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Enhancing Algorithm and Programming Education through Collaborative Blended Learning: A Problem-Based Approach for First-Year Students

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Abstract: This research study aims to compare the learning achievements of first-year students in an algorithm and programming course before and after participating in cooperative blended learning activities focused on variables, expressions, and control commands. By utilizing problem-based learning methods, the researchers sought to meticulously analyze the profound impact of these activities on students' academic advancement. The research tools deployed encompassed satisfaction questionnaires and achievement tests. The research cohort encompassed seven experienced specialists within higher education institutions, each endowed with a minimum of ten years of pedagogical experience, along with twenty-five participating students. Employing rigorous statistical analysis via T-tests, the study conclusively revealed a statistically noteworthy enhancement in student achievement post the program, underscoring the affirmative influence of cooperative blended learning activities. Moreover, the overall satisfaction level among learners engaging in the proposed learning activities was remarkably elevated, evident through an average satisfaction rating of 4.54 and a standard deviation of 0.73. These empirical insights succinctly underscore the demonstrable effectiveness of assimilating cooperative blended learning methods within algorithm and programming education, thereby accentuating the pivotal role of these pedagogical approaches in shaping contemporary educational practices.

Index Terms: Cooperative blended learning, Algorithm and programming education, Learning achievement, Problem-based learning, Learner satisfaction

1. Introduction

Education plays a central role in national development, facilitating human resource development and equipping individuals with the necessary skills to navigate the uncertainties of the future [1,2]. In order to meet these evolving demands, continuous learning and practice are essential within the realm of education. Instructors play a crucial role in promoting learner engagement through various activities, with the integration of technology providing personalized and self-paced learning opportunities [3-6]. It is imperative to foster learners' individual growth and wisdom by employing student-centered learning management models that encourage self-sufficiency and deeper understanding of oneself and the world [7-10].

In higher education settings, such as universities, cooperative learning approaches, particularly collaborative learning, have gained significant prominence within the student-centered learning paradigm [11]. This form of learning necessitates small group interactions, allowing individuals with diverse abilities to enhance their learning capacities while fostering mutual support and achieving shared goals [12]. Blended learning, as a crucial element of education management in the context of Thailand, has been highlighted in Education Development Plan No. 11 [13,14]. This approach combines face-to-face instruction with online computer-based learning, thereby enhancing overall learning efficiency [15,16]. By leveraging computer and communication technology, blended learning creates a student-centered environment that maximizes teaching and learning experiences[17,18]. The ratio between face-to-face and online learning is carefully determined to ensure an optimal blend, catering to the specific requirements of each subject [19]–[21].

Given the significance of education in human development, it is essential to design learning activities that prioritize learners, with instructors assuming the responsibility of supporting and facilitating learning through engaging activities and creating a conducive learning community. Such an environment should provide diverse and stimulating learning resources, enabling learners to apply their acquired knowledge and generate new insights through practical experiences [22-24]. Problem-Based Learning, which utilizes group work and problem-solving as catalysts, fosters critical thinking and problem-solving skills among learners, with teachers assuming the roles of facilitators and advisors [25-27]. This approach empowers students to independently analyze and resolve problems, thereby enhancing their analytical abilities, problem-solving skills, and academic achievements [28-30].

This study aims to address the challenges encountered in teaching and learning algorithms and programming, a fundamental subject for first-year students majoring in Digital Technology for Education. The research objectives are twofold: 1) to compare the academic achievements of students before and after engaging in collaborative blended learning activities, specifically focusing on variables, expressions, and control commands, using a problem-based learning approach, and 2) to evaluate learner satisfaction within the context of these collaborative blended learning activities. The paper is structured as follows: Literature review, the method section outlines the research design, including the participants, instruments, and procedures utilized; the Results and Discussion section presents the statistical analysis of the data and provides an interpretation of the findings; the Conclusion section summarizes the key findings, underscores the significance of the study, and offers recommendations for further research.

2. Literature Review

In the literature review section, the dynamic interplay between collaborative blended learning and problem-based methodologies in the realm of algorithm and programming education were illuminated. This comprehensive exploration is compartmentalized into distinct yet interconnected sub-topics, each enriched by relevant scholarly works and their interlinkages.

2.1. Paradigm Evolution in Algorithm and Programming Education

The realm of algorithm and programming education is currently in a state of metamorphosis, catalyzed by the infusion of contemporary pedagogical strategies. This transformation is exemplified by the ascendancy of blended learning – a potent amalgamation of conventional classroom teaching and online learning modalities. This paradigmatic shift has garnered prominence owing to its potential to meaningfully engage learners and nurture a multifaceted grasp of complex subjects.

Stieben et al [31] study underscores this metamorphosis by revealing how seamlessly integrating online lessons into a problem-based learning milieu resulted in marked enhancements in students' academic performances. Similarly, Schmid et al [32] work accentuates the benefits reaped by intertwining online instruction with problem-centric learning. These findings collectively underscore the potency of blended learning in bolstering educational outcomes through its adaptable and interactive character.

Synthesizing these scholarly endeavors, it becomes increasingly apparent that the convergence of blended learning with problem-based paradigms forms a promising trajectory for dynamic and interactive education within the ambit of algorithm and programming. This alignment acknowledges the necessity to transcend the limitations of conventional pedagogies, aligning with the evolving educational milieu. Nonetheless, this nascent alliance demands a nuanced scrutiny of how to seamlessly amalgamate these strategies to yield optimal outcomes.

2.2. Nexus of Collaborative Learning and Problem-Based Approaches

At the epicenter of this paradigm shift resides the symbiotic relationship between collaborative learning and problem-based methodologies. Collaborative learning, underscored by its emphasis on peer interaction and collective knowledge dissemination, forges an intellectually enriched environment that nurtures critical thinking and peer-driven exploration. This tenet finds resonance in Kuo et al [33], which corroborates that students manifested heightened engagement and satisfaction when exposed to web-based learning models seamlessly interwoven with problem-solving exercises. This affirmation bolsters the proposition that collaborative learning, when intricately woven with problem-based methodologies, has the potential to amplify engagement and holistic comprehension.

However, this entwined synthesis also invites a discourse on the harmonization of these methodologies. While collaborative learning and problem-based approaches are poised for synergy, this harmonious blend necessitates meticulous instructional design and pedagogical coherence. The study by Chu et al [34]exemplifies the intricacies of this integration, shedding light on the intricate choreography that intertwining e-learning with problem-based pedagogies entails. This prompts an interrogation into the pragmatic reconciliation of these methodologies to elicit optimal outcomes.

2.3. Synthesis and Prognostication

In culmination, the synthesis of the aforementioned scholarly elucidations underscores the tantalizing potential latent in the confluence of collaborative blended learning and problem-based methodologies in the panorama of algorithm and programming education. These pedagogical paradigms epitomize the trajectory towards surmounting conventional pedagogical limitations by imbuing the learning experience with dynamic engagement, practical application, and collaborative inquiry. Yet, the triumphant orchestration of these methodologies is contingent upon the judicious synergy of pedagogical acumen, technological infrastructure, and harmonization with the intricacies of the subject matter.

In its capacity to foster a profound comprehension of the interplay between collaborative blended learning and problem-based methodologies within algorithm and programming education, this paper assumes the mantle of a pivotal discourse. The research augments the current understanding by delving into the repercussions of a problem-based blended learning model. By unraveling these dimensions, this study aspires to endow educators and scholars with invaluable insights to fine-tune instructional paradigms, optimally harness technology, and elevate the landscape of algorithm and programming education.

3. Methodology

The methodological framework of this research project is organized into three distinct phases, each contributing to the systematic development of a collaborative blended learning model for the algorithms and programming course.

3.1 Phase 1: Analysis and Design

This phase entails a meticulous analysis and design process, which can be further subdivided into two parts including (1) Content analysis and (2) Designing learning activity patterns.

In the initial part, we engage in an in-depth examination of the learning outcomes data from the preceding academic year. This analysis serves as a crucial foundation for guiding the development of appropriate learning activities tailored to the specific requirements of the course in algorithms and programming. By thoroughly scrutinizing the subjects, variables, expressions, and control commands inherent to this domain, we discern the principal topics and subheadings that form the basis of the study. As illustrated in the figure 1, these components are organized into three distinct chapters.

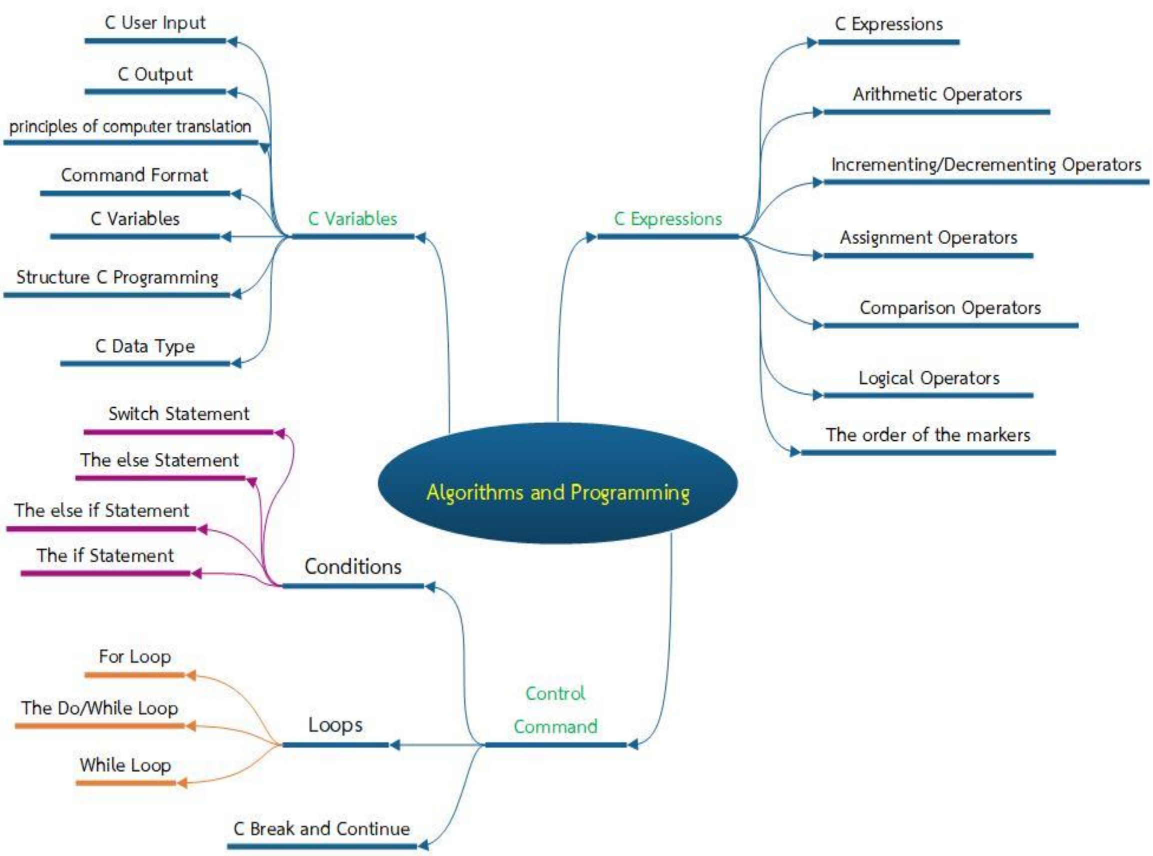

Fig. 1. Coral diagram showing the relationship of content.

Figure 1 depicts the coral diagram that comprises the analysis of learning outcomes data from the previous academic year, guiding the development of suitable learning activities for the algorithms and programming course. The subjects covered variables, expressions, and control command, with the identification and delineation of main and subheadings. Building upon the insights gained from the content analysis, we proceed to the critical task of designing learning activity patterns. Within this phase, we emphasize the incorporation of key elements derived from a collaborative blended learning model. Problem-based learning emerges as a fundamental approach, lending itself to the creation of a cohesive structure comprising three essential modules: the Learning Module, the Collaborative Module, and the Activity Module. The Activity Module, in particular, exhibits a synthetically derived functional structure, harmonizing the various components of problem-based learning activity processes that are rooted in rigorous research. To guide the design of effective learning activities, we delineate four crucial steps, namely: Step 1: Determine a problem, Step 2: Analysis, Step 3: Solving, and Step 4: Summary and Evaluation. These sequential steps serve as the foundation for the meticulous design of learning activities. The second component of Phase 1 is Designing Learning Activity Patterns, which encompasses the formulation of a collaborative blended learning activity model. Problem-based learning is employed as the foundation for this model. The activity model comprises three modules: Learning Module, Collaborative Module, and Activity Module. The Activity Module is further structured into four steps: Problem Definition, Problem Diagnosis, Problem Troubleshooting, and Summary and Evaluation. These steps are designed to guide the learning activities effectively.

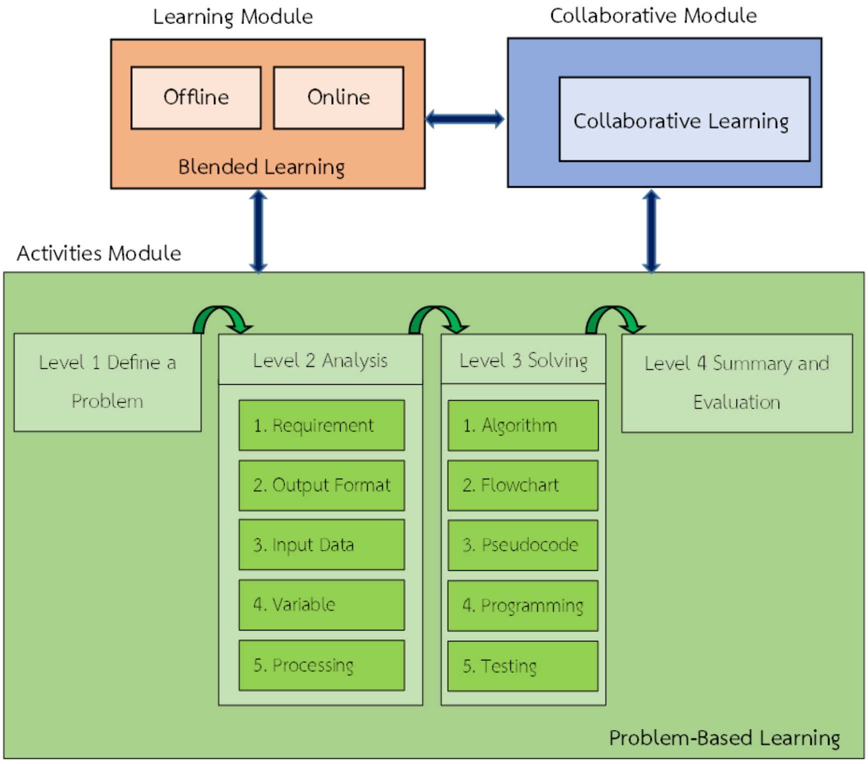

Fig. 2. Elements of a cooperative blended learning activity model through problem-based learning.

3.2 Phase 2: Tool Development

Phase 2 of this research paper focuses on the development of various tools essential to the study. These tools are designed to support the research objectives and facilitate the effective implementation of the collaborative blended learning model. The following components comprise Phase 2:

3.2.1. Lesson Management Plan:

A comprehensive course management plan and lesson management plans are prepared for each of the three chapters. These plans encompass both online and offline teaching materials, encompassing both theoretical and practical programming content. By creating well-structured lesson plans, we ensure the systematic delivery of course content.

3.2.2. Practice Exercises:

To enhance student engagement and foster problem-based learning activities, a series of practice exercises are developed. These exercises are carefully crafted to align with the behavioral objectives of each topic. They provide students with the opportunity to apply their knowledge and skills in a structured manner, following a sequence of four steps.

3.2.3. Academic Achievement Test:

To measure academic achievement, an assessment test comprising 60 questions is designed. The quality of the test is evaluated through the following procedures:

1) Content Validity:

Content validity is determined using the Index of Item Objective Congruence (IOC) technique. Purposive sampling is employed, involving seven experienced teachers with a minimum of 10 years of teaching experience in higher education institutions from six different institutions. The content validity values obtained range between 0.71 and 1.00, indicating high reliability. Values closer to 1.00 signify greater test reliability.

2) Test Analysis:

To ascertain the confidence value, difficulty value, and classification power value of the test, a sample of 40 undergraduate students enrolled in the Digital Technology for Education course is selected. The analysis reveals that the difficulty level of the test falls within the appropriate range of 0.35 to 0.75, ensuring an optimal level of challenge for students. The classification authority (r) ranges from 0.27 to 0.91, indicating an appropriate level of classification authority for the exam. The total confidence value is 0.91, approaching 1.00, which indicates a high level of confidence in the test's reliability.

3.2.4. Satisfaction Questionnaire:

A satisfaction questionnaire is developed to assess the stakeholders' perspectives on various aspects of the learning experience. The questionnaire consists of four dimensions: (1) lesson content, (2) teachers, (3) problem-based learning activities, and (4) learning evaluation. Expert opinions are sought to evaluate the appropriateness of the questions and analyze the overall quality of the questionnaire. The experts' responses indicate a high level of satisfaction, with an average score of 4.84 and a standard deviation of 0.43.

3.3 Phase 3: Activities

Phase 3 of this research project focuses on the implementation of the designed learning activities, which are divided into three main modules as depicted in Figure 2:

3.3.1. Learning Module:

The Learning Module encompasses both face-to-face classroom instruction and online learning. The instructor assumes the responsibility of supporting the learners throughout their learning journey. This includes managing lesson content, assigning tasks, preparing learning resources, conducting tests, and organizing learners into groups as deemed appropriate. Students, on the other hand, are responsible for actively engaging in the activities assigned by the instructor.

3.3.2. Collaborative Module:

The Collaborative Module fosters mutual learning exchange among group members through face-to-face and online interactions. Students are encouraged to communicate and collaborate with each other, both in the classroom and through virtual platforms. This module aims to develop their teamwork and collaboration skills while stimulating the exchange of ideas and knowledge among participants.

3.3.3. Activity Module:

The Activity Module aims to facilitate group activities that encourage learners to adopt a systematic approach to problem-solving. This module consists of a 60-question pre-study test followed by a problem-based learning activity that encompasses four sequential steps, as outlined below:

Step 1: Determine the problem:

1) Orientation: The instructor conducts an orientation session to ensure learners have a clear understanding of the learning activities.
2) Group Formation: Students are divided into groups of 4-5 individuals, creating an environment conducive to collaborative teamwork.
3) Content Delivery: The instructor delivers the necessary content for each topic and assigns similar problems to each group.

Step 2: Diagnose the problem:

Within this stage, group members collaboratively analyze and document their findings regarding the problem using the following activities:

1) Specify the problem's requirements: Students articulate the tasks they need to perform or the specific problem they aim to address.
2) Design the output format: The group collectively determines the desired format for presenting the results of their problem-solving efforts.
3) Identify the required input data: After conducting thorough analysis, students document the information necessary for completing the task.
4) Define the active variables: Group members specify the variables derived from input, processing, or configuration that are relevant to the problem at hand.
5) Outline the processing steps: Students describe the problem-solving process or data processing stages, including calculation methods, decision-making criteria, condition placement, or iterative processes, based on the nature of the problem.

Step 3: Troubleshoot the problem:

Building upon the analysis conducted in the previous step, students proceed to solve the problem using the obtained information. The activities within this step are as follows:

1) Establish solution steps: Each group member documents a sequential set of steps to solve the problem, starting from the initial stage and progressing towards the final outcome, using the paper provided by the instructor.
2) Create a flowchart: Group members translate the problem-solving process into a visual flowchart, utilizing appropriate descriptive symbols to represent the various steps.
3) Write pseudocode: Using the flowchart as a guide, each group member generates artificial code to explain the workflow of the problem-solving process.
4) Programming: Group members implement the resulting pseudocode by programming computers using the C language.
5) Program testing: Individual group members test the functionality of their created program. If any errors are detected, they collaborate to resolve them, aiming to achieve results that align precisely with the defined problem.

Step 4: Summary and Evaluation:

During this step, group members present the outcomes of their programming practices, enabling instructors and other learner groups to provide feedback, reflect on performance, and evaluate the learning outcomes achieved. This stage promotes critical analysis and constructive evaluation of the problem-solving process and the results obtained.

Upon the completion of the learning activities, the instructor instructs all learners to undertake a post-class test and satisfaction questionnaire. The questionnaire serves as a means to gauge satisfaction levels with the problem-based learning activities, allowing for the calculation of averages and standard deviations as indicators of overall satisfaction and variability among the learners' experiences.

In summary, the chosen methodology facilitates the achievement of the research objectives by providing a structured approach that enhances academic performance through problem-based learning, measures learner satisfaction, and leverages technology to create an engaging and effective learning environment. The methodology aligns with the research goals of improving student outcomes and enhancing the teaching process in algorithm and programming education.

Moreover, in our research, we ensured the reliability and accuracy of our findings through rigorous methodologies. We carefully designed our approach, selected diverse and representative participants, and employed validated data collection instruments. Pre- and post-testing minimized external influences, while robust statistical analyses provided a strong assessment of significance. Triangulation of data sources, peer review, and transparency in procedures further bolstered the study's credibility. Ethical considerations were observed to protect participant rights. We acknowledged limitations and maintained a comprehensive approach to ensure trustworthy results that contribute to the field's understanding.

4. Results

4.1. Comparison of Pre- and Post-Learning Achievement in Cooperative Blended Learning Activities: Algorithms and Programming Courses for First-Year Students

A comparison of the academic achievement before and after the study, focusing on learners' performance with cooperative blended learning activities in the context of algorithms and programming courses was shown in table 1. The specific topics covered in this study are variables, expressions, and control commands. The learning approach employed was problem-based learning, and the statistical analysis utilized a dependent t-test.

Table 1. Comparative analysis of pre- and post-learning academic achievement

		N	$\bar{x}$	S.D.	t	df	Sig
Academic achievement	**Pre-test**	25	19.04	5.48	-16.441	24	.000
	Post-test	25	40.92	8.44			

*Statistically significant at . 05

The results indicated that the average score for academic achievement on the pre-class test was 19.04 out of a total of 60 points. In contrast, the average score on the test administered after the classes was 40.92. These findings reveal a statistically significant increase in students' post-study achievement compared to their pre-study performance, at a significant level of .05.

4.2. Learner Satisfaction with Collaborative Blended Learning in Algorithm and Programming Courses for First-Year Students

The results of the satisfaction survey conducted with learners who engaged in collaborative blended learning activities in algorithm and programming courses were displayed in table 2. The study specifically focused on the subjects of variables, expressions, and control commands for first-year students, utilizing a problem-based learning approach.

Table 2. Results of student satisfaction with learning activities

Student's satisfaction	Satisfaction level		
	$\bar{x}$	S.D.	Interpretation
Instructors			
1. Have knowledge and expertise in the subjects taught	4.48	0.87	High
2. Be responsible and attend classes on time	4.52	0.77	Highest
3. Creating an atmosphere by encouraging learners to be enthusiastic about learning	4.44	0.87	High
4. There is a method of conducting teaching according to the sequence of steps from easy to rare.	4.44	0.77	High
5. Be able to answer students' questions or problems clearly.	4.64	0.70	Highest
6. Provide consistent examples to help build understanding of the content.	4.48	0.71	High
7. Able to convey content and practical methods in the subjects taught well.	4.64	0.64	Highest
8. Give students the opportunity to express their opinions Ask questions	4.68	0.69	Highest
9. Constant interaction between learners and instructors	4.76	0.66	Highest
10. There is a method of teaching and learning that encourages students to practice critical thinking skills. Design & Programming	4.48	0.77	High
11. Feedback is provided to reinforce appropriately.	4.28	1.10	High
12. Overall satisfaction with instructors	4.52	0.77	Highest
Average	4.53	0.78	Highest
Lesson content			
1. The content structure is clear and correlative, consistent with the learning objectives.	4.60	0.71	Highest
2. How to organize instruction suitable for each topic and promote learning skills according to the objectives.	4.48	0.77	High
3. Appropriateness of linking content with examples	4.44	0.77	High
4. Appropriateness of the hierarchy in presenting the content	4.44	0.71	High
5. Teaching materials are appropriate and clear.	4.64	0.70	Highest
6. Have exercises or homework programming that encourage objective learning skills	4.56	0.71	Highest
7. Adapt teaching methods or examples to suit the level of knowledge of the learners.	4.44	0.77	High
8. Overall content satisfaction	4.60	0.76	Highest
Average	4.51	0.73	Highest
3. Problem-based learning activities			
1. Consistency and appropriateness of using the problem as a base for the content of each topic.	4.40	0.87	High
2. Encourage thought processes Systematic and easy-to-understand problem solving	4.36	0.86	High
3. Promote group activities to learn and exchange ideas together to solve problems successfully.	4.52	0.87	Highest
4. Encourage learners to relate the theories they learn to solve problems in real events using consistent cause and effect. suitable	4.52	0.92	Highest
5. Promote the creation of knowledge in problem solving by means of finding diverse answers.	4.48	0.87	High
6. Encourage students to learn enthusiastically from hands-on experience.	4.32	0.85	High
7. Promote the knowledge, roles, duties and responsibilities in the group.	4.40	1.12	High
8. Overall satisfaction with problem-based learning activities	4.44	0.92	High
Average	4.43	0.90	High
4. Learning Assessment			
1. Evaluation of performance is fair.	4.72	0.46	Highest
2. The assessment covers the material learned.	4.68	0.48	Highest
3. Measurement and evaluation criteria are clearly defined in the course guide.	4.80	0.41	Highest
4. Clarity of instruction in exercises	4.64	0.49	Highest

5. Appropriateness of conditions and deadline for submission of work	4.76	0.44	Highest
6. Appropriateness of the format of the score display of each chapter	4.68	0.48	Highest
7. Teachers continuously observe and evaluate the development of learners.	4.68	0.56	Highest
8. Practice methods are collected. Performance during performance for evaluation.	4.60	0.58	Highest
9. Have a job inspection Regularly clarify the shortcomings of the tasks performed by the learners.	4.80	0.41	Highest
10. Let students know their learning outcomes continuously and consistently.	4.64	0.57	Highest
11. Overall satisfaction with assessment	4.72	0.46	Highest
Average	4.70	0.48	Highest
Overall average	4.54	0.73	Highest

Overall, the findings demonstrate a high level of satisfaction among students. The highest level of satisfaction was observed in the combined category, with a mean score of 4.54 and a standard deviation of 0.73. The satisfaction level with instructors received the next highest rating, with a mean score of 4.53 and a standard deviation of 0.78. Regarding lesson content, the satisfaction level was also high, with a mean score of 4.51 and a standard deviation of 0.73. Similarly, learners expressed very high satisfaction with the problem-based learning activities, which received a mean score of 4.43 and a standard deviation of 0.90.

5. Discussion

This study focused on organizing collaborative blended learning activities for first-year students in the algorithm and programming course, specifically targeting variables, expressions, and control commands. The results of the research are presented and discussed below.

5.1. Comparison of Pre- and Post-Study Achievement

The study revealed a statistically significant improvement in academic achievement, as indicated by a higher average score in the post-study test compared to the pre-study test ($p < 0.05$). Three key factors were identified as influencing this higher academic achievement. Firstly, the content analysis and arrangement of teaching materials in a progressive order, from easier to more challenging, contributed to sustained learner engagement throughout the learning activities. Individual student responsibilities were assigned based on their aptitudes, ensuring a sense of personal ownership and active participation within the specified timeframe. The instructor's continuous guidance, advice, and support further enhanced the learning experience. Secondly, the provision of online teaching resources through platforms like Google Classroom and video-sharing websites facilitated anytime access to learning materials. Additionally, online meeting rooms were established for each group, enabling effective collaboration and knowledge exchange. This finding aligns with many researchers which observed higher academic achievement among students who followed a problem-based learning management plan combined with online lessons compared to those following a traditional learning approach [35-37]. Consistently, [38] found a statistically significant difference in learning achievement between pre- and post-class sessions for students exposed to problem-based teaching and e-learning ($p < 0.05$). These findings support the hypothesis that the developed learning system results in significantly higher post-study achievements.

5.2. Student Satisfaction with Learning Activities

The satisfaction levels of students engaged in the organized learning activities were exceptionally high. The structured progression of learning from easy to difficult content fostered a relaxed and pressure-free environment. The presence of instructors providing guidance, explanations, and support, along with a wide range of accessible learning resources, contributed to this positive learning experience. Group activities enabled learners to exchange knowledge and collaborate towards specific goals, using problems as the basis for learning. Similarly, many researchers found high student satisfaction with web-based learning integrated with problem-solving activities.[37,39,40]. Several studies reported highly agreeable assessments of the learning atmosphere, very favorable assessments of the learning activities, and the most satisfactory assessments of the benefits derived from learning. [41, 42]

In summary, this study underscores the effectiveness of collaborative blended learning activities in enhancing academic achievements and student satisfaction. The structured progression of content and the integration of online resources significantly contribute to positive learning outcomes [43]. The alignment of these findings with prior research corroborates the robustness of the implemented approach and reinforces the significance of collaborative blended learning methodologies in modern educational contexts. Further exploration of these outcomes and deeper insights into their implications are warranted to provide a comprehensive perspective on the observed trends and their broader implications within the educational landscape [44].

6. Conclusion and Outlook

In summation, this study has delved deeply into the realm of collaborative blended learning activities within the context of the Algorithm and Programming course for first-year students, employing problem-based learning techniques.

The findings gleaned from this exploration have illuminated the efficacy of this pedagogical approach, shedding light on its profound influence on both academic achievement and student satisfaction.

The innovation of this study lies in its approach of integrating collaborative blended learning activities with problem-based learning in the specific domain of algorithm and programming education. This innovative combination has been systematically designed to foster critical thinking, analytical skills, and deeper comprehension among students. By juxtaposing traditional face-to-face instruction with digital resources, the proposed method orchestrates a symbiotic relationship between instructor-guided learning and self-directed exploration. This distinctive approach is rationally compared with traditional teaching methods that often rely solely on classroom-based instruction and linear content delivery. The results unmistakably demonstrate the superiority of the collaborative blended learning approach, evidenced by a statistically significant improvement in students' academic performance and their elevated satisfaction levels. Thus, this innovation propels the discourse on effective pedagogical methodologies forward.

The evidence conclusively indicates that the integration of collaborative blended learning activities has yielded a statistically significant enhancement in students' academic performance. A meticulous curation and sequencing of course content, unfolding progressively from rudimentary to intricate subjects, have emerged as a pivotal strategy for sustaining learner engagement and fostering perpetual curiosity. This coupled with the design of bespoke learning experiences, tailored to the essence of each subject, has granted students personalized responsibilities within collaborative enclaves, nurturing the exchange of knowledge and the cultivation of autonomous exploration. Leveraging digital tools like Google Classroom and video conferencing has further magnified accessibility and adaptability in the learning process. These outcomes harmonize seamlessly with prior research, underscoring the ascendancy of problem-based learning synergized with digital resources in amplifying academic accomplishments.

Moreover, the satisfaction levels of students within the orchestrated learning activities have soared significantly. The fluid transition from simplicity to complexity in content, coupled with unwavering instructor support and guidance, has fostered an environment imbued with ease and comfort for learners. The multifaceted availability of learning resources, bolstered by consistent mentorship, has emerged as a lynchpin in elevating overall student satisfaction. These revelations corroborate preceding studies, thereby reaffirming the affirmative influence of web-based learning harmonized with problem-solving paradigms on student contentment.

Against this backdrop of research findings, a series of recommendations emerge to optimize the implementation of collaborative blended learning activities:

1) As the integration of collaborative blended learning activities unfolds, instructors should continuously preside over the four learning activity phases, serving as pillars of support and guidance to fortify learners' educational journeys. Customizing learning experiences based on individual predilections and interpersonal nuances, alongside addressing queries or quandaries during group activities, stand as indispensable elements for effective learning that attains stipulated objectives.

2) Instructors must proactively participate in activities with all student groups, cultivating an ecosystem where all learners can introspect the fruits of collective endeavors. This trajectory significantly bolsters learners' self-assuredness, emboldening them to confidently present knowledge, articulate opinions, and contributes substantively to group accomplishments.

3) Prudent vigilance over all activities, with heightened attention to group endeavors and reflections on learning outcomes, emerges as an imperative. Neglecting the oversight of these activities might lead to certain students overlooking designated group tasks, bypassing the assessment of learning outcomes, and abstaining from productive learning exchanges. This detachment can impede students' mastery of subject matter, dent their confidence levels, and undermine their overall self-regard.

Looking ahead, future research voyages should traverse the integration of blended teaching and learning with problem-based pedagogies, integrating techniques such as Student Team Achievement Division (STAD) [45] or Team-Games-Tournament (TGT) [46]. By fomenting student engagement in studies and incentivizing collaboration for team rewards, these strategies could potentially yield heightened academic accomplishments.

In summative essence, this research resonates with the importance of innovative, learner-centric instructional modalities that foster effective learning outcomes and enrich the educational odyssey of first-year students undertaking algorithm and programming courses. By assimilating the research recommendations and embarking on explorations of further developmental trajectories, educators can forge a dynamic and rewarding learning landscape that emboldens students to excel in their academic quests. This study augments the ever-evolving corpus of literature on effective pedagogical approaches in higher education, serving as a cornerstone for subsequent inquiries within the domain of blended learning and problem-centered teaching methodologies. This work not only advances the field but also beckons us towards a horizon brimming with possibilities for more profound and impactful educational advancements.

References

[1] A. V. Oleksiyenko and V. Ros, "Human agency and legacy-innovation tensions in the internationalization of higher education: Re-orientations managed by internationally-educated scholars of Central Asia," *Int. J. Educ. Dev.*, vol. 97, p. 102716, Mar. 2023.

[2] A. Bozkurt *et al.*, “A global outlook to the interruption of education due to COVID-19 pandemic: Navigating in a time of uncertainty and crisis,” *Asian Journal of Distance Education*, vol. 15, no. 1, pp. 1–126, Jun. 2020.
[3] X. Liu and A. J. Moeller, “Promoting Learner Engagement through Interactive Digital Tools,” 2019.
[4] H. Y. Yow, “A case study of virtual anatomy museum: Facilitating student engagement and self-paced learning through an interactive platform,” *Journal of Information and Education Technology*, 2022.
[5] J. Rhode, “Interaction Equivalency in Self-Paced Online Learning Environments: An Exploration of Learner Preferences,” *IRRODL*, vol. 10, no. 1, Feb. 2009.
[6] D. L. Taylor, M. Yeung, and A. Z. Bashet, “Personalized and adaptive learning,” *Higher Education: Opportunities …*, 2021.
[7] P. Kwangmuang, S. Jarutkamolpong, W. Sangboonraung, and S. Daungtod, “The development of learning innovation to enhance higher order thinking skills for students in Thailand junior high schools,” *Heliyon*, vol. 7, no. 6, p. e07309, Jun. 2021.
[8] M. J. Hannafin and S. M. Land, “The foundations and assumptions of technology-enhanced student-centered learning environments,” *Instr. Sci.*, vol. 25, no. 3, pp. 167–202, 1997.
[9] M. Fontaine, “Student relationship management (SRM) in higher education: Addressing the expectations of an ever evolving demographic and its impact on retention.” [Online]. Available: http://jehdnet.com/journals/jehd/Vol_3_No_2_June_2014/7.pdf. [Accessed: 11-Jul-2023].
[10] P. Y. P. Hong, R. Hong, S. Choi, and D. R. Hodge, “Examining Psychological Self-Sufficiency Among Low-Income Jobseekers with Mental Health Barriers,” *Community Ment. Health J.*, vol. 57, no. 1, pp. 178–188, Jan. 2021.
[11] K. Scager, J. Boonstra, T. Peeters, J. Vulperhorst, and F. Wiegant, “Collaborative Learning in Higher Education: Evoking Positive Interdependence,” *CBE Life Sci. Educ.*, vol. 15, no. 4, Winter 2016.
[12] L. Markauskaite *et al.*, “Rethinking the entwinement between artificial intelligence and human learning: What capabilities do learners need for a world with AI?,” *Computers and Education: Artificial Intelligence*, vol. 3, p. 100056, Jan. 2022.
[13] S. Suwannaphisit, C. Anusitviwat, P. Tuntarattanapong, and C. Chuaychoosakoon, “Comparing the effectiveness of blended learning and traditional learning in an orthopedics course,” *Ann Med Surg (Lond)*, vol. 72, p. 103037, Dec. 2021.
[14] P. Koraneekij and J. Khlaisang, “Development of learning outcome based E-portfolio model emphasizing on cognitive skills in pedagogical blended E-learning environment for undergraduate students at faculty of education, Chulalongkorn university,” *Procedia Soc. Behav. Sci.*, vol. 174, pp. 805–813, Feb. 2015.
[15] D. H. Tong, B. P. Uyen, and L. K. Ngan, “The effectiveness of blended learning on students’ academic achievement, self-study skills and learning attitudes: A quasi-experiment study in teaching the conventions for coordinates in the plane,” *Heliyon*, vol. 8, no. 12, p. e12657, Dec. 2022.
[16] W. Banyen, C. Viriyavejakul, and T. Ratanaolarn, “A blended learning model for learning achievement enhancement of Thai undergraduate students,” *Int. J. Emerg. Technol. Learn.*, vol. 11, no. 04, p. 48, Apr. 2016.
[17] F. Alonso, D. Manrique, L. Martinez, and J. M. Vines, “How Blended Learning Reduces Underachievement in Higher Education: An Experience in Teaching Computer Sciences,” *IEEE Trans. Educ.*, vol. 54, no. 3, pp. 471–478, Aug. 2011.
[18] S. Hadjerrouit, “Towards a Blended Learning Model for Teaching and Learning Computer Programming: A Case Study,” *Informatics in Education - An International Journal*, vol. 7, no. 2, pp. 181–210, 2008.
[19] J. Singh, K. Steele, and L. Singh, “Combining the Best of Online and Face-to-Face Learning: Hybrid and Blended Learning Approach for COVID-19, Post Vaccine, & Post-Pandemic World,” *Journal of Educational Technology Systems*, vol. 50, no. 2, pp. 140–171, Dec. 2021.
[20] A. Krake, “Lessons in blended learning: Implementing an online learning platform in the adult education sector,” *Blended learning in English language teaching: Course design and implementation*, p. 213, 2013.
[21] D. R. Garrison and H. Kanuka, “Blended learning: Uncovering its transformative potential in higher education,” *Internet High. Educ.*, vol. 7, no. 2, pp. 95–105, Apr. 2004.
[22] J. Singh *et al.*, “Online, hybrid, and face-to-face learning through the eyes of faculty, students, administrators, and instructional designers: Lessons learned and directions for the post-vaccine and post-pandemic/COVID-19 world,” *J. Educ. Technol. Syst.*, vol. 50, no. 3, pp. 301–326, Mar. 2022.
[23] L. Ortquist-Ahrens and R. Torosyan, “The role of the facilitator in faculty learning communities: Paving the way for growth,productivity, and collegiality,” *Learning Communities Journal*, vol. 1, no. 1, 2009.
[24] F. T. Dayagbil, D. R. Palompon, L. L. Garcia, and M. M. J. Olvido, “Teaching and Learning Continuity Amid and Beyond the Pandemic,” *Frontiers in Education*, vol. 6, 2021.
[25] Savin-Baden and Maggi, *Problem-Based Learning In Higher Education: Untold Stories: Untold Stories*. McGraw-Hill Education (UK), 2000.
[26] C. H. Major and B. Palmer, “Assessing the effectiveness of problem-based learning in higher education: Lessons from the literature,” *Academic exchange quarterly*, vol. 5, no. 1, pp. 4–9, 2001.
[27] E. Ersoy and N. Başer, “The effects of problem-based learning method in higher education on creative thinking,” *Procedia Soc. Behav. Sci.*, vol. 116, pp. 3494–3498, Feb. 2014.
[28] W. Birch, “Towards a model for problem-based learning,” *Studies in Higher Education*, vol. 11, no. 1, pp. 73–82, Jan. 1986.
[29] A. A. Jensen, D. Stentoft, and O. Ravn, *Interdisciplinarity and Problem-Based Learning in Higher Education: Research and Perspectives from Aalborg University*. Springer Nature, 2019.
[30] E. H. J. Yew and K. Goh, “Problem-based learning: An overview of its process and impact on learning,” *Health Prof. Educ.*, vol. 2, no. 2, pp. 75–79, Dec. 2016.
[31] M. E. Stieben, T. A. Pressley, and M. L. Matyas, “Research experiences and online professional development increase teachers’ preparedness and use of effective STEM pedagogy,” *Adv. Physiol. Educ.*, vol. 45, no. 2, pp. 191–206, Jun. 2021.
[32] R. F. Schmid, E. Borokhovski, R. M. Bernard, D. I. Pickup, and P. C. Abrami, “A meta-analysis of online learning, blended learning, the flipped classroom and classroom instruction for pre-service and in-service teachers,” *Computers and Education Open*, vol. 5, no. 100142, p. 100142, Dec. 2023.
[33] F.-R. Kuo, G.-J. Hwang, and C.-C. Lee, “A hybrid approach to promoting students’ web-based problem-solving competence and learning attitude,” *Comput. Educ.*, vol. 58, no. 1, pp. 351–364, Jan. 2012.

[34] H.-C. Chu, T.-Y. Chen, C.-J. Lin, M.-J. Liao, and Y.-M. Chen, "Development of an adaptive learning case recommendation approach for problem-based e-learning on mathematics teaching for students with mild disabilities," *Expert Syst. Appl.*, vol. 36, no. 3, pp. 5456–5468, Apr. 2009.

[35] I. J. Sistermans, "Integrating competency-based education with a case-based or problem-based learning approach in online health sciences," *Asia Pac. Educ. Rev.*, vol. 21, no. 4, pp. 683–696, Dec. 2020.

[36] N. Hoic-Bozic, V. Mornar, and I. Boticki, "A Blended Learning Approach to Course Design and Implementation," *IEEE Trans. Educ.*, vol. 52, no. 1, pp. 19–30, Feb. 2009.

[37] V. Woltering, A. Herrler, K. Spitzer, and C. Spreckelsen, "Blended learning positively affects students' satisfaction and the role of the tutor in the problem-based learning process: results of a mixed-method evaluation," *Adv. Health Sci. Educ. Theory Pract.*, vol. 14, no. 5, pp. 725–738, Dec. 2009.

[38] K. Thongkoo, P. Panjaburee, and K. Daungcharone, "Integrating inquiry learning and knowledge management into a flipped classroom to improve students' web programming performance in higher education," *Knowl. Manag. E-learn.: Int. J.*, vol. 11, no. 3, pp. 304–324, Sep. 2019.

[39] K.-S. Hong, "Relationships between students' and instructional variables with satisfaction and learning from a Web-based course," *Internet High. Educ.*, vol. 5, no. 3, pp. 267–281, Sep. 2002.

[40] G.-J. Hwang, F.-R. Kuo, N.-S. Chen, and H.-J. Ho, "Effects of an integrated concept mapping and web-based problem-solving approach on students' learning achievements, perceptions and cognitive loads," *Comput. Educ.*, vol. 71, pp. 77–86, Feb. 2014.

[41] K.-Y. Lin, K.-C. Yu, H.-S. Hsiao, Y.-S. Chang, and Y.-H. Chien, "Effects of web-based versus classroom-based STEM learning environments on the development of collaborative problem-solving skills in junior high school students," *Int. J. Technol. Des. Educ.*, vol. 30, no. 1, pp. 21–34, Mar. 2020.

[42] G.-J. Hwang, P.-H. Wu, and C.-C. Chen, "An online game approach for improving students' learning performance in web-based problem-solving activities," *Comput. Educ.*, vol. 59, no. 4, pp. 1246–1256, Dec. 2012.

[43] Z. Sun and Y. Yang, "The mediating role of learner empowerment in the relationship between the community of inquiry and online learning outcomes," *Internet High. Educ.*, vol. 58, no. 100911, p. 100911, Jun. 2023.

[44] N. Al-Kahtani, A. Almurayh, A. V. Subbarayalu, T. Sebastian, H. Alkahtani, and D. Aljabri, "Sustaining blended and online learning during the normal and new normal conditions in a Saudi higher education institution: health science students' perspectives," *Heliyon*, vol. 8, no. 10, p. e10898, Oct. 2022.

[45] P. Amornsinlaphachai, "Designing a learning model using the STAD technique with a suggestion system to decrease learners' weakness," *Procedia Soc. Behav. Sci.*, vol. 116, pp. 431–435, Feb. 2014.

[46] A. Veloo and S. Chairhany, "Fostering students' attitudes and achievement in probability using teams-games-tournaments," *Procedia Soc. Behav. Sci.*, vol. 93, pp. 59–64, Oct. 2013.

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