects of the blended learning model on the development of Computer and Information and Communication Technology (CICT) skills among BA undergraduate students?

RQ3. How do students perceive the effectiveness and utility of the BA-TPACK blended learning model in enhancing their learning experiences and outcomes in the CIA course?

This research problem is of paramount importance as it not only addresses the immediate needs of BA undergraduate students in Thailand but also contributes to the broader discourse on instructional design and technology integration in higher education. By detailing the specific challenges and opportunities associated with enhancing CICT skills and academic achievement through a blended learning approach, this study aims to provide valuable insights and practical recommendations for educators, policymakers, and researchers seeking to promote effective teaching and learning practices in the digital age.

3. Research Design and Procedures

This research comprises two phases: (1) the development of the blended learning Model (BLM) based on the TPACK concept to enhance the Thai undergraduate CICT skills and achievement, and (2) the implementation of the new BA-TPACK learning model.

3.1. Phase1

The researchers employed the ten stages of the Dick and Carey instructional design model [8] to formulate a BLM grounded in the TPACK concept for enhancing CICT skills and achievement among BA undergraduate students (Figure 1).

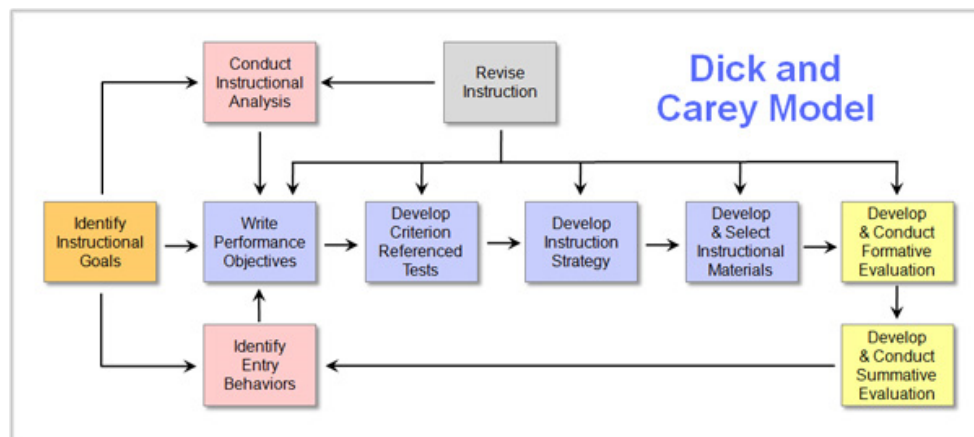


Figure 1. The Dick and Carey model. Source: [8].

The Dick and Carey instructional design model is a systematic approach to instructional design that guides the development of effective learning experiences [8,53]. It consists of nine stages, each serving a specific purpose in the instructional design process. Here is a brief overview of each stage:

Identify Instructional Goals: In this stage, the instructional designer identifies the overarching goals and objectives of the instruction. This involves understanding the desired outcomes and what learners should be able to accomplish by the end of the instruction [54].

Conduct Instructional Analysis: This stage involves analyzing the content to be taught, as well as the characteristics of the learners. Instructional designers gather information about the content, the learners' prior knowledge, and any contextual factors that may influence the design of the instruction [55].

Write Performance Objectives: Performance objectives articulate what learners should be able to do after completing the instruction. These objectives are specific, measurable, achievable, relevant, and time-bound (SMART), providing clear targets for assessment [56].

Identify Entry Behaviors: This is the process of determining the existing knowledge, skills, and abilities that learners should possess before beginning the instructional program. These entry behaviors are essential because they provide a foundation upon which new learning can be built. It involves: 1. Analyzing the characteristics and prerequisites of the learners. 2. Identifying any prerequisite knowledge, skills, or attitudes that learners need to have to successfully engage with the instructional content. 3. Assessing the readiness of learners to undertake the instructional program [57]. By identifying entry behaviors, instructional designers can ensure that the content is appropriately sequenced and tailored to the needs of the learners, thereby maximizing the effectiveness of the instructional program.

Develop Criterion-Referenced Tests: Assessment instruments are created to measure learners' attainment of the performance objectives [58]. This may include tests, quizzes, projects, or other forms of assessment that align with the instructional goals.

Design Instruction Strategy: In this stage, the actual instructional materials and activities are developed. This includes selecting appropriate instructional strategies, designing learning materials, and planning instructional activities [59].

Develop and Select Instructional Materials: Instructional materials, such as textbooks, slides, videos, or interactive multimedia, are developed or selected to support the instruction. These materials should be aligned with the instructional goals and designed to engage learners effectively [60].

Develop and Conduct Formative Evaluation: Formative evaluation occurs during the instructional design process, typically after the initial development of instructional materials but before their final implementation [61]. The purpose of formative evaluation is to gather feedback and make iterative improvements to the instructional materials and activities. It helps identify any deficiencies or areas for improvement in the instructional design and allows designers to make necessary adjustments. Formative evaluation methods may include pilot testing, peer review, expert feedback, and learner feedback through surveys or observations. The focus is on refining the instructional materials and activities to ensure they effectively facilitate learning and achieve the desired instructional goals.

Develop and Conduct Summative Evaluation: Summative evaluation takes place after the instructional program has been fully implemented and completed [62]. The purpose of summative evaluation is to assess the overall effectiveness of the instructional program in achieving its objectives and outcomes. It provides a final assessment of learner performance and the extent to which instructional goals have been met. Summative evaluation methods may include standardized tests, performance assessments, final exams, project presentations, or portfolio reviews. The focus is on determining the extent to which learners have acquired the intended knowledge, skills, and attitudes as outlined in the instructional objectives.

In summary, formative evaluation occurs during the instructional design process to refine and improve instructional materials, while summative evaluation occurs after implementation to assess the overall success of the instructional program.

Revise Instruction: Based on the feedback from formative evaluation, the instructional materials and activities are revised as needed. This iterative process continues until the instruction meets the desired standards of quality and effectiveness.

Overall, the Dick and Carey instructional design model provides a structured framework for developing high-quality instructional materials and activities that align with the needs of learners and the goals of the instruction. It emphasizes the importance of careful analysis, systematic planning, and ongoing evaluation to ensure effective learning outcomes.

3.1.1. Instructional Design Process

The ten stages of the Dick and Carey instructional design model were systematically executed. Firstly, instructional goals were delineated by analyzing the content of the CIA course for BA undergraduates. An online questionnaire was utilized to assess the learning environment and technological facilitation, and the obtained data were analyzed by five academic experts to conduct instructional analysis. Subsequently, a need assessment analysis was conducted to identify entry behaviors and learner traits based on responses from 110 participants [9–15]. The identified performance objectives were reviewed and qualified by five academic experts. Achievement tests and skill evaluation forms were developed and qualified by the same experts. A tryout test involving 30 third-year BA undergraduates who had previously passed the CIA course was conducted to assess reliability, index of difficulty, and index of discrimination power for the achievement test. Similarly, the analytic rubric score of the CICT skills evaluation form was subjected to qualification criteria. All components of the instructional plan, including technologies, pedagogies, content, activities, and materials, were arranged and selected based on the BA-TPACK framework. Formative and summative evaluations, including pretests, practices, solo/group assignments, and games, were conducted to assess achievement and CICT skills. An online satisfaction questionnaire meeting the qualification criterion was administered to gauge the satisfaction level of BA undergraduates with the BA-TPACK model.

3.1.2. Participants

A total of one hundred and seventy-nine (179) BA undergraduates enrolled in the Computer and Information Applications (CIAs) course during the second semester of the academic year 2022 at the Faculty of Business Administration (BA), KMITL in Thailand participated in the study. They were administered an online questionnaire to explore their

learning context and conduct a needs assessment [63,64], and data were collected from a sample group of one hundred and ten (110) respondents.

3.1.3. Instruments

The research instruments utilized in Phase 2 included an instructional plan, achievement tests, a CICT skills evaluation form, and a satisfaction questionnaire. The details of these instruments and their validity/reliability assessments are as follows:

1. **Instructional Plan:** The 16-unit, 8-lesson instructional plan developed during Phase 1 was implemented according to the established schedule. Five experts evaluated the appropriateness of the plan, resulting in a high mean score of 4.68 (S.D. = 0.178), deeming it suitable for implementation.
2. **Achievement Tests:** Participants underwent various achievement tests, including a pretest (T1), post-test (T2), and a 2-week retest (T3) following the one-group repeated measures design (Table 1). The 100-item test was validated by five academic experts (IOC index > 0.8) and tried out with 30 third-year BA students who had previously completed the course. The results indicated that 93 items demonstrated high reliability (KR-20 = 0.9755, Cronbach's alpha = 0.976) and appropriate difficulty and discrimination levels (P and r between 0.2 and 0.8). These 93 items were approved for use in the pretest, post-test, and 2-week retest examinations.
3. **CICT Skills Evaluation Form:** The instructor used this form to assess participants' CICT skills through their engagement in various activities. A rubric score form was utilized to evaluate three CICT skills: use and understand, create, and access. The form's validity was confirmed by five experts, with an average IOC score of 0.911 (S.D. = 0.105). Additionally, 50 items were assessed using the CICT evaluation form by the instructor and an independent certified MS Office specialist (two raters). The inter-rater reliability (IRR) was confirmed through correlation (r) coefficients, indicating high agreement levels for all CICT skills (0.971 overall; use and understand: $r = 0.819$; create: $r = 0.783$; access: $r = 0.739$). Hence, the CICT skills evaluation form was validated.
4. **Online Satisfaction Questionnaire:** Participants completed a 16-item online satisfaction questionnaire upon the course's conclusion in week 18. The questionnaire was evaluated by five experts and determined to be ready for implementation, with a mean IOC index of 0.96 (S.D. = 0.98).

Descriptive statistics were used to assess each student's response, which included the use of a five-level Likert-type opinion scale (Figure 2).



Figure 2. Five-level Likert opinion scale values and interpretations.

Table 1. The one-group time series of this experimental diagram.

Group	Pre Measurement	Intervention	Post Measurement
179 participants	Pretest (T1)	BA-TPACK Model	Post-test (T2) 2W-Retest (T3)

3.1.4. Data Analysis

The quantitative data analysis methods employed in Phase 2 were as follows:

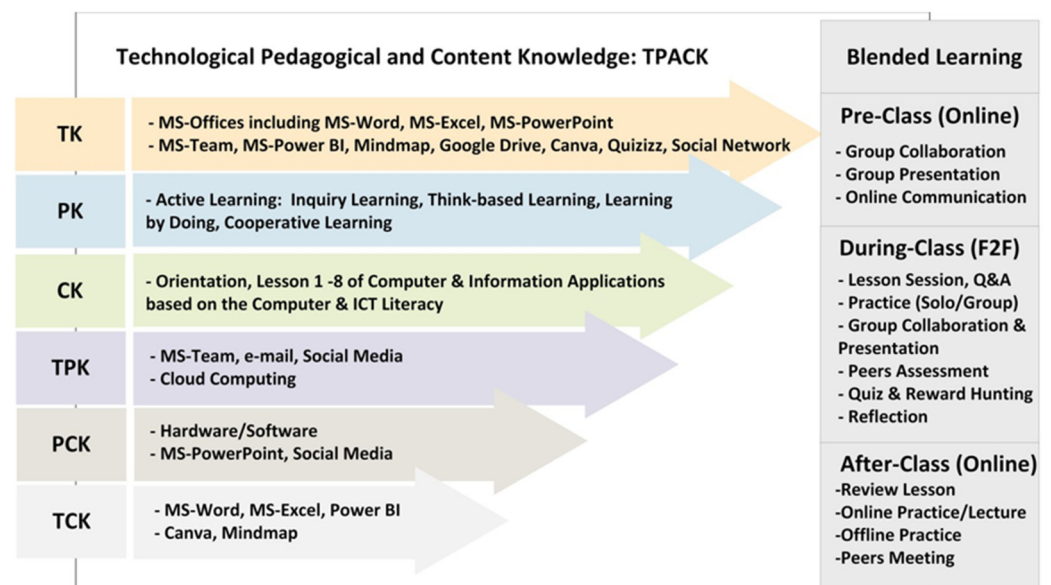
1. Achievement scores from the pretest, post-test, and 2-week retest were analyzed and compared using one-way repeated measures ANOVA and Tukey's post hoc tests.
2. Participants' CICT skills scores were compared against a benchmark of 80% using one-sample *t*-tests.
3. Participants' satisfaction levels were analyzed using descriptive statistics (mean and standard deviation).
4. Demographic data were analyzed using frequency and percentage.

The main independent variable was the BA-TPACK blended learning model, while the dependent variables were achievement scores, CICT skills, and satisfaction levels. The hypotheses tested were as follows:

- Participants' achievement scores would significantly differ between the pretest, post-test, and 2-week retest at the 0.01 level.
- Participants' CICT skills after the intervention would be significantly higher than the 80% benchmark at the 0.01 level.

3.2. Phase2

In Phase 2, the researcher implemented the BA-TPACK model (Figure 3) within KMITL's BA course during the 2nd semester of 2022. All three sections of second-year BA students ($n = 179$) who registered for the course underwent an 18-week study period from January to April 2023. Qualitative and quantitative data were collected and analyzed throughout the duration of the course. Online satisfaction questionnaires were distributed to all participants after the course, with responses received from 106 participants. Low response rates were due to the online questionnaires being sent to the participants after the class was completed. Additionally, two weeks after the course concluded, all participants ($n = 179$) underwent a retest to enable the researchers to collect 2-week retest achievement data.

**Figure 3.** The component activities in the BA-TPACK blended learning model.

3.2.1. Methods

In this phase, the one-group time series design, also known as the repeated measures design [65], was employed for mean comparison.

In this design, the same group of participants is measured multiple times before and after the intervention to assess changes over time. The participants serve as the control group. Table 2 provides an overview of the experimental diagram illustrating the design:

- Group: Represents the experimental group.
- Pre-measurement: Refers to the initial measurement taken before the intervention.
- Intervention: Denoted by “X,” represents the implementation of the instructional intervention.
- Post measurement: Refers to the measurements taken after the intervention. “T1”, “T2”, and “T3” indicate different post-intervention measurement time points.

Table 2. The one-group time series design of the experimental diagram.

Group	Pre Measurement	Intervention	Post Measurement
E	T1	X	T2, T3

E: Experimental group, X: Treatment, T: Dependent variable.

The instruction of the CIA course (ID.no. 14026114, Credit 3 [3-0-6]) entailed three hours each week during the second semester of the 2022 academic year. The course was developed from the new BLM using TPACK concepts for BA undergraduate students (BA-TPACK model). During 18 weeks from January to April 2023, the instruction plan and academic schedule were followed.

During the initial period, the course orientation and research presentation were conducted by the instructor to provide clear instructions to all students participating in the course. Letters of consent for research were voluntarily signed by all participants. A pretest examination was conducted, and all pretest scores were collected. Individual and group assignments were then assigned after dividing all participants into small groups (5 to 7 members), while the first lesson was delivered. The MS Team application was introduced by the instructor as the main tool for the course’s online community, accessible via both smartphone and computer platforms. Participants were assigned after-class and pre-class homework for the following week, including setting up their teams, reviewing lesson 1, and completing the first group assignment to present in front of the classroom with their team members using online tools such as MS Team, Line group chat, or Google Drive.

Throughout the 18-week intervention period, various learning activities were conducted to foster the participants’ learning processes and enhance their CICT skills following the BA-TPACK learning model. All elements of TPACK, including TK, PK, CK, TPK, PCK, and TCK, were seamlessly integrated into pre-class, during-class, and after-class activities. Concurrently, both qualitative and quantitative data were systematically collected and analyzed. Feedback from students prompted adjustments and improvements to the learning activities in real time. Additionally, all participants’ CICT skills and achievement scores were assessed using research instruments administered by the instructor.

Any issues that arose during the intervention were promptly addressed through collaboration among stakeholders, including the instructor, researchers, and participants. All three CICT skills—use and understand, create, and access—were evaluated in this study, as adapted from [3].

In the final week of the 18 weeks, a summative examination was conducted to gather participants’ post-test scores. Subsequently, the instructor collected all participants’ CICT skills and achievement scores for final grading (Table 3). Meanwhile, an online satisfaction questionnaire was distributed to all participants, with responses received from 110 respondents.

Table 3. CICT skills evaluation criteria.

CICT Skills	Evaluation Criteria
Use and understand	Students can use and understand MS Team and search engines to make their individual and group assignments (15%).
Create	Students can create their assignments (25%), including the following: Economic report using MS Word; Business Dashboard using Power BI; Presentation using MS PWP; CV/resume using MS Word/Canva; Mind mapping using mind map software.
Access	Students can access and share the ICT online information through MS Team, Line group, and social media (10%).

Two weeks after the conclusion of the 18 weeks, all 179 participants underwent a retest of their 2-week retest examination, with all the scores collected by the researchers. Consequently, all the collected data were carefully analyzed and interpreted following the one-group time series diagram, as delineated in Table 3.

3.2.2. Participants

All 179 BA undergraduates who were enrolled in the CIA course during the 2nd semester of the academic year 2022 participated in this study.

3.2.3. Research Instruments and Validity/Reliability Assessment

The following instruments were utilized during Phase 2, and their validity and reliability were assessed as follows:

1. **Instruction Plan:** The instruction plan developed during Phase 1 was implemented as per the established schedule. The instruction plan comprised 16 units with 8 lessons and underwent evaluation by five experts, receiving a high rating (mean = 4.68, S.D. = 0.178). Consequently, the instruction plan was deemed suitable for implementation.
2. **Achievement Tests:** Participants underwent various achievement tests throughout the intervention, including pretests, mid-term tests, post-tests, and a 2-week retest.

The researchers administered a try-out test comprising 100 items that met the validity criteria (IOC index > 0.8) as determined by five academic experts. This test was given to 30 third-year BA students who had previously completed the course. The results indicated that 93 items demonstrated high reliability (KR-20 = 0.9755, Cronbach's Alpha = 0.976) and appropriate difficulty and discrimination levels (P and r between 0.2 and 0.8). Consequently, the test items were approved for use in the pretest, post-test, and 2w-retest examinations.

3. **CICT Skills Evaluation Form:** This form was employed by the instructor to assess participants' CICT skills through their engagement in various activities such as practices, solo assignments, group assignments, and learning activities. A rubric score form was utilized to evaluate three CICT skills, ensuring validity and interrater reliability (IRR). The average IOC validity score from five experts was 0.911, with a standard deviation of 0.105. Additionally, 50 items were assessed using the CICT evaluation form by the instructor and an independent certified MS Office specialist (two raters). The IRR was confirmed through correlation (r) coefficients, indicating agreement levels for all CICT skills was 0.971 (use and understand: $r = 0.819$; create: $r = 0.783$; access: $r = 0.739$). Hence, the CICT evaluation form was validated.
4. **Online Satisfaction Questionnaire:** Participants were administered an online satisfaction questionnaire upon the conclusion of the course in week 18. A satisfaction questionnaire consisting of 16 items was evaluated by the five experts and determined to be ready for implementation (mean IOC index = 0.96, S.D. = 0.98). Subsequently, the questionnaire was formatted for online use.

Finally, the BA-TPACK blended learning model was revised with increased detail compared to the original draft.

3.2.4. Procedures

The step-by-step procedures followed in Phase 2 were as follows:

1. Orientation and consent: The researchers introduced the learning objectives and obtained voluntary consent from participants to participate in the study.
2. Pretest and baseline data collection: Participants completed the pretest achievement test.
3. Implementation of the BA-TPACK model: The instruction followed the processes and steps of the BA-TPACK model for 16 weeks (3 h per week) from January to April 2023. After completing the model, participants took the post-test achievement test, the satisfaction questionnaire, and the CICT skills assessment.
4. 2-week retest: Two weeks after the intervention, participants completed the achievement test again.

3.2.5. Data Analysis

The data analysis techniques employed in Phase 2 were as follows:

- Achievement scores from the pretest, post-test, and 2-week retest were analyzed and compared using one-way repeated measures ANOVA and Tukey's post hoc tests.
- Participants' CICT skills were compared against the 80% benchmark using one-sample *t*-tests.
- Participants' satisfaction levels were analyzed using descriptive statistics (mean and standard deviation).
- Demographic data were analyzed using frequency and percentage.

The independent variable was the BA-TPACK blended learning Model, while the dependent variables were achievement scores, CICT skills, and satisfaction levels. The hypotheses tested were as follows:

- Participants' achievement scores would significantly differ between the pretest, post-test, and 2-week retest at the 0.01 level.
- Participants' CICT skills after the intervention would be significantly higher than the 80% benchmark at the 0.01 level.

4. Results

4.1. Learner Characteristics and Needs Assessment

This subsection provides an overview of learner characteristics and their identified needs concerning the CIA course.

4.1.1. Development of the Blended Learning Model (BLM)

In Phase 1, we embarked on developing a preliminary draft of the blended learning model (BLM) based on the Technological Pedagogical and Content Knowledge (TPACK) framework. The primary goal was to bolster the Computer and Information Communication Technology (CICT) skills and academic achievement of undergraduate students.

The draft BLM comprised three core components, pre-class, during-class, and after-class activities, depicted as a cyclical process of online and offline engagements. Pre-class activities were designed to prepare students for upcoming lessons, while during-class activities took place in traditional face-to-face classroom settings. After-class activities centered on lesson review and reflective practices.

Moreover, the draft model incorporated six key components derived from the TPACK framework:

- Technological Knowledge (TK);
- Pedagogical Knowledge (PK);
- Content Knowledge (CK);

- Technological Pedagogical Knowledge (TPK);
- Pedagogical Content Knowledge (PCK);
- Technological Content Knowledge (TCK).

Each component played a crucial role in guiding instructional design and implementation to effectively integrate technology, pedagogy, and content knowledge into the learning process.

4.1.2. Learner Needs Assessment

The learner needs assessment for the CIA course was presented, offering insights into the perceived importance and success degree of various learning activities among BA undergraduates. The Priority Needs Index Modified (PNI_{modified}) was utilized to evaluate the significance of each activity.

4.1.3. Learner Needs Assessment Results

The results of the learner needs assessment for the CIA course are presented in Table 4, offering insights into the perceived importance and success degree of various learning activities among BA undergraduates. The Priority Needs Index Modified (PNI_{modified}) serves as a measure to evaluate the significance of each activity, with higher values indicating greater importance [63,64].

Table 4. Learner needs assessment for the CIA course ($n = 110$).

Learning Activities	Important (I)	Degree to Success (D)	PNI _{modified}	Ranking
1. Ethics and Discipline				
Active and engagement	4.22	3.96	0.071	3
Attendance criteria	4.11	4.03	0.023	4
Online learning	4.39	3.88	0.159	1
Online assignments	4.48	4.00	0.147	2
2. Knowledge				
Online tests	3.76	3.72	0.021	3
Research and presentation	3.69	3.64	0.017	4
E-learning and e-Book	3.66	3.56	0.027	2
Online sharing	3.83	3.72	0.029	1
3. Intellectual practice				
Solo design project	3.75	3.60	0.044	1
Soft skills	3.73	3.66	0.016	3
In-class practices	3.81	3.74	0.019	2
Out-class practices	3.87	3.83	0.012	4
4. Relationships				
Work-based learning	4.03	3.88	0.041	3
Group design project	4.00	3.90	0.027	4
Decision making	4.17	3.80	0.095	2
Online collaboration	4.23	3.79	0.117	1
5. CICT skills				
Web services	4.33	3.93	0.100	2
Business applications	4.06	3.75	0.086	4
Online tools	4.13	3.78	0.087	3
Social networks	4.25	3.74	0.137	1

The methodology of ‘needs assessment’ has been a pivotal aspect of research across various contexts, with its roots tracing back to initiatives by the United Nations Development Programme (UNDP) in the 1990s [11,12,66]. Other scholars like Shea [67] and Ul Haq [68] have highlighted its systematic approach, which aids in gathering comprehensive data on social, economic, and environmental conditions by engaging individuals to understand their unique circumstances, aspirations, and challenges.

In Thailand, the concept of needs assessments has evolved into the PNI_{modified} (Priority Needs Index) formula [63], which assesses and prioritizes development needs based on various indicators and criteria tailored to Thailand's specific context and requirements [64]. The formula for calculating the outcome of this process was as follows [69].

$$\text{PNI}_{\text{Modified}} = (I - D)/D \quad (1)$$

PNI = priority needs index

I = the mean for the intended outcome

D = the mean for the actual results or success

While the UNDP's groundwork laid the foundation for targeted global development efforts, the adaptation of this approach into formulas like PNI_{modified} in Thailand reflects an ongoing commitment to comprehensively addressing community needs [14,15,70,71].

Various studies illustrate the practical application of needs assessments. The work of [15] has highlighted their role in aiding educators in developing management skills and competency, while [11] utilized PNI_{modified} to rank digital competencies among students in Thai open universities. The work in [12] reported on teacher management strategies in private elementary schools, and [66] emphasized educator needs in developing smart schools, focusing on staff, management, media use, and supporting technology.

In Table 4, several key findings emerge:

Ethics and Discipline: BA students prioritize the need for online learning and monitoring their progress outside the classroom, as evidenced by the high PNI_{modified} value for activities related to online learning and assignments. This underscores the importance of incorporating online platforms and tools to facilitate learning and track progress.

Knowledge Development: The students express a strong need for online sharing and collaborative learning, indicating a preference for peer interaction and knowledge exchange through online channels. This emphasizes the significance of incorporating collaborative activities and online resources into the curriculum.

Intellectual Practice: The students value solo design projects and in-class practices, highlighting the importance of hands-on learning experiences and skill development within the classroom environment.

Relationships and Responsibility: BA students prioritize online collaboration and decision-making activities, indicating a desire for opportunities to work collaboratively and develop interpersonal skills.

CICT Skills Development: There is a strong emphasis on the use of social networks for learning and the need for online tools and applications to enhance business practice. This highlights the importance of integrating technology-enhanced learning methods and providing access to relevant online resources to develop students' CICT skills.

Overall, the results in Table 4 suggest a clear preference for online learning and collaboration among BA undergraduates, emphasizing the need for incorporating online platforms, tools, and activities into the curriculum to enhance learning outcomes and student engagement. Additionally, the findings underscore the importance of considering students' preferences and needs when designing and implementing instructional strategies for the CIA course.

4.2. Development and Implementation of the BA-TPACK Blended Learning Model

In this subsection, we detail the development and implementation of Phase 2's BA-TPACK blended learning model (BLM) and its impact on student outcomes (Figure 4).

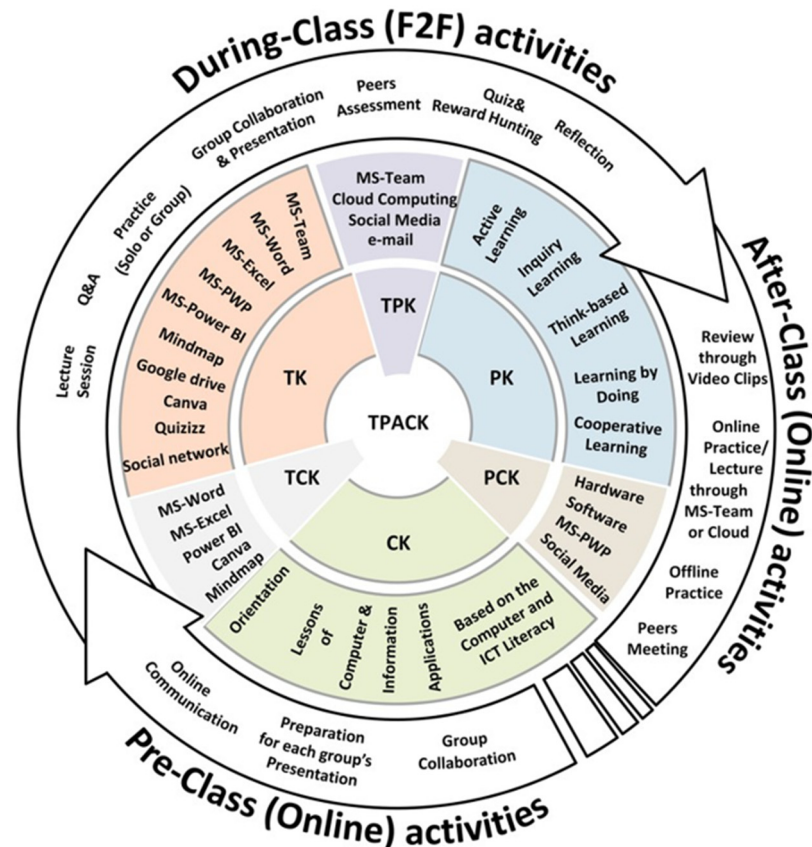


Figure 4. The BA-TPACK learning model (Source: Authors).

4.2.1. Development of the BA-TPACK Blended Learning Model (BLM)

This section offers an overview of the BA-TPACK blended learning model (BLM), detailing its components and alignment with the Technological Pedagogical and Content Knowledge (TPACK) framework.

The BA-TPACK BLM was developed in Phase 2 to enhance the Computer and Information Communication Technology (CICT) skills and academic achievement of Thai Business Administration (BA) undergraduate students. The model was designed to integrate technological, pedagogical, and content knowledge seamlessly to optimize learning outcomes.

Key Components of the BA-TPACK BLM:

1. Technological Knowledge (TK): This component emphasizes the understanding and utilization of various technologies relevant to the CIA course.
2. Pedagogical Knowledge (PK): Focuses on effective teaching strategies and instructional methods tailored to the needs of BA undergraduate students.
3. Content Knowledge (CK): Encompasses the subject matter expertise required for teaching and learning in the CIA course.
4. Technological Pedagogical Knowledge (TPK): Integrates technology and pedagogy to facilitate meaningful learning experiences.
5. Pedagogical Content Knowledge (PCK): Addresses the intersection of pedagogy and content knowledge to enhance teaching effectiveness.
6. Technological Content Knowledge (TCK): Integrates technology and content knowledge to support effective instructional design and delivery.

Alignment with the TPACK Framework:

The BA-TPACK BLM aligns closely with the TPACK framework by integrating technological, pedagogical, and content knowledge into the instructional design process. By incorporating these components, the model aims to create a dynamic learning environment

that fosters the development of CICT skills and promotes academic achievement among BA undergraduate students.

4.2.2. Implementation of the BA-TPACK Blended Learning Model (BLM)

This section delves into the implementation process of the BA-TPACK blended learning model (BLM), elucidating its application in enhancing student outcomes.

Implementation Process:

The implementation of the BA-TPACK BLM involved a systematic approach to integrate the model into the instructional design of the CIA course for Thai BA undergraduate students. The following steps were undertaken:

1. **Model Familiarization:** Educators and instructional designers familiarized themselves with the components and principles of the BA-TPACK BLM, ensuring a comprehensive understanding of its objectives and methodologies.
2. **Curriculum Integration:** The BA-TPACK BLM was seamlessly integrated into the existing curriculum of the CIA course, aligning with the course objectives and learning outcomes.
3. **Resource Preparation:** Adequate resources and materials were prepared to support the implementation of the model, including digital learning materials, technological tools, and instructional aids.
4. **Training and Support:** Faculty members received training and ongoing support to effectively implement the BA-TPACK BLM, including workshops, seminars, and one-on-one consultations with instructional designers.
5. **Classroom Implementation:** The model was implemented in the classroom setting, with educators employing a blend of online and offline instructional strategies to engage students and facilitate learning.
6. **Monitoring and Evaluation:** Continuous monitoring and evaluation were conducted throughout the implementation process to assess student progress, identify challenges, and make necessary adjustments to optimize learning outcomes.

Application in Enhancing Student Outcomes:

The BA-TPACK BLM demonstrated efficacy in enhancing student outcomes across various dimensions, including academic achievement, CICT skills development, and overall satisfaction with the learning experience. By integrating technological, pedagogical, and content knowledge, the model provided students with a holistic learning experience that fostered a deeper understanding and application of course concepts. Additionally, the blended learning approach promoted student engagement and autonomy, enabling them to take ownership of their learning journey and achieve meaningful learning outcomes. Overall, the implementation of the BA-TPACK BLM yielded positive results and contributed to the enhancement of student outcomes in the CIA course.

4.3. Impact of the BA-TPACK BLM on Student Outcomes

In this subsection, we present the findings related to the impact of the BA-TPACK BLM on student achievement and CICT skills development.

4.3.1. Achievement Scores Analysis

Descriptive statistics and analysis of achievement scores at different assessment points (pretest, post-test, and 2-week retest) are provided (Table 5), indicating the effectiveness of the BA-TPACK BLM in improving student performance. The scores were measured at three different times: pretest, post-test, and 2-week retest.

- **Pretest:** The average score is 40.22, with a standard deviation of 15.44.
- **Post-test:** The average score significantly increases to 78.19, with an S.D. of 16.71.
- **2W-Retest:** The average score further improves to 81.39, with an S.D. of 11.84.

Table 5. The descriptive statistics of the achievement scores. (n = 179).

Achievement Scores	Mean	Std. Deviation
Pretest	40.22	15.44
Post-test	78.19	16.71
2W-Retest	81.39	11.84

The repeated measures one-way analysis of variance (ANOVA) was conducted to assess changes in achievement scores across pretest, post-test, and 2-week retest intervals for a total of 179 participants. The results revealed a significant effect of time on achievement scores, indicating that the BA-TPACK learning model had a noticeable impact on student performance (Wilks' Lambda = 0.126, $F(2, 177) = 0.061$, $p < 0.01$). Further pairwise comparisons confirmed the significant differences between each test time, demonstrating a consistent increase in scores over time ($p < 0.01$).

Specifically, students exhibited a substantial improvement in achievement scores from the pretest (mean = 40.22, S.D. = 15.44) to the post-test (mean = 78.19, S.D. = 16.71), signifying the effectiveness of the instructional intervention (Table 6). Notably, the highest mean score of 81.39, S.D. = 11.84 was achieved during the 2-week retest (2W-Retest), indicating sustained learning gains even after the course had concluded. These findings underscore the positive impact of the BA-TPACK learning model on enhancing student achievement in Computer and Information Applications.

Table 6. The pairwise comparisons.

(I) Test Time	(J) Test Time	Mean Difference (I-J)	Standard Error (SE)	Sig.*
Pretest	Post-test	−37.972 ***	1.524	0.000
	2W-Retest	−41.173 ***	1.242	0.000
Post-test	Pretest	37.972 ***	1.524	0.000
	2W-Retest	−3.201 ***	0.667	0.000
2W-Retest	Pretest	41.173 ***	1.242	0.000
	Post-test	3.201 ***	0.667	0.000

Note: *** Sig. < 0.001.

Table 6 shows pairwise comparisons between the achievement scores at different test times, along with mean differences and statistical significance.

- Pretest vs. Post-test: The mean difference is −37.972, indicating a significant increase in scores from pretest to post-test ($p < 0.001$).
- Pretest vs. 2W-Retest: The mean difference is −41.173, showing a significant improvement in scores from the pretest to the 2-week retest.
- Post-test vs. 2W-Retest: The mean difference is −3.201, indicating a slight decrease in scores from the post-test to the 2-week retest, although still statistically significant.

These results suggest a notable enhancement in achievement scores over time, with significant improvements observed from pretest to post-test and 2-week retest. However, there is a slight decrease in scores between the post-test and 2-week retest, albeit still showing significant improvement compared to the pretest.

4.3.2. CICT Skills Development Analysis

The results of the one-sample t-tests were analyzed to compare the average CICT skills scores of undergraduate students with a predefined criterion of 80%. The null hypothesis tested whether the average CICT skills scores exceeded 80% [72]. Table 7 provides descriptive statistics of the CICT skills scores, including use and understand, create, and access skills, as well as the total average score. The mean scores for use and understand, create, and access skills were found to be 98.44%, 90.21%, and 85.63%,

respectively, with a total average score of 91.76%. These scores indicate that students performed significantly above the 80% criterion level in all three categories of CICT skills.

Table 7. The satisfaction level of the new blended learning model ($n = 106$).

Items	Mean	S.D.	Interpret
TK	4.54	0.69	Strongly agree
PK	4.62	0.60	Strongly agree
CK	4.60	0.59	Strongly agree
TPK	4.63	0.61	Strongly agree
PCK	4.63	0.57	Strongly agree
TCK	4.64	0.58	Strongly agree
TPACK	4.61	0.61	Strongly agree
Pre-class	4.60	0.71	Strongly agree
During-class	4.57	0.64	Strongly agree
After-class	4.59	0.62	Strongly agree
Use and Understand	4.72	0.51	Strongly agree
Create	4.69	0.52	Strongly agree
Access	4.73	0.50	Strongly agree
BA-TPACK	4.65	0.58	Strongly agree

The outcomes of the one-sample *t*-tests conducted to assess the significance levels (*p*-values) for each category of CICT (Communication and Information Communication Technology) skills are detailed in the following:

Use and understand skills: the mean score for use and understand skills was 77.91, with a *p*-value of 0.000, indicating statistical significance. The mean difference between the observed scores and the criterion value of 80% was 18.44%.

Create skills: for create skills, the mean score was 30.54, with a *p*-value of 0.000, also demonstrating statistical significance. The mean difference from the criterion value was 10.20%.

Access skills: access skills yielded a mean score of 5.97, with a *p*-value of 0.000, indicating statistical significance. The mean difference from the criterion value was 5.63%.

Total: The overall mean score across all CICT skills was 38.00, with a *p*-value of 0.000, highlighting statistical significance. The total mean difference from the criterion value was 11.76%.

The results suggest that the 179 undergraduate students made significant advancements in their CICT skills, particularly in the areas of use and understand, create, and access skills while participating in the BA-TPACK BLM. The consistent statistical significance across all skill categories, as indicated by the *p*-values below 0.01, provides robust evidence to reject the null hypothesis, indicating genuine skill development. The substantial mean differences from the criterion value further emphasize the effectiveness of the instructional intervention in fostering skill acquisition and proficiency among the participants. These findings underscore the positive impact of the BA-TPACK BLM in enhancing students' capabilities in utilizing communication and information communication technology tools effectively.

4.3.3. Student Satisfaction with the BA-TPACK BLM

Findings on student satisfaction with the BA-TPACK BLM, including its components and outcomes, are presented, highlighting high levels of satisfaction across various aspects of the model.

The results indicate that the participants' satisfaction with the new blended learning model, including its various components and outcomes, reached a strongly agreed level, with mean scores ranging from 4.54 to 4.73 and standard deviations from 0.50 to 0.71. The participants strongly agreed with all components of the model, including technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), technological

pedagogical knowledge (TPK), pedagogical content knowledge (PCK), technological content knowledge (TCK), and overall TPACK. They also strongly agreed with the pre-class, during-class, and after-class activities facilitated by the model.

Furthermore, the participants expressed strong agreement with the development of Computer and Information Communication Technology (CICT) skills, including use and understand, create and access skills. The mean satisfaction level for the overall BA-TPACK model was 4.65, with an S.D. of 0.58, indicating a high level of satisfaction across all the aspects evaluated.

4.4. Analysis of Student Hardware and Software Support

Ensuring adequate hardware and software support is crucial for facilitating effective learning experiences, particularly in the context of technology-enhanced education. In this section, we analyze the availability and proficiency levels of hardware and software among the participants, shedding light on the technological resources accessible to them. Understanding these factors is essential for optimizing instructional strategies and addressing potential barriers to learning.

4.4.1. Learner Hardware Support

Table 8 provides comprehensive details on learners' access to hardware support tools, including personal computers, laptops, tablets, smartphones, digital cameras, and internet connectivity. Assessing the availability of these devices among participants offers insights into their technological infrastructure and potential limitations that may affect their learning experiences.

Table 8. The hardware support for learning activities ($n = 110$).

Items	Available (n)	% Available	Able to Provide (n)	%	Not Available (n)	%
Own PC	28	25.46	54	49.09	28	25.45
Laptop	59	53.63	36	32.72	15	13.63
iPad/Tablet	95	86.36	11	10.00	4	3.63
iPhone/Smart Phone	105	95.45	5	4.54	0	0.00
Digital Camera	25	22.72	51	46.36	34	30.90
Available Internet	97	88.18	12	10.90	1	0.00

4.4.2. Learner Software Support

The data presented in Table 9 explore the availability and proficiency levels of various software utilized for learning activities. By examining the accessibility and skill levels associated with software applications such as MS Office, Moodle, Canva, and others, we gain valuable insights into the technological competencies of the participants. Furthermore, identifying disparities in software proficiency highlights areas for targeted intervention and skill development initiatives.

Table 9. The software for learning activities ($n = 110$).

Software	Available (n)	% Available	Able to Provide (n)	%	Not Available (n)	%
MS Office	70	63.63	37	33.63	3	2.72
MS Team	96	87.27	14	12.73	0	0.00
Moodle	6	5.45	61	55.45	43	39.09
Canva	90	81.81	20	18.18	0	0.00
MS Word	95	86.36	15	13.63	0	0.00
MS Excel	74	67.27	36	32.72	0	0.00
MS PWP	90	81.81	20	18.18	0	0.00
Power BI	10	9.09	62	56.36	38	34.54

Among the software listed, MS Team, MS Word, MS Excel, MS PowerPoint, and Canva were widely available to the participants, with high percentages of availability ranging from 81.81% to 87.27%. Additionally, a significant portion of participants demonstrated proficiency in using the software, with percentages ranging from 13.63% to 33.63%.

The analysis of student hardware and software support underscores the importance of addressing technological gaps and promoting equitable access to resources for all learners. Strategies aimed at enhancing proficiency levels in essential software applications and bridging disparities in hardware accessibility can significantly contribute to the effectiveness of technology-integrated educational initiatives.

However, the data highlight a notable disparity in the availability and proficiency levels for Moodle (LMS) and Power BI compared to other software. Only a small percentage of participants had access to Moodle (5.45%) and Power BI (9.09%), indicating limited availability of these platforms among the participants. Moreover, the proficiency levels for Moodle and Power BI were considerably lower, with only 55.45% and 56.36% of participants, respectively, demonstrating an ability to use them.

These findings suggest a need for focused attention on training and skill development for Moodle and Power BI, as they are essential tools for learning activities but are currently underutilized and underdeveloped among the participants. Strategies such as targeted training sessions and collaborative learning activities may be beneficial in enhancing participants' proficiency in using these platforms. Additionally, the participants' expressed needs for access to technology and equipment, as well as their expectations for engaging in learning activities, should be considered in designing future instructional interventions.

5. Discussion

The findings of this study underscore the transformative potential of the BA-TPACK learning model in enhancing student learning outcomes within the context of the Computer and Information Applications (CIA) course. Through a comprehensive analysis of 179 BA undergraduates over 18 weeks, significant improvements were observed in both academic achievement and Computer and Information Communication Technology (CICT) skills. Additionally, their CICT skills, encompassing use and understand, create, and access abilities, saw a marked improvement, with all students achieving scores above the 80% threshold.

The success of the BA-TPACK model can be attributed to its flexible approach to learning activities [73], which is facilitated by a variety of instructional tools and media. A crucial aspect of this flexibility lies in the initial stage of instructional design, where the researchers analyzed the background and context of the BA students. Through survey questionnaires and needs assessments [9–15], valuable insights into learners' expectations and limitations were gained. Notably, it was discovered that a small percentage of students faced challenges accessing online resources outside the classroom or at home [74,75]. This underscores the importance of carefully selecting educational technology that supports both offline and online learning environments [76].

The BA-TPACK model, grounded in the Technological Pedagogical and Content Knowledge (TPACK) framework, facilitated flexible instructional approaches tailored to the diverse technological backgrounds of students. By leveraging various instructional tools and media, such as MS Team, MS PowerPoint, and Power BI, students were able to develop their digital literacy alongside core CICT skills [2,77,78]. The incorporation of just-in-time formative assessment enabled timely adjustments to instructional practices, addressing students' technology-related challenges effectively.

As highlighted by previous studies, the design of blended learning (BL) settings requires careful consideration of contextual factors to ensure optimal outcomes [79]. Differences in application platforms, such as variations in MS Office functions across different devices, can present challenges for students. The prevalence of smartphones among participants compared to PCs and laptops further emphasizes the need for tailored instructional design that accounts for platform differences [80]. Integrating online and face-to-face (F2F)

approaches in the CIA course adds another layer of complexity [81], underscoring the importance of aligning instructional strategies with students' technological preferences and capabilities.

Drawing on recommendations from the literature analyzing post-pandemic scenarios, it is evident that implementing high-quality BL involves navigating various strengths [22–42] and challenges [37,43–46].

Building institutional BL frameworks grounded in theoretical and contextual perspectives is crucial for adapting education delivery methods in higher education. In this study, careful attention was given to all components of instructional design, with a focus on integrating educational technologies to suit the specific context, needs, and expectations of BA undergraduates.

A key strength of the BA-TPACK model lies in its adaptability to different learning contexts and environments [6,82,83]. The initial analysis of students' entry behaviors and learner traits revealed the varying technological access and proficiency levels among participants. Despite some students facing obstacles such as limited internet connectivity or access to personal computers, the majority recognized the importance of online technologies for their learning journey. This highlights the model's ability to accommodate learners' needs and provide appropriate support through instructional design.

Furthermore, the results of the 2w-retest demonstrated sustained learning retention among participants, indicating the long-term efficacy of the BA-TPACK model. Student satisfaction levels were notably high, with strong agreement across all components of the blended learning experience. While some students expressed concerns about the workload associated with pre-class and after-class activities, many appreciated the flexibility and support provided by the instructional tools.

Comparative analyses with studies from other regions, such as the interior of mainland China [84,85] and India [77], shed light on common challenges and opportunities in online learning environments. Issues such as Wi-Fi efficiency [84], information literacy skills [85], and digital literacy were identified as key obstacles in these contexts. However, the proactive attitude of BA undergraduates in overcoming these challenges underscores the importance of learner-centered approaches and targeted instructional support.

Overall, the findings highlight the potential of the BA-TPACK model to enhance student learning outcomes in the context of the CIA course. By leveraging flexible instructional approaches and considering students' diverse technological backgrounds [86], the model demonstrates promise for improving both academic achievement and CICT skills among BA undergraduates.

In conclusion, the BA-TPACK learning model represents a promising approach to enhancing student learning outcomes in the BA undergraduate curriculum. By integrating flexible instructional strategies and leveraging technology effectively, educators can empower students to develop essential skills for success in the digital age. Moving forward, continued research and refinement of instructional practices will be crucial in further optimizing the BA-TPACK BLM and maximizing its impact on student learning and achievement.

6. Conclusions

The empirical findings presented in this study unequivocally demonstrate the significant impact of the BA-TPACK blended learning model on enhancing the Computer and Information Communication Technology (CICT) skills and academic achievement of BA undergraduate students enrolled in the CIA course. As a result, the BA-TPACK model holds promise as a viable solution for addressing the challenges of digital literacy and CICT skills development among students in Thailand and beyond.

The flexibility inherent in the blended learning (BL) model, coupled with the adaptive nature of the Technological Pedagogical and Content Knowledge (TPACK) framework, enables educators to seamlessly integrate technology, pedagogy, and content to meet the diverse needs of learners. Numerous educators and researchers have attested to the efficacy of the TPACK framework across various training domains, from leveraging social media

for educational purposes to fostering interactive online teamwork. The BA-TPACK model represents a tailored application of this framework, specifically designed to enhance CICT skills among BA undergraduate students within the context of the CIA course.

Looking ahead, future research endeavors could explore the applicability of the BA-TPACK model to other courses within the BA curriculum or extend its implementation to different fields altogether. By expanding the scope of inquiry, researchers can further validate the efficacy and versatility of the BA-TPACK model in fostering holistic student development in the digital age.

In essence, the findings of this study underscore the transformative potential of the BA-TPACK learning model in preparing BA undergraduate students for success in an increasingly technology-driven world. Through continued refinement and implementation, the BA-TPACK model stands poised to shape the future of education by empowering students with the essential skills and competencies needed to thrive in the digital era.

Author Contributions: Conceptualization, C.N., T.K. and P.P.; methodology, C.N.; software, C.N.; validation, C.N., P.P., S.S. and K.B.; formal analysis, C.N.; investigation, C.N. and K.B.; resources, C.N.; data curation, C.N. and K.S.; writing original draft preparation, C.N.; writing review and editing, C.N. and K.S.; visualization, C.N. and K.S.; supervision, P.P. and S.S.; project administration, C.N. and K.S.; funding acquisition, C.N. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Ethical considerations were carefully addressed throughout this study. Approval was obtained from the Institution Human Research Ethics Management Committee Board of KRIS (KMITL Research and Innovation Services), with the assigned ID.no. EC KMITL_66_029. Participants were duly informed about the study and provided their consent by signing a consent form before its commencement. They were informed of their right to withdraw from the activities at any point during the teaching intervention, and none opted to withdraw from this study. All research procedures adhered to the code of ethics stipulated by KRIS.

Informed Consent Statement: Informed consent was obtained from all subjects involved in this study. Written informed consent has been obtained from the participant(s) to publish this paper.

Data Availability Statement: <https://tinyurl.com/3dppkecn> (accessed on 18 April 2024).

Acknowledgments: The authors wish to thank Ajarn Charlie for his guidance and support in the manuscript's multiple revisions English language editing and final proofing.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

BA	Business Administration
BA-TPACK	Business Administration- Technological Pedagogical and Content Knowledge
BL	Blended Learning
BLM	Blended Learning Model
CIA	Computer and Information Applications
CICT	Computer and Information and Communication Technology
F2F	Face to Face
KMITL	King Mongkut's Institute of Technology Ladkrabang
TPACK	Technological Pedagogical and Content Knowledge
2w-retest	2 Weeks Retest

References

1. Parnich, V. *Teacher for Student: Flip Your Classroom*; SR Printing Mass Product Ltd.: Bangkok, Thailand, 2013.
2. Umnapiang, P. The development of intelligence learning media for improving occupational competence in Thailand Information and Digital Content Competency Level 3. *J. Tech. Educ. Train.* **2022**, *14*, 14–23. Available online: <https://tinyurl.com/42x9fbk9> (accessed on 8 April 2024).

3. MHESI. *Higher Education, Science, Research and Innovation Development: From Pandemic Recovery to Sustainability*; Ministry of Higher Education, Science, Research and Innovation: Bangkok, Thailand, 2022. Available online: <https://tinyurl.com/bdh2ky5j> (accessed on 8 April 2024).
4. Abuhassna, H.; Van, N.T.; Yahaya, N.; Zakaria, M.A.Z.M.; Awae, F.; Al Zitawi, D.U.D.; Bayoumi, K. Strategies for successful blended learning-A bibliometric analysis and reviews. *Int. J. Interact. Mob. Technol.* **2022**, *16*, 66–80. [CrossRef]
5. Liu, H.; Kong, D.; Zhang, Z.; Shu, J.; Cao, T. Cloud-class blended learning pattern innovation and its applications. In Proceedings of the 2017 International Symposium on Educational Technology (ISET), Hong Kong, China, 27–29 June 2017; IEEE: Piscataway, NJ, USA, 2017; pp. 19–23.
6. Thakkar, A. Blended learning: The new normal. In *The Blended Teaching and Learning-Methods & Practices*; Shanmugam, P., Ed.; A2Z EduLearning Hub Research and Publications: Kerala, India, 2023.
7. Müller, F.A.; Wulf, T. Blended learning environments that work: An evidence-based instructional design for the delivery of qualitative management modules. *Int. J. Manag. Educ.* **2021**, *19*, 100530. [CrossRef]
8. Dick, W.; Carey, L.; Carey, J.O. *The Systematic Design of Instruction*; Pearson Education: Hoboken, NJ, USA, 2015.
9. Al-Ismail, M.S.; Naserallallah, L.M.; Hussain, T.A.; Stewart, D.; Alkhiyami, D.; Abu Rasheed, H.M.; Nazar, Z. Learning needs assessments in continuing professional development: A scoping review. *Med. Teach.* **2023**, *45*, 203–211. [CrossRef] [PubMed]
10. Borriraklert, A.; Kiattisin, S. User experience design (UXD) competency model: Identifying well-rounded proficiency for user experience designers in the digital age. *Arch. Des. Res.* **2021**, *34*, 61–79. [CrossRef]
11. Chanyawudhiwan, G.; Mingsiritham, K.; Brahmawong, W. An analysis of digital competencies of the digital open universities. *Kasetsart J. Soc. Sci.* **2023**, *44*, 1101–1108. Available online: <https://tinyurl.com/s76kf98s> (accessed on 8 April 2024).
12. Chimnoy, W.; Xupravati, P.; Siribanpitak, P. Academic management strategies of private elementary schools based on the concept of quality citizenship attributes in the 21st century. *Kasetsart J. Soc. Sci.* **2023**, *44*, 1039–1050. Available online: <https://tinyurl.com/584huf92> (accessed on 8 April 2024).
13. Khang, A.; Jadhav, B.; Birajdar, S. Industry Revolution 4.0: Workforce competency models and designs. In *Designing Workforce Management Systems for Industry 4.0*; CRC Press: Boca Raton, FL, USA, 2023; pp. 11–34. [CrossRef]
14. Prasittichok, P.; Klaykaew, K.K. Meta-skills development needs assessment among undergraduate students. *Heliyon* **2022**, *8*, e08787. [CrossRef]
15. Sittisak, R.; Sukkamart, A.; Kantathanawat, T. Thai Pre-Service Teacher Learning Management Model Development for Online Learning and Coaching. *J. High. Educ. Theory Pract.* **2022**, *22*, 23–37. [CrossRef]
16. Nantha, C.; Pimdee, P.; Sitthiworachart, J. A quasi-experimental evaluation of classes using traditional methods, problem-based learning, and flipped learning to enhance Thai student-teacher problem-solving skills and academic achievement. *Int. J. Emerg. Technol. Learn.* **2022**, *17*, 20–38. Available online: <https://www.learntechlib.org/p/223205/> (accessed on 18 April 2024). [CrossRef]
17. Pamuk, S.; Ergun, M.; Cakir, R.; Yilmaz, H.B.; Ayas, C. Exploring relationships among TPACK components and development of the TPACK instrument. *Educ. Inf. Technol.* **2015**, *20*, 241–263. [CrossRef]
18. Koehler, M.J.; Mishra, P.; Cain, W. What is technological pedagogical content knowledge (TPACK)? *J. Educ.* **2013**, *193*, 13–19. [CrossRef]
19. Harris, J.B.; Phillips, M.; Koehler, M.J.; Rosenberg, J.M. TPACK/TPACK research and development: Past, present, and future directions. *Australas. J. Educ. Technol.* **2017**, *33*, 1–8. [CrossRef]
20. Niess, M.L.; Gillow-Wiles, H.; Angeli, C. *Handbook of Research on TPACK in the Digital Age*; IGI Global: Hershey, PA, USA, 2018. [CrossRef]
21. Lai, D.; Lew, S.L.; Ooi, S.Y. Modified TPACK Framework for teachers' efficiency, students' performance, and students' engagement. In Proceedings of the Sixth International Congress on Information and Communication Technology: ICICT 2021, London, UK, 25–26 February 2021; Springer: Singapore, 2022; Volume 1, pp. 827–835. [CrossRef]
22. Graham, C.R. Blended learning system: Definition, current trends, and future directions. In *The Handbook of Blended Learning: Global Perspectives, Local Designs*; Bonk, C.J., Graham, C.R., Eds.; Wiley, John & Sons: Hoboken, NJ, USA, 2006; pp. 1–21.
23. Bonk, C.J.; Graham, C.R. *The Handbook of Blended Learning: Global Perspectives, Local Designs*; Wiley+ ORM: Hoboken, NJ, USA, 2012. [CrossRef]
24. Driscoll, M. Blended learning: Let's get beyond the hype. *E-Learn* **2002**, *1*, 1–4. Available online: <https://tinyurl.com/nhe9r22j> (accessed on 8 April 2024).
25. Driscoll, M. *Web-Based Training: Creating e-Learning Experiences*; Wiley: Hoboken, NJ, USA, 2010.
26. Garrison, D.R.; Kanuka, H. Blended learning: Uncovering its transformative potential in higher education. *Internet High. Educ.* **2004**, *7*, 95–105. [CrossRef]
27. Norberg, A.; Dziuban, C.D.; Moskal, P.D. A time-based blended learning model. *On Horiz.* **2011**, *19*, 207–216. [CrossRef]
28. Siripongdee, K.; Pimdee, P.; Tuntiwongwanich, S. A blended learning model with IoT-based technology: Effectively used when the COVID-19 pandemic? *J. Educ. Gifted Young Sci.* **2020**, *8*, 905–917. [CrossRef]
29. Okaz, A.A. Integrating blended learning in higher education. *Proc. Soc. Behav. Sci.* **2015**, *186*, 600–603. [CrossRef]
30. Hassan, F.A.; Abidin, N.A.N.Z.; Abedin, N.F.Z.; Purwarno, P.; Shanthi, A. The effect of the face-to-face, online, and blended teaching modes on students' performance in listening. *Int. Res. Educ.* **2023**, *11*, 1. [CrossRef]

31. Alamri, H.A.; Watson, S.; Watson, W. Learning technology models that support personalization within blended learning environments in higher education. *TechTrends* **2021**, *65*, 62–78. [CrossRef]
32. Dangwal, K.L. Blended learning: An innovative approach. *Univ. J. Educ. Res.* **2017**, *5*, 129–136. Available online: <https://tinyurl.com/4wckev57> (accessed on 8 April 2024).
33. Reichlmayr, T. Enhancing the student project team experience with blended learning techniques. In Proceedings of the Frontiers in Education 35th Annual Conference, Indianapolis, IN, USA, 19–22 October 2005; IEEE: Piscataway, NJ, USA, 2005; p. T4F-6. [CrossRef]
34. Lu, D. Students' perceptions of a blended learning environment to promote critical thinking. *Front. Psychol.* **2021**, *12*, 696845. [CrossRef] [PubMed]
35. Dias, S.B.; Diniz, J.A. Towards an enhanced learning management system for blended learning in higher education incorporating distinct learners' profiles. *J. Educ. Technol. Soc.* **2014**, *17*, 307–319. Available online: <https://www.jstor.org/stable/jeductechsoci.17.1.307> (accessed on 18 April 2024).
36. Holden, J.T.; Westfall, P. USDLA: An instructional media selection guide for distance learning. *Online J. Space Commun.* **2021**, *6*, 14. Available online: <https://tinyurl.com/5exchnce> (accessed on 18 April 2024).
37. Ashraf, M.A.; Yang, M.; Zhang, Y.; Denden, M.; Tlili, A.; Liu, J.; Burgos, D. A systematic review of systematic reviews on blended learning: Trends, gaps, and future directions. *Psychol. Res. Behav. Manag.* **2021**, *14*, 1525–1541. [CrossRef] [PubMed]
38. Nikolopoulou, K.; Zacharis, G. Blended learning in a higher education context: Exploring university students' learning behavior. *Educ. Sci.* **2023**, *13*, 514. [CrossRef]
39. Hadiyanto, H.; Failasofah, F.; Armiwati, A.; Abrar, M.; Thabran, Y. Students' practices of 21st-century skills between conventional learning and blended learning. *J. Univ. Teach. Learn. Pract.* **2021**, *18*, 7. [CrossRef]
40. Malekigorji, M.; Hatahet, T. Classroom response system in a super-blended learning and teaching model: Individual or team-based learning? *Pharmacy* **2020**, *8*, 197. [CrossRef]
41. Collins, T.M. Investigating the Relationship between Student Perceptions of Needs Support and a Blended Learning Classroom. Ph.D. Thesis, Oklahoma State University, Stillwater, OK, USA, 2021. Available online: <https://tinyurl.com/332ahbfd> (accessed on 8 April 2024).
42. Rao, V.C.S. A new hybrid teaching methodology. *J. Res. Scholars Prof. Engl. Lang. Teach.* **2019**, *3*, ED611486. Available online: <https://eric.ed.gov/?id=ED611486> (accessed on 8 April 2024).
43. Rasheed, R.A.; Kamsin, A.; Abdullah, N.A. Challenges in the online component of blended learning: A systematic review. *Comput. Educ.* **2020**, *144*, 103701. [CrossRef]
44. Bruggeman, B.; Tondeur, J.; Struyven, K.; Pynoo, B.; Garone, A.; Vanslambrouck, S. Experts speaking: Crucial teacher attributes for implementing blended learning in higher education. *Int. High. Educ.* **2021**, *48*, 100772. [CrossRef]
45. Chowdhury, F. Blended learning: How to flip the classroom at HEIs in Bangladesh. *J. Res. Innov. Teach. Learn.* **2020**, *13*, 228–242. [CrossRef]
46. Mielikäinen, M. Towards blended learning: Stakeholders' perspectives on a project-based integrated curriculum in ICT engineering education. *Ind. High. Educ.* **2022**, *36*, 74–85. [CrossRef]
47. Valiathan, P. Blended learning models. *Learn. Circuits* **2002**, *3*, 50–59. Available online: <https://tinyurl.com/yhn9vjxm> (accessed on 8 April 2024).
48. Miller, G. *The Sound of The Third Wave: Science Fiction, Imaginary Machines and the Future of Techno*; York University: Toronto, ON, Canada, 2005; Available online: <https://tinyurl.com/bty9phkp> (accessed on 8 April 2024).
49. Andaluz-Delgado, S.; Olmedo, E.O.; Gutiérrez-Martín, N. Assessment of digital teaching competence in non-university education. *Educ. Sci.* **2023**, *13*, 1237. [CrossRef]
50. Bibi, S.; Khan, S.H. TPACK in action: A study of a teacher educator's thoughts when planning to use ICT. *Australas. J. Educ. Technol.* **2017**, *33*, 70–87. [CrossRef]
51. Ripka, G. Promoting Pre-Service Teachers' TPACK Development in Social Virtual Practice Theory-Oriented Development and Evaluation of a Pedagogical Concept for Initial Teacher Education. Ph.D. Thesis, Universität Würzburg, Würzburg, Germany, 2023.
52. Boschman, F.; McKenney, S.; Voogt, J. Exploring teachers' use of TPACK in design talk: The collaborative design of technology-rich early literacy activities. *Comput. Educ.* **2015**, *82*, 250–262. [CrossRef]
53. Sabri, S.; Abdul, M. Integration of Dick and Carey design in string ensemble class instructional material design. *Int. J. Innov. Creat. Change.* **2020**, *14*, 359–388. Available online: <https://tinyurl.com/52zue9xd> (accessed on 6 April 2024).
54. Kawasaki, J.; Sandoval, W.A. Examining teachers' classroom strategies to understand their goals for student learning around the science practices in the next generation science standards. *J. Sci. Teach. Educ.* **2020**, *31*, 384–400. [CrossRef]
55. Wu, S.Y. How teachers conduct online teaching during the COVID-19 pandemic: A case study of Taiwan. *Front. Educ.* **2021**, *6*, 675434. [CrossRef]
56. Glushchenko, V.V. Ergodesign and “specific”, “measurable”, “achievable”, “relevant”, and “time-bound” (SMART) technologies as tools for the formation of innovative leadership programs. *ASEAN J. Econ. Econ. Educ.* **2023**, *2*, 23–34. Available online: <https://tinyurl.com/3ruttw7b> (accessed on 7 April 2024).

57. Chung, E.; Noor, N.M.; Mathew, V.N. Are you ready? An assessment of online learning readiness among university students. *Int. J. Acad. Res. Prog. Educ. Dev.* **2020**, *9*, 301–317. [PubMed]
58. Asad, M.M.; Khan Soomro, R.B.; Shamsy, A.; Churi, P. Students' satisfaction towards e-assessment for academic achievement in ESL at public schools and colleges. *Educ. Res. Int.* **2021**, *2021*, 1–10. [CrossRef]
59. Bloomberg, L.D. *Designing and Delivering Effective Online Instruction: How to Engage Adult Learners*; Teachers College Press: New York, NY, USA, 2021.
60. Yulianti, T.; Sulistiyawati, A. The blended learning for student's character building. In Proceedings of the International Conference on Progressive Education (ICOPE 2019), Bandar Lampung, Indonesia, 26–27 October 2019; Atlantis Press: Amsterdam, The Netherlands, 2019; pp. 56–60. [CrossRef]
61. Dlab, M.H.; Candrilic, S.; Pavlic, M. Formative assessment activities to advance education: A case study. *J. Ed. Innov. Pract.* **2021**, *20*, 37. [CrossRef] [PubMed]
62. Ishaq, K.; Rana, A.M.K.; Zin, N.A.M. Exploring summative assessment and effects: Primary to higher education. *Bull. Educ. Res.* **2020**, *42*, 23–50. Available online: <https://tinyurl.com/5ykcxkjs> (accessed on 7 April 2024).
63. Wongwanich, S.; Wiratchai, N. A follow-up and evaluation of the government educational reform results based on the state fundamental policy and the national act. *J. Res. Meth.* **2005**, *18*, 93–124.
64. Wongwanich, S. *Needs Assessment*, 3rd ed.; Chulalongkorn University Press: Bangkok, Thailand, 2015. (In Thai)
65. Campbell, D.T.; Stanley, J.C. *Experimental and Quasi-Experimental Designs for Research*; Ravenio Books: Paris, France, 2015.
66. Choomsri, C.; Chansirisira, P. The smart school development model in the digital age under the Office of the Basic Education Commission. *J. Multidiscip. Humanit. Soc. Sci.* **2023**, *6*, 1419–1436. Available online: <https://tinyurl.com/3ada3ax7> (accessed on 8 April 2024).
67. Shea, M.A. The UNDP's Human Development Index: A User's Guide. 1997. Available online: <https://tinyurl.com/4cemu8xb> (accessed on 8 April 2024).
68. Ul Haq, M. *Reflections on Human Development*; Oxford University Press: Oxford, UK, 1995.
69. Khamcharoen, N.; Kantathanawat, T.; Sukkamart, A. Developing student creative problem-solving skills (CPSS) using online digital storytelling: A training course development method. *Int. J. Emerg. Technol. Learn.* **2022**, *17*, 29931. [CrossRef]
70. Chainut, A.; Suwanjan, P.; Pupat, P.; Pimdee, P. Needs assessment for the global-mindedness of vocational certificate students under the Office of the Vocational Education Commission. *Mediterr. J. Soc. Sci.* **2019**, *10*, 25–33. [CrossRef]
71. Pitiporntapin, S.; Butkatanyoo, O.; Piyapimonsit, C.; Thanarachataphoom, T.; Chotitham, S.; Lalitpasan, U. The development of a professional development model focusing on outdoor learning resources to enhance in-service teachers' STEM literacy. *Kasetsart J. Soc. Sci.* **2023**, *44*, 489–496.
72. Al-Naami, B.; Fraihat, H.; Owida, H.A.; Al-Hamad, K.; De Fazio, R.; Visconti, P. Automated detection of left bundle branch block from ECG signal utilizing the maximal overlap discrete wavelet transform with ANFIS. *Computers* **2022**, *11*, 93. [CrossRef]
73. Lee, C.J.; Kim, C. An implementation study of a TPACK-based instructional design model in a technology integration course. *Educ. Technol. Res. Dev.* **2014**, *62*, 437–460. [CrossRef]
74. KewalRamani, A.; Zhang, J.; Wang, X.; Rathbun, A.; Corcoran, L.; Diliberti, M.; Zhang, J. Student Access to Digital Learning Resources Outside of the Classroom. NCES 2017-098. National Center for Education Statistics. 2018. Available online: <https://tinyurl.com/3zet2kk2> (accessed on 8 April 2024).
75. Kohli, H.; Wampole, D.; Kohli, A. Impact of online education on student learning during the pandemic. *Stud. Learn. Teach.* **2021**, *2*, 1–11. [CrossRef]
76. Roddy, C.; Amiet, D.L.; Chung, J.; Holt, C.; Shaw, L.; McKenzie, S.; Mundy, M.E. Applying best practice online learning, teaching, and support to intensive online environments: An integrative review. *Front. Educ.* **2017**, *2*, 59. [CrossRef]
77. Dhawan, S. Online learning: A panacea in the time of COVID-19 crisis. *J. Educ. Technol. Syst.* **2020**, *49*, 5–20. [CrossRef]
78. Adedoyin, O.B.; Soykan, E. COVID-19 pandemic and online learning: The challenges and opportunities. *Interact. Learn. Environ.* **2020**, *31*, 863–875.
79. Tsai, C.W.; Shen, P.D.; Tsai, M.C. Developing an appropriate design of blended learning with web-enabled self-regulated learning to enhance students' learning and thoughts regarding online learning. *Behav. Inf. Technol.* **2011**, *30*, 261–271. [CrossRef]
80. Suartama, I.K.; Setyosari, P.; Ulfa, S. Development of an instructional design model for mobile blended learning in higher education. *Int. J. Emerg. Technol. Learn.* **2019**, *14*, 4–22. [CrossRef]
81. Singh, J.; Steele, K.; Singh, L. Combining the best of online and face-to-face learning: Hybrid and blended learning approach for COVID-19, post-vaccine, & post-pandemic world. *J. Educ. Technol. Syst.* **2021**, *50*, 140–171. [CrossRef]
82. Elmaadaway, M.A.N.; Abouelenen, Y.A.M. In-service teachers' TPACK development through an adaptive e-learning environment (ALE). *Educ. Inf. Technol.* **2023**, *28*, 8273–8298. [CrossRef]
83. Brianza, E.; Schmid, M.; Tondeur, J.; Petko, D. Situating TPACK: A systematic literature review of context as a domain of knowledge. *Contemp. Issues Technol. Teach. Educ.* **2022**, *22*, 707–753. Available online: <https://www.learntechlib.org/p/221446/> (accessed on 7 April 2024).
84. Yi, L. Current problems with the prerequisites for flipped classroom teaching—A case study in a university in Northwest China. *Smart Learn. Environ.* **2018**, *5*, 2. [CrossRef]

85. Wu, M. Designing for problem-based learning in information literacy instruction: A case study at University of Chinese Academy Sciences. In Proceedings of the 16th annual International Conference of Education, Research and Innovation, Seville, Spain, 13–15 November 2023. [[CrossRef](#)]
86. Pimdee, P.; Sukkamart, A.; Nantha, C.; Kantathanawat, T.; Leekitchwatana, P. Enhancing Thai student-teacher problem-solving skills and academic achievement through a blended problem-based learning approach in online flipped classrooms. *Heliyon* **2024**, *10*, e29172. [[CrossRef](#)] [[PubMed](#)]

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.