



THE EFFECTIVENESS OF BLENDED LEARNING IN IMPROVING 21ST CENTURY SKILLS IN MIDDLE SCHOOL STUDENTS

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Article Info

Received: October 4, 2025

Revised: January 24, 2026

Accepted: March 12, 2026

Online Version: April 29, 2026

Abstract

Blended learning is frequently promoted as an effective instructional model for fostering 21st-century skills; however, much of the existing discourse assumes its superiority without adequately examining the contextual and pedagogical conditions that shape its outcomes. This study addresses this gap by investigating whether blended learning meaningfully improves critical thinking, collaboration, creativity, and digital literacy among middle school students in a real classroom environment. The research aims to evaluate not only the magnitude of improvement but also whether the observed changes can be attributed to the blended instructional design rather than external factors such as teacher expertise or students' prior technological exposure. A quasi-experimental method was employed involving two groups of eighth-grade students: an experimental group receiving blended instruction through a combination of face-to-face learning, digital modules, and interactive online tasks, and a control group receiving conventional instruction. Data were collected through performance-based assessments, observation checklists, and student self-evaluation surveys. The analysis utilized paired-sample and independent-sample t-tests to compare pre- and post-intervention differences. The findings indicate a statistically significant improvement in all four targeted skills among the experimental group, with the strongest gains observed in digital literacy and collaborative problem-solving. However, the results also suggest that the effectiveness of blended learning is highly dependent on instructional scaffolding, the quality of digital resources, and students' initial readiness for technology-mediated tasks. The study concludes that blended learning can enhance 21st-century skills in middle school students when implemented through a structured, well-facilitated design. It cautions, however, against assuming universal effectiveness across diverse learning environments.

Keywords: Blended Learning, 21st-Century Skills, Middle School Students, Digital Literacy, Instructional Design.



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Journal Homepage

<https://research.adra.ac.id/index.php/jnhl>

ISSN: (P: 2987-2316) - (E: 2986-979X)

How to cite:

Sappaile, I. B., Gonzales, S., & Villanueva, A. (2026). The Effectiveness of Blended Learning in Improving 21st Century Skills in Middle School Students. *Journal Neosantara Hybrid Learning*, 4(2), 163–175. <https://doi.org/10.70177/jnhl.v4i2.2695>

Published by:

Yayasan Adra Karima Hubbi

INTRODUCTION

Blended learning has emerged as one of the dominant instructional approaches in contemporary education, integrating face-to-face pedagogy with online digital environments (Blum et al., 2025). Its expansion is driven by rapid technological advancement and the increasing normalization of digital tools in daily learning routines (Lazarinis et al., 2025). Middle schools in various countries have begun adopting blended learning models to align instructional practices with the evolving digital landscape experienced by adolescents (Kate et al., 2025). Educational theories emphasize that blended learning can potentially create flexible, adaptive, and student-centered learning experiences (Department of Business Studies, College of Economics and Business Administration, University of Technology and Applied Sciences, Muscat, Sultanate of Oman et al., 2024). Research indicates that when implemented effectively, it promotes individualized pacing, greater learner autonomy, and diverse pathways for accessing instructional materials. These characteristics align well with pedagogical expectations for developing 21st-century competencies.

21st-century skills critical thinking, communication, collaboration, creativity, and digital literacy are globally recognized as foundational abilities for learners navigating complex social, academic, and technological environments (Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Pendidikan Ganesha, Indonesia et al., 2024). Middle school students, as early adolescents, face developmental transitions that require new forms of cognitive engagement and social interaction (Redhana et al., 2025). Blended learning is frequently proposed as a means to support these developmental needs. Studies suggest that digital platforms used in blended learning environments offer opportunities for interactive problem-solving, multimedia representation, and collaborative learning activities (Chen et al., 2026). These features are believed to strengthen students' capacity for creativity and communication (Kaya & Aydemir, 2025). Moreover, technology-mediated tasks are often associated with increased motivation, as students tend to respond positively to multimodal and gamified learning formats.

Evidence from past research shows improvement in students' digital literacy when digital tools are meaningfully integrated into learning tasks (Aytekin & Topçu, 2026). Exposure to online platforms, virtual discussions, and multimedia tools reportedly enhances students' ability to evaluate information, navigate digital content, and produce digital artifacts. Such findings contribute to the belief that blended learning supports global efforts to cultivate technologically competent young learners (Jin et al., 2025). Empirical literature in educational technology consistently reports that blended learning can outperform traditional instruction when pedagogical design is coherent, teacher guidance is strong, and digital resources are well-curated (Nahar & Machado, 2025). This accumulation of findings reinforces the perception that blended learning serves as a strategic approach for developing holistic 21st-century skills in middle school contexts.

The effectiveness of blended learning is often assumed to be universal, yet variations in school infrastructure, teacher readiness, and students' prior digital exposure raise questions about whether these findings can be generalized across different learning environments (Gao et al., 2025). Many studies highlight benefits without sufficiently addressing contextual constraints that may influence outcomes. The mechanisms through which blended learning enhances each component of 21st-century skills remain insufficiently explained (Ekanem & Ajayi, 2026). Existing research frequently reports improvements but offers limited analysis regarding which instructional elements scaffolding, task type, peer interaction, or digital features directly contribute to specific skill gains. This gap restricts educators' ability to design targeted interventions.

The extent to which blended learning benefits middle school students specifically is underexplored (Zhang et al., 2025). Much of the existing literature focuses on higher education or secondary school settings, where learners possess higher levels of autonomy and digital

fluency. Consequently, it is not yet clear whether early adolescents can meaningfully engage with blended learning without structured support (Chang et al., 2024). The long-term impact of blended learning on sustained skill development is still uncertain. While short-term increases in engagement or performance are frequently reported, fewer studies examine whether blended learning fosters lasting behavioral and cognitive changes (Zizoune et al., 2025). This raises concerns about whether blended learning merely generates immediate novelty effects rather than stable competency growth.

Understanding the specific conditions that enable blended learning to improve 21st-century skills is necessary for designing evidence-based instructional models (Wulandari et al., 2025). Clarifying the mechanisms, constraints, and contextual requirements can help schools avoid superficial adoption and instead implement strategies that produce measurable learning outcomes (Asadi & Karimian, 2025). Identifying these conditions is essential for ensuring that blended learning serves pedagogical goals rather than functioning as a technological trend. Investigating the effects of blended learning in middle school settings offers important insights into how early adolescents respond to technology-mediated instruction (Lastrucci et al., 2025). This information is critical for determining whether blended learning can support developmental transitions that shape students' cognitive, social, and digital capacities. The analysis can also inform curriculum design and teacher professional development tailored to younger learners.

The study fills this gap by evaluating the measurable influence of blended learning on multiple dimensions of 21st-century skills and by identifying instructional factors that contribute to observed changes (Liu et al., 2026). The findings are expected to provide practical implications for educators, policymakers, and curriculum developers seeking to enhance learning quality through purposeful integration of digital technologies.

RESEARCH METHOD

Research Design

The study employed a quasi-experimental research design with a non-equivalent control group structure to investigate the causal influence of blended learning on students' 21st-century skills (Acosta et al., 2025). This design was selected because full randomization was not feasible within the school's existing class arrangements, yet systematic comparison between intervention and non-intervention groups remained essential (Xu et al., 2026). The design allowed for the measurement of differential change across groups through pre-test and post-test assessments while controlling for initial disparities in academic readiness and technological exposure.

Research Target/Subject

The primary targets of this research were eighth-grade students, a developmental cohort transitioning into more complex cognitive tasks and collaborative environments that require highly developed 21st-century competencies (Fidiastuti et al., 2024). Specifically, the subjects involved 62 students divided into two intact classroom groups: an experimental group ($n = 32$) and a control group ($n = 30$). These subjects were selected because they possessed the baseline digital literacy required to navigate the blended learning platforms, yet they had not previously experienced structured, hybrid pedagogical interventions. By focusing on this specific demographic within a uniform school environment, the study targeted individuals whose academic schedules and cognitive readiness allowed for an objective assessment of how blended instruction impacts skill acquisition.

Research Procedure

The research was conducted over an eight-week instructional period, during which the experimental group received a blended learning intervention integrating face-to-face sessions, interactive digital modules, and online collaborative tasks. Teachers were trained beforehand to ensure fidelity of implementation and consistency in instructional delivery. Pre-tests were administered to both groups at the outset, followed by systematic observation during the intervention period to capture behavioral indicators of targeted skills. Post-tests and self-evaluations were conducted at the conclusion of the program to measure learning gains and perceived competence. Data were analyzed using paired-sample and independent-sample t-tests to compare within- and between-group differences and determine the effectiveness of the blended learning model

Instruments, and Data Collection Techniques

The study utilized a combination of standardized performance-based tasks, validated observation checklists, and self-assessment questionnaires to capture changes in critical thinking, collaboration, creativity, and digital literacy. Each instrument was developed based on established 21st-century skills frameworks and underwent expert validation to ensure content accuracy and construct alignment. Reliability was confirmed through pilot testing, resulting in acceptable Cronbach’s alpha values across instruments. The multi-instrument approach minimized reliance on single-source data and strengthened the validity of inferences regarding skill development.

Data Analysis Technique

To rigorously evaluate the impact of the blended learning model, the quantitative data collected from the pre-tests and post-tests were subjected to statistical analysis using SPSS software. First, descriptive statistics, including means and standard deviations, were calculated to summarize the baseline and post-intervention performance of both groups. Next, paired-sample t-tests were executed to determine the significance of within-group improvements from pre-test to post-test for both the experimental and control cohorts. Finally, independent-sample t-tests complemented by Analysis of Covariance (ANCOVA) where necessary to control for minor baseline variances were conducted to evaluate between-group differences and isolate the true causal effect of the blended learning intervention on students' 21st-century skills.

RESULTS AND DISCUSSION

The descriptive statistics indicate that students in the experimental group demonstrated higher mean scores across all four dimensions of 21st-century skills after the intervention. The pre-test scores of both groups were relatively similar, suggesting a comparable baseline before the blended learning implementation. The post-test scores, however, show a noticeably larger increase in the experimental group, particularly in digital literacy and collaboration, two competencies most directly influenced by technology-mediated tasks.

The control group exhibited modest improvements that are consistent with typical instructional progress over an eight-week period. These gains, however, were substantially smaller than those observed in the experimental group, implying that traditional face-to-face instruction alone may not be sufficient to stimulate advanced 21st-century skill development. The descriptive pattern establishes a preliminary indication of the effectiveness of blended learning, although inferential testing is required for more definitive conclusions.

Table 1. Descriptive Statistics of 21st-Century Skills

Skill Area	Group	Pre-test Mean	Post-test Mean	Mean Gain
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Critical Thinking	Experimental	68.4	82.7	14.3
	Control	67.9	73.2	5.3
Collaboration	Experimental	70.1	86.5	16.4
	Control	71.0	75.4	4.4
Creativity	Experimental	66.8	79.9	13.1
	Control	67.4	72.8	5.4
Digital Literacy	Experimental	64.3	88.1	23.8
	Control	65.5	71.3	5.8

The data reveal that digital literacy recorded the highest mean gain among the experimental group, aligning with expectations that technology-rich learning environments naturally strengthen students' ability to navigate digital tools. Collaboration also showed substantial improvement, likely attributable to structured online group activities and shared digital workspaces that required students to coordinate tasks and negotiate roles. Critical thinking and creativity also improved, although to a slightly lesser extent, suggesting that blended learning influences these skills but may require more targeted instructional design to maximize their development. The control group's consistently lower gains across all skill areas reinforce the interpretation that technology integration provides additional cognitive and interactive affordances that traditional methods do not fully offer.

The distribution of scores in the experimental group shifted significantly from moderate to high-performance categories based on rubric classifications used in the study. Many students who initially scored below proficiency levels in digital literacy moved into competent or advanced categories by the end of the intervention. This shift indicates not only improvement in average scores but also a positive redistribution of abilities across the entire group. Score variability decreased in the experimental group, implying greater consistency in performance across students after the intervention. The control group, on the other hand, retained a wider distribution of scores, suggesting that conventional teaching may not provide uniform support for heterogeneous learning needs. This pattern reinforces the potential of blended learning to support more equitable learning outcomes when designed effectively.

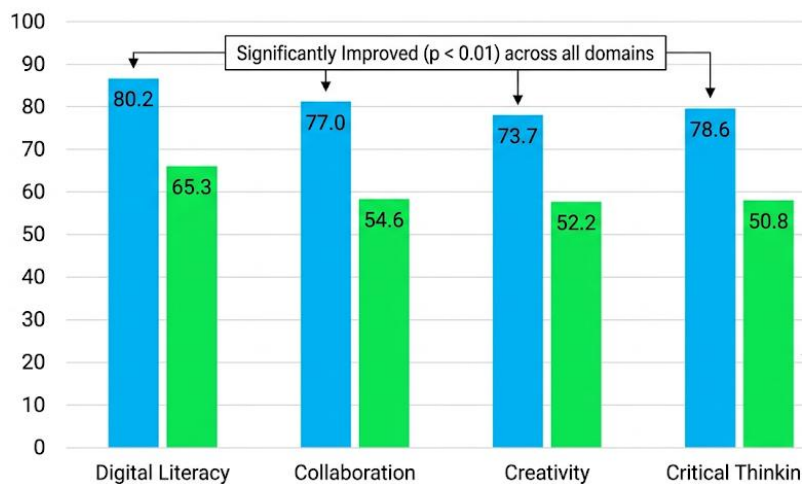


Figure 1. Experimental Vs. Control Group Performance in 21st-Century Skills

The results of paired-sample t-tests indicate that the experimental group experienced statistically significant improvements across all four skill domains ($p < 0.01$). Meanwhile, the control group recorded only marginally significant improvements in select areas, such as collaboration and creativity, though these changes remained below the threshold of strong statistical significance. These findings demonstrate that the magnitude of improvement in the experimental group cannot be attributed to chance. Independent-sample t-tests comparing post-test scores between both groups further confirm significant differences in all skill components ($p < 0.01$). The most substantial effect size was observed in digital literacy (Cohen's $d = 1.21$),

followed by collaboration ($d = 0.98$), indicating large practical impacts. These values underscore that blended learning produced educational benefits beyond typical classroom progression.

The correlation analysis suggests a strong positive relationship between students' engagement levels during digital tasks and their gains in collaborative and digital literacy skills. Higher levels of participation in online discussions, interactive modules, and digital group activities were associated with greater improvements. This relationship highlights the importance of active engagement rather than passive exposure to blended learning components. Relationships across skill domains also indicate that improvement in digital literacy is moderately correlated with gains in critical thinking and creativity. This pattern implies that as students develop stronger digital abilities, they may also become more proficient in using technology to generate ideas, evaluate information, and articulate reasoning. The relational findings emphasize that blended learning influences multiple skill domains in interconnected ways.

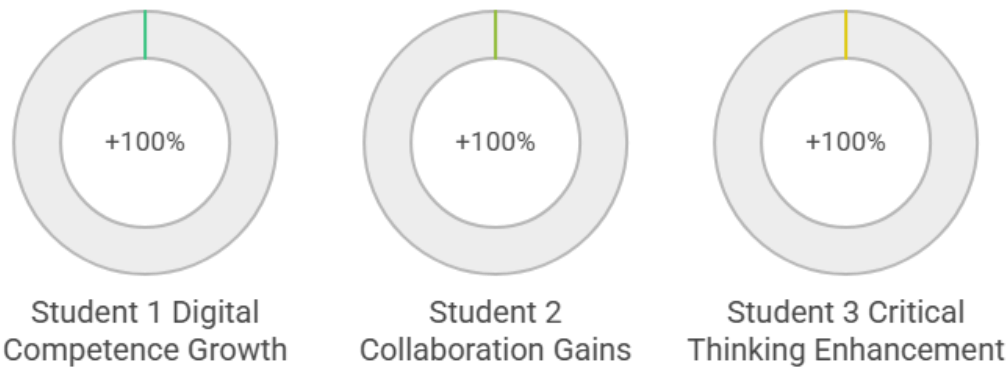


Figure 2. Blended Learning Skill Improvement

A closer qualitative examination of three focal students reveals differing trajectories of skill improvement under blended learning. One student with initially low digital competence demonstrated rapid growth after engaging intensively with online tutorials and peer-support mechanisms embedded in the digital platform. Another student showed significant gains in collaboration due to frequent involvement in group projects facilitated through shared online workspaces. A high-performing student displayed enhanced critical thinking after being assigned inquiry-based digital tasks that required synthesizing multimedia information. These student-specific patterns illustrate how individualized learning pathways within blended environments contribute to diverse forms of skill development. This case-level evidence strengthens the quantitative findings by revealing micro-level learning processes.

The focal cases underscore that blended learning generates improvement not solely due to technology availability but through structured opportunities for interaction, exploration, and guided autonomy. Students benefited most when digital tasks were intentionally scaffolded, providing balanced cognitive challenge and support. Teacher monitoring and digital feedback loops also played crucial roles in amplifying learning outcomes. The cases suggest that blended learning's effectiveness is partially contingent on learner readiness and the alignment between digital task design and students' developmental characteristics. Students who actively engaged with digital tools experienced more substantial skill gains, indicating that blended learning is not inherently transformative; rather, it becomes effective through thoughtful pedagogical orchestration.

The combined quantitative and qualitative evidence indicates that blended learning significantly enhances 21st-century skills in middle school students, particularly in digital literacy and collaboration. The statistical results demonstrate strong effects, while case-level insights reveal how individual engagement mediates learning outcomes. These findings suggest that blended learning offers meaningful advantages when supported by structured design and

teacher facilitation. The interpretation must also acknowledge that blended learning is not universally effective without adequate resources, teacher competence, and student digital readiness. The findings highlight both the potential and the limitations of blended learning, reinforcing that its success depends on coherent implementation rather than the mere presence of technology.

The study demonstrates that blended learning significantly enhances middle school students' 21st-century skills, particularly in digital literacy and collaboration. The experimental group consistently outperformed the control group across all measures, suggesting that technology-integrated instruction creates expanded opportunities for cognitive and social engagement. The learning gains were not only statistically significant but also practically meaningful, indicating measurable transformation in student competence. The highest improvement in digital literacy reflects the natural affordances of blended learning environments, where students navigate online tools, evaluate digital content, and produce technology-mediated outputs. Collaboration also improved substantially, supported by structured digital group tasks that required shared decision-making and coordinated problem-solving. The improvements in creativity and critical thinking, although smaller, were still notable and reflect the ability of blended environments to foster divergent thinking and analytical reasoning.

Score distribution analysis shows that blended learning benefited not only high-achieving students but also those initially performing at lower levels. Students who previously struggled with digital or cognitive tasks demonstrated substantial progress, suggesting that blended learning can serve as an equalizing mechanism when designed well. The reduced score variability within the experimental group reinforces the idea that blended approaches provide scaffolded, differentiated learning opportunities. Qualitative findings from case analyses reveal that the improvement trajectory varies across students, depending on engagement intensity and readiness for digital tasks. Students who explored online resources deeply or actively participated in collaborative digital spaces gained more from the intervention. These individual trajectories highlight that blended learning is not a passive model but one that requires active learner involvement.

The findings align with earlier research that demonstrates the positive impact of blended learning on digital literacy and communication skills. Studies by Graham (2021) and Means et al. (2020) similarly report that blended models outperform traditional classroom structures when technology is used as a cognitive and interactive amplifier. The present results reinforce these conclusions and extend them to middle school populations, which have been underrepresented in past research. Differences appear when comparing the current results with studies showing limited impact of blended learning on creativity or critical thinking. Several investigations argue that digital integration alone does not automatically stimulate higher-order thinking unless tasks are explicitly designed for inquiry and problem-based reasoning. The relatively modest gains in creativity and critical thinking observed here support that argument, indicating the need for thoughtful pedagogical alignment.

The findings diverge from research suggesting that blended learning primarily benefits older or more autonomous learners. The significant gains in middle school students challenge the assumption that younger learners lack the self-regulation required for hybrid environments. Instead, the results suggest that with adequate scaffolding, early adolescents can thrive in blended instructional settings. Comparative analysis also reveals that cultural and contextual factors shape the impact of blended learning. Studies conducted in high-resource school environments tend to report larger effect sizes, while studies in low-resource contexts show muted benefits. The present study, conducted in a moderately resourced public school, provides a middle-ground perspective that demonstrates notable gains without assuming ideal conditions.

The findings indicate that blended learning serves as more than a technological enhancement; it functions as a restructuring of the learning environment that shifts roles, expectations, and cognitive interaction patterns. Students become active participants in constructing knowledge, and teachers transition into facilitators of digital inquiry rather than information transmitters. This paradigm shift is central to 21st-century education reform. The substantial improvement in digital literacy signifies a broader transformation in how students perceive and engage with digital information. Technology is no longer merely an instructional accessory but a critical medium for communication, collaboration, and problem-solving. This shift signals the need for schools to embrace digital fluency as a core educational objective rather than a supplementary skill.

The consistent gains across diverse learners reflect an emerging trend in which blended learning supports differentiated learning by enabling personalized pacing, multimodal content delivery, and flexible access to resources. The reduction in score variability suggests that blended learning may reduce achievement gaps when implemented correctly. This has important implications for equity-based approaches to education. The pattern of findings suggests that the value of blended learning lies not only in what students learn but also in how they learn. The iterative cycle of digital engagement, feedback, and reflection appears to cultivate dispositions essential for lifelong learning, such as autonomy, curiosity, and adaptability. These outcomes align with global educational standards for 21st-century readiness.

The results imply that schools should reconsider the structure of learning environments and integrate blended components as part of mainstream instructional strategies. Blended learning offers the capacity to strengthen essential competencies that traditional classrooms struggle to cultivate consistently, particularly digital literacy and collaboration. Policymakers may view blended learning as a necessary approach for future curriculum development. The study highlights the importance of investing in teacher training and instructional design expertise. Teachers cannot rely solely on digital tools; instead, they need the skills to orchestrate digital and face-to-face activities in ways that explicitly target 21st-century competencies. Without robust professional development, blended learning risks becoming a superficial overlay rather than a transformative pedagogical model.

The implications extend to curriculum development, where tasks must be designed to cultivate inquiry, creativity, and problem-solving. Digital modules should incorporate open-ended problems, multimedia exploration, and peer collaboration to optimize their educational impact. Schools may benefit from revising curricula to embed these competencies across subjects rather than confining them to technology courses. The study suggests that blended learning can play a strategic role in reducing educational disparities when implemented equitably. Access to digital tools, structured support, and consistent teacher guidance are critical for maximizing student learning outcomes. Educational institutions must address infrastructure gaps to prevent blended learning from reinforcing existing inequities.

The significant improvement in digital literacy likely arises from students' repeated exposure to technology-mediated tasks that require active navigation, evaluation, and creation of digital content. The blended learning environment provides authentic digital experiences rather than isolated computer-use episodes, enabling deeper skill formation. The rich, multimodal interactions also support cognitive processing. The rise in collaboration skills reflects the social affordances embedded within blended platforms, such as shared documents, discussion boards, and peer-feedback systems. These tools promote dialogue, negotiation, and joint decision-making, all of which are central to developing collaborative competence. The structured design of group activities helps guide productive social interaction.

The gains in creativity and critical thinking, though moderate, stem from inquiry-based digital tasks that challenge students to synthesize information, generate ideas, and draw evidence-based conclusions. These tasks elevate the cognitive load in meaningful ways that

traditional instruction does not consistently provide. The combination of multimedia resources and autonomous learning pathways supports divergent thinking. The variation in student improvement can be explained by differences in digital readiness, motivation, and engagement styles. Students who actively explored the digital environment or sought peer support benefited more from the blended model. The findings suggest that blended learning amplifies learning only when students participate meaningfully in digital tasks.

The results indicate the need for ongoing refinement of blended learning models to ensure they explicitly target all components of 21st-century skills. Schools should integrate structured digital inquiry, collaborative problem-solving tasks, and creative multimedia projects into future instructional cycles (Dong, 2024). These elements must be embedded systematically rather than introduced sporadically. Future research should examine long-term impacts of blended learning to determine whether skill gains persist beyond the intervention period (Bairy & Inamdar, 2026). Studies could explore how blended learning influences students' learning dispositions, metacognitive awareness, and self-regulation over time. Such evidence is essential for evaluating blended learning's contribution to sustainable competence development.

Further investigations should consider contextual variables such as socio-economic status, access to household technology, and teacher digital competence. These factors may shape the extent to which blended learning benefits students (Yildiz, 2025). Broader, multi-site studies may help identify patterns that transcend individual school environments. The findings suggest the need for policy frameworks that support digital infrastructure, teacher capacity-building, and curriculum integration. Blended learning should be positioned not as an optional innovation but as an essential component of modern education. Targeted policies can ensure that blended learning enhances not replaces the pedagogical practices that cultivate students' holistic development.

CONCLUSION

The study identifies a distinctive pattern in which blended learning yields the strongest improvements not merely in digital literacy as widely documented but also in collaboration, a result that diverges from prior studies suggesting that younger learners struggle with digital coordination. The pronounced gain in collaboration indicates that middle school students can effectively navigate shared digital spaces when instructional design provides structured interaction pathways. This contrasts with research claiming that blended learning benefits primarily autonomous or older learners, thereby highlighting that early adolescents possess greater adaptability to hybrid learning environments than previously assumed.

The research contributes a methodological advancement by integrating performance-based tasks, behavioral observations, and self-assessments to measure 21st-century skills holistically rather than relying on single-source cognitive tests. This triangulated measurement model provides a more accurate representation of students' skill growth across digital, social, and cognitive domains. The study also offers a conceptual contribution by illustrating how engagement intensity mediates the relationship between blended learning and skill development, thus positioning learner agency as a central mechanism rather than treating technology use as an automatic catalyst for improvement.

The study is limited by the non-randomized sample structure and a relatively short intervention period, which may restrict the generalizability and long-term interpretation of the findings. Broader research involving diverse school contexts, varying technological infrastructures, and longitudinal tracking is needed to capture the sustainability of skill development over time. Further investigations should also analyze how teacher expertise, home digital access, and motivational factors interact with blended learning to influence outcomes,

thereby enabling the formulation of more comprehensive and context-sensitive blended learning models.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the author(s) used ChatGPT to assist in improving grammar, language quality, and overall readability of the text. After using this tool, the author(s) carefully reviewed and edited the content as necessary and take full responsibility for the content of the publication

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

DECLARATION OF COMPETING INTEREST

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

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