INTEGRATING BLENDED LEARNING IN PROGRAMMING COURSE: A COMPREHENSIVE SYSTEMATIC REVIEW

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Abstract. This systematic review examines the integration of blended learning in programming courses, addressing the increasing diversity of student backgrounds and the consequent challenges in teaching programming effectively. The study synthesizes findings from recent research to identify effective strategies and best practice outcomes associated with blended learning approaches in this context. A comprehensive methodology was employed, involving the selection and analysis of relevant articles from databases such as Scopus and Web of Science, focusing on studies published between 2020 and 2024. The study was conducted following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) framework. The database found (n=30) final primary data was analysed. Numerical results from the chosen literature reveal three main themes: (1) Effectiveness of Blended Learning in K-12 Education, (2) Best Practice of Blended Learning in Higher Education and Professional Development, and (3) Students' Understanding on Blended Learning in Programming and Computer Science Education. This review concludes that integrating blended learning in programming courses not only addresses diverse learning needs but also fosters improved academic outcomes and student engagement. Future research should continue to explore innovative blended learning strategies and their long-term impacts on programming education.
Keywords: *blended learning, programming, K-12 of education, higher learning, computer science*

Introduction

In the contemporary educational landscape, the integration of blended learning has become a cornerstone of innovative teaching methodologies, particularly in the domain of computer programming. Blended learning combines traditional face-to-face instruction with digital learning activities, leveraging the strengths of both approaches to create a more flexible, engaging, and effective learning environment. This pedagogical model addresses the diverse needs of students by offering personalized learning experiences, thereby enhancing their understanding and application of complex programming concepts (Müller et al., 2023; Li et al., 2022; Müller and Mildenberger, 2021). As the demand for skilled programmers continues to rise in the global job market, integrating blended learning into programming courses is increasingly recognized as a vital strategy for fostering essential technical skills and cognitive abilities (Buschetto Macarini et al., 2019). Computer programming, an essential skill in the digital age, requires students to develop a deep understanding of algorithms, data structures, and problem-solving techniques (Rahman et al., 2022). Traditional classroom settings, while effective in delivering foundational knowledge, often fall short in providing the individualized attention and practice necessary for mastering these intricate topics (Kelly et al., 2024). Blended learning, with its combination of in-person and online instructional methods, addresses this gap by allowing students to learn at their own pace and revisit challenging concepts as needed. Online resources such as interactive coding platforms, video tutorials, and virtual labs supplement classroom

instruction, offering students the opportunity to engage with the material in a variety of formats that cater to different learning styles (Heilporn et al., 2021).

The flexibility of blended learning is one of its most significant advantages. In a programming course, this flexibility enables students to access learning materials and complete assignments at times that best suit their schedules, thereby balancing their educational pursuits with other responsibilities. This aspect is particularly beneficial for non-traditional students, such as working professionals or those with familial obligations own pace and revisit challenging (Srivatanakul, 2023). By reducing the time and logistical constraints associated with traditional classroom learning, blended learning makes programming education more accessible and inclusive. Empirical research supports the efficacy of blended learning in enhancing student outcomes in programming courses. Studies have shown that students in blended learning environments often exhibit higher levels of engagement and motivation compared to those in traditional settings. This increased engagement can be attributed to the interactive nature of online learning tools and the ability to receive immediate feedback on assignments and exercises (Romero et al., 2021). For instance, coding platforms like Codecademy and Coursera provide instant feedback on coding tasks, enabling students to quickly identify and correct errors, thus reinforcing learning through practice.

Furthermore, blended learning fosters the development of critical thinking and problem-solving skills, which are crucial in programming. The iterative process of coding, debugging, and refining programs requires a methodical and analytical approach (Shihab et al., 2023). By integrating online components such as discussion forums and peer collaboration tools, blended learning environments encourage students to engage in collaborative problem-solving and knowledge sharing. These interactions not only enhance their technical skills but also prepare them for real-world scenarios where teamwork and communication are essential (Bonitasya et al., 2021; Herayantı et al., 2020). The COVID-19 pandemic has underscored the importance of adaptable and resilient educational models. During this period, the rapid shift to online learning highlighted both the potential and challenges of digital education. While some institutions struggled with the transition, others successfully leveraged blended learning frameworks to ensure continuity and quality of education. This experience has accelerated the adoption of blended learning and demonstrated its viability as a long-term solution for programming education (Murai and Muramatsu, 2020). However, to fully realize its benefits, it is crucial to address challenges such as ensuring equitable access to technology, providing adequate training for educators, and designing comprehensive curricula that seamlessly integrate online and offline components.

Integrating blended learning in programming courses offers a multitude of benefits, including enhanced flexibility, increased student engagement, and the development of essential cognitive and technical skills. As the digital landscape continues to evolve, the adoption of blended learning models will play a critical role in preparing students for the demands of the modern workforce. By embracing this innovative approach, educational institutions can provide a more inclusive and effective programming education, ultimately contributing to the cultivation of a skilled and adaptable workforce equipped to navigate the complexities of the digital era. Ongoing research and strategic implementation are essential to optimizing blended learning environments and ensuring their success in fostering the next generation of programmers.

Literature review

The integration of blended learning in programming courses has garnered significant attention in recent educational research. Blended learning, which combines online digital media with traditional classroom methods, offers a comprehensive approach to education that addresses the diverse needs of students. Various studies have highlighted the effectiveness of blended learning in improving student engagement, performance, and satisfaction in programming courses. For instance, a flipped classroom (FC) approach in a computer programming course significantly improved students' academic performance and satisfaction (Moumoutzis et al., 2021a). This approach allowed for more active learning during class time when using the WampServer application in a blended learning environment facilitated the teaching-learning process in web programming by enhancing students' understanding and skills (Salas-Rueda, 2020). The importance of computational thinking in blended teaching is not only improved students' learning performance but also enhanced their ability to solve real-world problems effectively (Zhao and Liu, 2022). The implementation of blended learning in programming courses also involves various pedagogical strategies to maximize its benefits. The use of online resources and pre-class activities enables students to prepare before attending in-person classes, thus making in-class activities more focused and productive (Moumoutzis et al., 2021a). The method which utilized the WampServer application to allow students to engage in practical tasks at home, thereby deepening their understanding through hands-on experience (Salas-Rueda, 2020). Additionally, the effectiveness of the SPOC (Small Private Online Course) platform in enhancing teaching quality by integrating traditional classroom teaching with MOOC (Massive Open Online Course) elements, which provided a structured yet flexible learning environment for students (Chen et al., 2021). Teacher training and professional development play crucial roles in the successful implementation of blended learning in programming courses. The Computer Science Teacher Training Programme Promoting Python Code Clubs also known as Py4hs training program focused on equipping computer science teachers with the necessary skills to use Python for educational purposes, both inside and outside the classroom adopted a blended learning approach, which helped teachers from remote areas to participate and later establish local code clubs, thereby extending the impact to students (Moumoutzis et al., 2021a).

The application of creative learning principles in a blended professional development program for elementary and middle school teachers in Japan nurtured a community of practice among teachers, providing moral support and collaborative opportunities that encouraged the adoption of innovative teaching practices (Murai and Muramatsu, 2020). The effectiveness of blended learning is also evident in its ability to adapt to changing educational landscapes, such as those induced by the COVID-19 pandemic. The shift to blended teaching during the pandemic highlighted the need for integrating computational thinking into the curriculum to better prepare students for future challenges (Zhao and Liu, 2022). The use of Google Classroom in a blended learning setup for a programming course significantly improved the quality of learning and increased both teacher and student satisfaction (Abuzant et al., 2021). The collaborative knowledge construction activities in a blended learning environment revealing that such activities enhanced teachers' practical knowledge and their ability to deliver effective programming education (Sun et al., 2023). Integrating blended learning approaches in programming courses has demonstrated considerable promise in improving student engagement and learning outcomes across various educational contexts. A blended approach to design an introductory Python programming course tailored for non-

Computer Science (non-CS) majors highlights the use of diverse teaching methods, including pre and post-reading materials, live coding, discussions, and both individual and collaborative assessments, to enhance student engagement. The feedback from 26 students revealed that informal interactions and collaborative assessments were particularly effective in fostering a supportive learning environment (Cho et al., 2023). A gamified lecture and a MOOC for first-semester students to bridge the knowledge gap in Computer Science indicated that blended learning frameworks can significantly motivate students with no prior knowledge in CS, especially when supplemented with offline lectures that follow the principles of flipped classroom and inverse blended learning (Spieler et al., 2020).

The importance of digital competencies in modern education which is a system of tasks based on Bloom's revised taxonomy to enhance algorithmic competence among future computer science teachers used electronic learning resources (ELR) in a blended learning environment, demonstrating that the development of algorithmic competence significantly improves students' readiness to create and utilize algorithms in teaching (Baranova and Simonova, 2021). The impact of using Python to teach computational thinking in remote schools, the curriculum is designed to bridge the gap between block-based and text-based programming then it was evaluated using established surveys and showed that students benefited significantly in terms of computational thinking development and engagement in the blended learning course (Kamak and Mago, 2023). The effectiveness of flipped learning in a Japanese university's computer programming course, noting a marked increase in the number of students finding online courses challenging compared to offline ones. The study found that students preferred direct consultation and varied in their opinions on the efficacy of pre-learning activities. This variability suggests that a blended learning approach that combines online and offline elements may cater to diverse student preferences and learning styles (Hirata, 2022). The training program for computer science teachers in Greece which used blended learning to introduce Python programming success in establishing local Python code clubs highlights the potential of blended learning to create engaging, fun, and meaningful learning experiences (Moumoutzis et al., 2021b). The implementation of blended learning approach in a programming course found that K-12 students with lower performance benefited the most from the course. Their instructional unit combined student-centered learning with teacher-centered instruction, utilizing performance-based assessments and student feedback to continually refine the course design (Zhang and Cui, 2021). The use of an educational underwater vehicle (EDUV) was evaluated in a blended learning programming course for high school students found that the EDUV platform significantly increased student motivation and creativity, demonstrating the effectiveness of integrating educational robotics with blended learning to enhance student engagement (Rousouliotis et al., 2024).

The integration of blended learning in programming courses has proven to be highly effective in improving student engagement, performance, and satisfaction. The combination of online and traditional teaching methods provides a flexible and comprehensive learning environment that caters to diverse student needs. The success of these programs hinges on well-structured pre-class and in-class activities, robust teacher training, and the adaptability of educational strategies to meet contemporary challenges. As the educational landscape continues to evolve, blended learning remains a promising approach to enhancing the quality and effectiveness of programming education.

Materials and Methods

This section provides an overview of the four significant sub-sections: identification, screening, eligibility, and data abstraction.

Identification

Several key steps in the systematic review process were used to choose a great deal of relevant literature for this study. First, keywords are selected, and then related terms are searched for using dictionaries, thesaurus, encyclopedias, and past research. All relevant terms were selected once the search strings for the Scopus and Web of Science databases were created (*Table 1*). During the first stage of the systematic review process, 325 publications were successfully retrieved for the current study project from both databases.

***Table 1**. The search string.*

Category	Description
Scopus	TITLE-ABS-KEY (("blended learning" OR bl) AND programming AND (school OR education)) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023) OR LIMIT-TO (PUBYEAR , 2024)) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp"))
WOS	("blended learning" OR bl) AND programming AND (school OR education) (Title) and 2024 or 2023 or 2022 or 2021 or 2020 (Publication Years) and Article or Proceeding Paper (Document Types) and English (Languages)

Screening

During the screening process, the collection of potentially pertinent research items is reviewed for content that aligns with the predetermined research topic or questions. The selection of research topics based on the integrating blended learning in programming course is one of the content-related criteria that is commonly employed in the screening phase. All duplicate papers will be eliminated from the list of papers that were searched in this step. 287 publications were eliminated in the first screening stage, and 38 papers were reviewed in the second stage of the screening process using various inclusion and exclusion criteria from this study (*Table 2*). As the main source of useful suggestions, the literature (research articles) and proceeding paper was the first criterion to be applied. In addition, books, book series, chapters, reviews, and meta-synthesis that were left out of the most recent study are included. Moreover, the review was limited to English-language publications. To make sure the fact-finding is still relevant, credible and compatible with current academic standard, references from the past five years in research is used. Therefore, the strategy was limited to the years 2020-2024. Due to duplicate criteria, one paper was rejected overall.

***Table 2**. The selection criterion.*

Criteria	Inclusion	Exclusion
Language	English	Non-English
Timeline	2020-2024	<2020
Literature type	Journal (Article), Proceeding Paper	Book, Review
Publication stage	Final	In Press

Eligibility

A collection of 37 articles was put together during the third stage, which is known as the eligibility evaluation. In order to verify the papers matched the inclusion criteria and were pertinent to the research goals of the ongoing study, a thorough review of the titles and body of each article was carried out during this phase. Seven data/papers/articles were thus eliminated because they did not meet the requirements: they were out of field; their titles did not significantly link to the study's objective; their abstracts did not relate to the abstract's purpose; and their full text access was not supported by empirical evidence. Consequently, 30 are left for the next evaluation.

Data abstraction and analysis

In this study, an integrative analysis was employed as a strategy to review and synthesize various research designs, focusing specifically on quantitative methods. The goal was to identify key topics and subtopics. The first step in developing themes involved data collection. As shown in *Figure 1*, the authors thoroughly analyzed 30 publications, extracting relevant assertions and material. They then evaluated significant existing studies on the integrating blended learning in programming course, examining both their methodologies and findings. Subsequently, the authors collaborated with co-authors to develop themes based on the evidence from the study. During the data analysis process, a log was kept recording analyses, viewpoints, puzzles, or thoughts related to data interpretation. Finally, the authors compared the results to identify inconsistencies in the theme development process. Any disagreements were discussed and resolved among the authors. The final themes were refined to ensure consistency. Two experts conducted the analysis selection to verify the validity of the issues. The expert review phase ensured the clarity, importance, and appropriateness of each subtheme by establishing domain validity. The questions are listed: (1) How effective are blended learning programs in enhancing the academic performance of K-12 students? (2) What are the best practices for implementing blended learning programs in higher education institutions? (3) What are the benefits and challenges of using blended learning in computer science education?

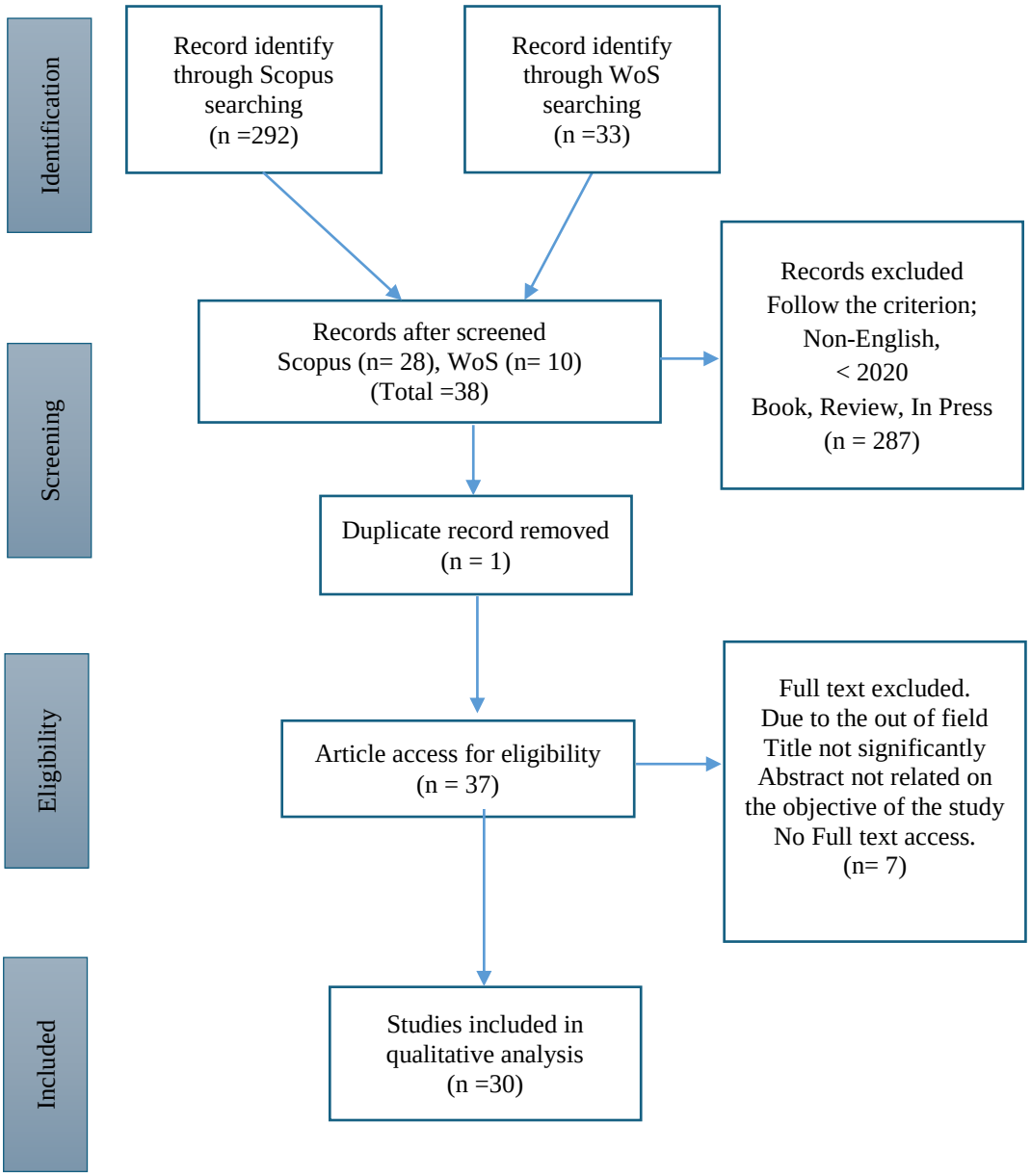

Figure 1. *Flow diagram of the proposed searching study.*
Source: Moher et al. (2009).

Results and Discussion

Numerical results from the chosen literature reveal three main themes: (1) Effectiveness of Blended Learning in K-12 Education, (2) Best Practice of Blended Learning in Higher Education and Professional Development, and (3) Students' Understanding on Blended Learning in Programming and Computer Science Education.

Effectiveness of blended learning in K-12 education

A growing number of Educational frameworks are including blended learning programs, especially in K-12 education, where they provide a combination of traditional face-to-face and virtual learning experiences. The development of a blended teacher education program is one such endeavour that aimed at how to help educators become

more proficient in both personalised and blended learning. The study involved two iterations, teacher educators and project directors worked closely together to build and revise online courses over two years. The results demonstrate that teacher educators and candidate thought the blended program was beneficial, offering insight into the components necessary for successful implementation in K-12 schools (Shin, 2021). Promising outcomes have also been observed when middle school math education is personalised through the use of technology. Nitkin, Ready and Bowers used platforms like Khan Academy and Zearn, which gather a vast data on students engagement and outcomes to perform a research across five public schools. Their investigation using clustergram heatmaps and hierarchal cluster analysis revealed that even the blended approach was successful in delivering a personalised learning environment, it encountered challenges due to policy and logistical limitation. Moreover, long-term project-based learning modalities were found to yield higher student outcomes, particularly for certain student clusters, compared to other learning modalities (Nitkin et al., 2022). A research conducted in Bangkok on blended learning program designed at preventing cyber sexual harassment among female high school students online. By comparing the intervention group, which took part in the integrated program to control group (quasi-experimental study) revealed substantial gains in knowledge, attitudes and coping strategies related to cyber sexual harassment compared to control group.This indicates that blended learning can effectively address sensitive issues like cyber harassment, providing a structured approach to enhance students' resilience and response strategies (Santre and Pumpaibool, 2022).

The COVID-19 epidemic has highlighted the importance of blended learning further, especially in helping students maintain their mental health. During the epidemic, high school students participated in a combined mindfulness program designed to reducing stress and improving concentration, self-esteem and self-control. Students who took part in the 10-week program showed significant improvements in these areas, demonstrating blended learning's ability to boost students' emotional and mental health during challenging times (Kang and Kim, 2023). Furthermore, the evaluation of the Lexia PowerUp Literacy program demonstrated its effectiveness in improving reading skills among middle school students involving low-SES schools revealed that students who used the blended learning program made significant gains in word identification, syntactic processing, and basic reading comprehension compared to those using alternative programs. The study emphasizes the value of explicit, skills-based instruction within a blended learning framework to bolster reading proficiency (Hurwitz et al., 2022). Lastly, a research on designing MOOC on robotics, programming and computational thinking for primary school teachers and early childhood educators demonstrates the use of blended learning in teacher professional development. The pilot test of this MOOC highlighted its quality and relevance, offering a robust framework for integrating advanced technological competencies into early education curricula. The findings suggest that well-structured MOOCs can effectively enhance educators' skills, ultimately benefiting students through improved instructional quality in technology-related subjects (Amante et al., 2023). *Table 3* shows the summary of studies on Blended Learning in K-12 Education.

***Table 3**. Summary of Studies on Blended Learning in K-12 Education.*

Authors	Participants	Study/program	Findings
Shin (2021)	Teacher educators and candidates	Blended Teacher Education Program	Effective in fostering blended learning competencies. Insights on successful implementation in K-12

			schools.
Nitkin et al. (2022)	Students in five public schools	Personalized Middle School Math Instruction	Effective personalized learning; challenges due to policy/logistics; better outcomes with long-term project-based learning.
Santre and Pumpaibool (2022)	Female high school students	Cyber Sexual Harassment Prevention in Bangkok	Significant improvement in knowledge, attitudes, and coping strategies in the intervention group.
Kang and Kim (2023)	High school students	Blended Mindfulness Program	Significant improvements in stress, concentration, self-esteem, and self-control among participants.
Hurwitz et al. (2022)	Middle school students	Lexia PowerUp Literacy Program	Significant gains in word identification, syntactic processing, and reading comprehension compared to alternatives.
Amante et al. (2023)	Early childhood educators and primary teachers	MOOC for Early Childhood Educators & Teachers	MOOC demonstrated quality and relevance; effective in enhancing technological competencies for early education curricula.

These studies collectively underscore the multifaceted benefits of integrating blended learning into K-12 education, particularly in programming courses and related fields. They highlight the importance of well-designed curricula, the integration of technology, and the potential to address both academic and social-emotional learning needs. The evidence suggests that blended learning, when implemented thoughtfully, can significantly enhance educational outcomes, making it a valuable approach in contemporary education.

Best practice of blended learning in higher education and professional development

Integrating blended learning in programming courses within higher education has garnered attention due to its potential to enhance learning outcomes and adapt to various learning preferences (*Table 4*). The flexibility and efficacy of blended learning, a hybrid teaching strategy that combines online and face-to-face methods, have been demonstrated in a number of academic fields, including emergency medicine, nursing and economics. For instance, the perioperative nursing education program in Canada implemented a blended learning approach comprising online modules, videos, skills labs, and clinical placements, which resulted in novice nurses feeling confident and prepared for practice (Li and Conway, 2024). This example shows how blended learning may be used to successfully prepare students for professional settings, which is important to keep in mind when designing courses in programming where practical skills are required. Additionally, it has been demonstrated that blended learning improves critical thinking abilities in higher education, which is necessary for any programming course where analytical thinking and problem-solving are required. A study on a blended learning curriculum in economics revealed that incorporating work-based learning with input from labor market trainers significantly improved students' critical thinking abilities (Dumitru et al., 2023). The combination of academic theory with real-world applications can be particularly beneficial in programming education, where understanding practical applications of coding and software development is as important as theoretical knowledge.

***Table 4**. Summary of Studies on Blended Learning in Higher Education Programming Courses.*

Authors	Participants	Study/program	Findings
Li and Conway (2024)	Novice nurses	Perioperative Nursing Education Program	Enhanced confidence and preparedness for practice through online modules, videos, skills labs, and clinical placements.
Dumitru et al. (2023)	Economics students	Blended Learning in Economics Curriculum	Significant improvement in critical thinking by integrating work-based learning with academic theory.

Harel-Sterling and McLean (2022)	Pediatric emergency medicine students	POCUS Training in Pediatric Emergency Medicine	Improved communication, goal reinforcement, and comprehensive training through asynchronous learning and longitudinal scanning.
Gómez et al. (2023)	Social sciences students	Post-Pandemic Blended Learning in Social Sciences	Enhanced motivation, resource utilization, and learning outcomes with small-group seminars and cooperative work.
Weppner et al. (2024)	Medical students	Comparison of Traditional Lectures and Procedural Videos	Both traditional lectures and microvideos are effective; microvideos offer convenience and accessibility advantages.

The adaptability of blended learning is further highlighted by its successful implementation in emergency medicine education. The curriculum was enhanced using a blended learning methodology that incorporated asynchronous learning, longitudinal scanning shift and progress reporting for POCUS (point-of-care ultrasound) training in paediatric emergency medicine. This approach not only improved communication and goal reinforcement but also served as a model for other training programs aiming to enhance their curricula (Harel-Sterling and McLean, 2022). Programming school might utilise this approach by adding project-based learning, asynchronous coding exercises and regular feedback sessions. This would offer a well-rounded education that promotes skill development and continuous progress. Many educational institutions were compelled to use blended learning models as a result of the COVID-19 epidemic, which brought to light the advantages and difficulties of this approach. An analysis of a forced blended-learning program in social sciences during the post-pandemic period highlighted the importance of incorporating face-to-face interaction to enhance motivation, resource utilization, and learning effectiveness (Gómez et al., 2023). After COVID-19, blended learning has shown to be an essential educational approach that successfully combines online and in-person training to meet the requirements of a wide range of students, increase engagement, and preserve educational continuity (Park, 2021). Blended learning improves inclusion and accessibility, increasing educational opportunity for a range of student populations (Hanny et al., 2023). Post COVID-19 allows flexible, self-paced learning which is important for mastering programming skills that often require extended practice and individualized problem-solving. According to the study, cooperative learning and small group seminars greatly enhanced students engagement and learning results. This finding is particularly relevant for programming courses, where peer interactions and collaborative projects can significantly enhance the learning experience and simulate real-world software development settings. Moreover, the comparison between traditional lectures and procedural videos in teaching medical skills has shown that both methods can be equally effective, yet microvideos offer convenience and accessibility advantages (Weppner et al., 2024). This insight is applicable to programming education, where microvideos can be used to teach complex coding concepts and procedures, providing students with flexible learning options that accommodate different learning styles and schedules.

Integrating blended learning into programming courses in higher education can significantly enhance learning outcomes by combining the strengths of both online and face-to-face instructional methods. The success of blended learning in various fields, from nursing and economics to emergency medicine, underscores its potential to improve critical thinking, practical skills, and student engagement. By incorporating elements such as asynchronous learning, real-world applications, and collaborative

projects, programming courses can create a dynamic and effective learning environment that prepares students for professional success.

Students' understanding on blended learning in programming and computer science education

For students' understanding on blended learning in programming and computer science education main theme, it can be categories into four subthemes which are: (a) Best Practices in Blended Learning, (b) Curriculum Design in Blended Learning, (c) Cultural Adaptation and Technological Tools, and (d) Challenges and Future Directions.

Best practices in blended learning

The integration of blended learning has shown bigger potential when included into programming classes, especially in terms of raising student achievement and engagement. Several best practices have led from the research, such as the Flipped Learning Engagement (FLE) model, which encourages students to interact with the content outside of the classroom in order to promotes active learning. With the help of this model, interactive problem-solving activities may take place during class time, increasing students' engagement and achievement (Shaarani and Bakar, 2021). Likewise, it has been discovered that active learning techniques in virtual settings, such as hands-on activities, student-created content, and teacher evaluations, have been found to improve students' confidence, self-efficacy, and academic performance. These approaches assist narrow the gender performance gap and beneficial for female students (Ariza, 2023). The use of specific technological tools, such as WampServer in blended learning environments, has also proven effective in enhancing students' understanding and skills in web programming languages such as Hypertext Preprocessor (PHP), HyperText Markup Language (HTML), and Structured Query Language (SQL), demonstrating the importance of integrating practical, hands-on learning opportunities in blended formats (Salas-Rueda, 2020).

Curriculum design in blended learning

In terms of curriculum design, it has been successful to satisfy the varied demands of modern students by combining traditional and innovative methods. For instance, automated assessment tools and parameterised test, along with a shift in pedagogy form instructor-centered to student-centered learning, have greatly increased student performance and engagement (Sharma et al., 2020). However, these approaches come back with challenges, such as the requirement for a strong technological infrastructure and the need to carefully strike a balance between structured and and open-ended activities, especially when teaching programming to students who are post-millennial students. Open-ended learning, while fostering creativity and self-reflection, can increase anxiety among some students, highlighting the need for continuous support and feedback (Grace et al., 2022).

Cultural adaptation and technological tools

Blended learning approaches must also adapt to different cultural contexts and student preferences. For instance, a study conducted in Japan found that while students initially found online flipped classes challenging, they ultimately appreciated the

flexibility and opportunities for direct consultation with peers and instructors. This suggests that blended learning models must be adaptable to varying cultural contexts to be effective (Hirata, 2022). Additionally, virtual classrooms like Google Classroom have improved learning procedures and raised satisfaction among teachers and students, while open-access platform like Robotics-Academy have been successful in giving students real-world, hands-on experience in technical education. However, these digital tools require reliable technological infrastructure to ensure successful implementation (Abuzant et al., 2021; Cañas et al., 2020).

Challenges and future directions

Finally, the flipped classroom model has been particularly effective in programming education, promoting increased interaction between teachers and students, as well as independent learning. While this approach offers flexibility and caters to different learning styles, it also requires robust technological infrastructure and faces challenges in ensuring student engagement with pre-class materials (Taşpolat et al., 2021). Overall, integrating blended learning into programming courses has shown to have the ability to enhance students learning outcomes and experiences; even though in order to successfully solve technological and instructional problems, ongoing innovation and adaptation are needed. Integrating blended learning approaches in programming courses can significantly enhance student learning experiences and outcomes. By combining traditional and innovative teaching methods, utilizing educational data mining, implementing the flipped classroom model, analyzing help-seeking behaviors, and incorporating practical learning tools, educators can address the diverse needs of students and improve their engagement and performance in programming courses.

Integrating blended learning into programming courses in higher education has shown significant potential to enhance learning outcomes by leveraging a hybrid approach that combines online and face-to-face methods. This approach has been effective across various disciplines, including nursing, economics, and emergency medicine, demonstrating its adaptability and effectiveness. For instance, a perioperative nursing education program in Canada utilized blended learning to successfully prepare novice nurses for practice, highlighting the model's ability to equip students with practical skills. Similarly, a blended learning curriculum in economics, which incorporated work-based learning, significantly improved students' critical thinking abilities-an essential component for programming courses. In emergency medicine, a blended learning model for POCUS training improved communication and skill acquisition, providing a framework that could be adapted for programming education with asynchronous exercises and regular feedback. The pandemic-driven shift to blended learning revealed the importance of face-to-face interactions in enhancing motivation and engagement, a crucial consideration for collaborative programming projects. Additionally, the effectiveness of microvideos in teaching medical skills underscores their potential for delivering flexible and accessible coding instruction. Overall, blended learning in programming courses can create a dynamic and comprehensive educational environment, combining theoretical knowledge with practical skills to prepare students for professional success.

Conclusion

Integrating blended learning in programming courses has demonstrated significant promise in enhancing student engagement and achievement by combining traditional and innovative teaching methods. The Flipped Learning Engagement (FLE) model, which shifts instructional content outside the classroom to prioritize interactive, problem-solving activities during in-class time, has shown that students in experimental groups outperform those in traditional settings. Active learning strategies, including hands-on activities and student-created content, have improved motivation, self-efficacy, and academic performance, especially among female students. The use of technology tools like WampServer in at-home assignments has significantly enhanced understanding and practical skills in programming languages such as Hypertext Preprocessor (PHP), HyperText Markup Language (HTML), and Structured Query Language (SQL). Blended learning approaches also adapt well to the changing educational landscape, incorporating automated assessment tools and parameterized exams to provide immediate feedback and personalized learning experiences. Open-ended learning projects, while fostering creativity and self-reflection, require a balance to mitigate student anxiety. Studies in various cultural contexts, such as in a Japanese university, emphasize the need for adaptability in blended learning models to meet diverse student preferences. Platforms like Robotics-Academy highlight the benefits of hands-on experience in technical education, while professional development programs for teachers underscore the broader applicability of blended learning across educational levels and subjects. Virtual classrooms, such as Google Classroom, have been shown to enhance learning quality and satisfaction. Overall, the integration of blended learning in programming courses offers a dynamic and effective approach to improving student engagement, performance, and readiness for professional success.

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Conflict of interest

The authors confirm that there is no conflict of interest involve with any parties in this research study.

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