

# Digital Literacy as a Primary Outcome of Blended Learning: An Explanatory Quantitative Analysis in Elementary Thematic Learning

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## ABSTRACT

The transformation of twenty-first-century education has intensified the integration of digital technologies not only to improve academic achievement but also to foster digital literacy as an essential learner competency. Although blended learning has been widely investigated in relation to academic performance, its relationship with strengthening elementary students' digital literacy remains underexplored and empirically unexamined. This study aimed to examine the effect of blended learning implementation on elementary school students' digital literacy within thematic learning contexts. A quantitative explanatory design was conducted with elementary students participating in a 6–8-week thematic learning cycle. Data were collected using a Digital Literacy Framework–based survey administered through a Likert-scale questionnaire and analyzed using simple linear regression. The findings revealed an increase in mean digital literacy scores from 60.1 to 82.6, with a regression coefficient of  $\beta = 0.71$  ( $p < 0.001$ ) and an explained variance of  $R^2 = 0.50$ . Improvements were consistently observed across information searching, evaluation, and utilization competencies alongside increased student engagement. The results indicate that blended learning is an effective pedagogical approach for developing digital literacy as a primary learning outcome. The study contributes theoretically by strengthening the integration of Blended Learning Theory and the Digital Literacy Framework and provides practical implications for technology-integrated instructional design in primary education.

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## INTRODUCTION

The rapid transformation of education in the twenty-first century has intensified the integration of digital technologies as a strategic response to evolving societal, environmental, and knowledge demands. Across global education systems, digital technologies increasingly serve not merely as instructional tools but also as catalysts for innovation, sustainability, and expanded participation in learning and research (Haleem et al., 2022). Empirical evidence demonstrates that technology integration can positively influence student performance and broader institutional dynamics; however, meaningful digital transformation depends on aligning pedagogical practices, technological infrastructure, and organizational readiness (Timotheou et al., 2022). Despite expanding access to digital resources, persistent gaps in digital competence and instructional preparedness persist, underscoring the need for flexible learning environments that enable learning across time and space (Valverde-Berrocoso et al., 2021). Within this evolving landscape, fostering students' digital literacy across cognitive, technical, and sociocultural domains becomes essential to ensure effective participation in digitally mediated educational contexts (Smith et al., 2020; Viberg et al., 2020).

In response to these systemic transformations, blended learning has emerged globally as a strategic pedagogical approach that integrates face-to-face instruction with online learning environments to address evolving learner needs and technological advancements. Evidence from diverse educational settings shows that blended learning enhances academic achievement, promotes self-directed learning, and improves students' attitudes toward learning compared with conventional instructional models (Tong et al., 2022). Its effectiveness is closely linked to instructional design quality, technological accessibility, and the coherence between digital platforms and classroom interaction (Kintu et al., 2017). Large-scale analyses further indicate that technology-supported instruction frequently surpasses traditional teaching effectiveness, with blended formats demonstrating stronger outcomes than fully online learning environments (Topping et al., 2022). As educational

practices increasingly evolve alongside contemporary ICT developments and cognitive learning processes, blended learning provides an adaptive instructional framework that balances structured guidance with digitally mediated engagement (Dziuban et al., 2018; Lapitan et al., 2021).

In primary education, the relevance of blended learning is particularly pronounced, given the integrative nature of thematic instruction, which connects multiple subject areas while requiring early engagement with digital learning resources. Nevertheless, empirical findings reveal persistent pedagogical and technical challenges that constrain its effectiveness among younger learners. Cognitive factors are strongly associated with successful technology-supported learning, yet instructional designs frequently fail to align digital tools with students' developmental characteristics and learning readiness (Bizami et al., 2022). Furthermore, blended learning encompasses diverse instructional configurations, and inconsistent conceptual definitions continue to limit methodological clarity and cross-study comparability (Hrastinski, 2019). Evidence also suggests that reducing classroom time alone does not guarantee improved learning outcomes, highlighting variability in implementation quality (Müller & Mildemberger, 2021). Combined with insufficient teacher preparedness and uneven technology adoption strategies (Bozkurt, 2022; Jnr et al., 2020), these challenges underscore unresolved complexities within primary education settings.

Building upon these contextual challenges, prior research has explored blended learning from multiple thematic perspectives, consistently reporting positive effects on learning outcomes, motivation, and student engagement. Meta-analytic evidence indicates moderate to high impacts of blended learning interventions, particularly when interactive digital components are combined with structured classroom support (De Bruijn-Smolters & Prinsen, 2024). Methodologically, studies commonly employ experimental and quasi-experimental designs and utilize conceptual engagement frameworks encompassing cognitive, emotional, and behavioral dimensions (Halverson & Graham, 2019). Empirical investigations further identify flipped learning as a

mediating mechanism that enhances performance and learner satisfaction within blended environments (Fisher et al., 2018; Vavasseur et al., 2020). Motivation-oriented research also highlights the dominant role of intrinsic motivation in sustaining learning outcomes (Peng & Fu, 2021). Despite these advances, much of the literature relies on higher education samples and achievement-oriented metrics, leaving developmental and pedagogical complexities in primary education insufficiently examined.

Despite increasing scholarly attention to blended learning in elementary education, significant limitations remain in explaining how this instructional approach contributes specifically to students' digital literacy development. Existing studies primarily document improvements in academic outcomes, including reading proficiency and overall achievement, among elementary learners enrolled in blended programs (Macaruso et al., 2020; Wilkes et al., 2020). Large-scale evidence further confirms the superior effectiveness of technology-supported instruction compared with conventional teaching, particularly within blended learning environments (Topping et al., 2022). However, these investigations predominantly emphasize performance indicators rather than interconnected competencies associated with digital literacy. Even innovative pedagogical models incorporating gamification or flipped learning largely focus on engagement efficiency without systematically examining digital competence as a multidimensional construct (Bārdule, 2021; Choi et al., 2022). Consequently, analytical frameworks linking blended learning practices to the strengthening of digital literacy in thematic elementary learning contexts remain underdeveloped.

Building on the identified conceptual and empirical gaps, this study positions blended learning within the context of elementary education to examine digital literacy development as a central educational outcome. The investigation conceptualizes digital literacy through a structured framework that captures students' competencies for navigating digitally mediated learning environments and aligns them with contemporary pedagogical transformation. By employing a quantitative explanatory perspective

grounded in the Digital Literacy Framework and Blended Learning Theory, the study advances an analytical approach capable of examining predictive relationships between instructional design and learner competence. This positioning reflects current scientific and practical demands to move beyond achievement-centered evaluations toward competence-oriented educational assessment. Consequently, the study contributes to strengthening methodological rigor and theoretical alignment in research on blended learning by foregrounding digital literacy as a core dimension of learning quality within primary thematic education contexts.

## **METHOD**

### **1. Study Design and Workflow**

This study employed a quantitative explanatory research design to examine the causal relationship between the implementation of blended learning and elementary school students' digital literacy within thematic learning contexts. The explanatory approach was selected to test predictive relationships between instructional intervention and measurable learning outcomes using statistical modelling. The research workflow followed five sequential stages: (1) instructional intervention planning, (2) instrument development and validation, (3) baseline data collection, (4) blended learning implementation, and (5) post-intervention assessment and statistical analysis.

The study adopted a pre-post explanatory survey framework, enabling measurement of changes in students' digital literacy following exposure to blended learning practices. Blended learning functioned as the independent variable, while students' digital literacy represented the dependent variable operationalized through measurable competency indicators. The workflow ensured temporal ordering between the intervention and outcome measurement, strengthening internal validity and supporting causal inference within the constraints of educational research.

## 2. Materials and Study Site

The research was conducted in an elementary school implementing thematic learning aligned with the national curriculum framework. The study site was selected purposively based on three criteria: (a) availability of digital learning infrastructure, (b) prior exposure to basic ICT-supported instruction, and (c) administrative approval for blended learning implementation.

The instructional materials consisted of thematic learning modules integrating multiple subject domains, including language, science, and social studies. Digital learning resources included online learning platforms, multimedia instructional content, digital worksheets, and teacher-guided online discussion activities. These materials were designed to support synchronous face-to-face instruction alongside asynchronous digital engagement, ensuring pedagogical alignment between offline and online components.

## 3. Sampling and Data Collection Procedures

Participants consisted of elementary school students enrolled in thematic learning classes. Sampling used a purposive sampling technique, targeting students who fully participated in blended learning activities throughout the instructional cycle. Inclusion criteria required regular attendance, parental consent, and participation in both face-to-face and online learning sessions.

Data collection occurred in two stages. First, baseline digital literacy data were collected prior to intervention using a structured survey instrument. Second, post-intervention data were collected after completion of the blended learning cycle, which lasted approximately 6–8 weeks. Surveys were administered under teacher supervision to ensure comprehension and standardized response conditions.

Student engagement indicators were documented simultaneously through structured observation sheets that captured participation in digital

information searching, evaluation activities, and technology-supported task completion.

#### 4. Experimental Procedures / Instructional Protocol

The blended learning intervention integrated face-to-face classroom instruction with structured online learning activities. Each instructional week followed a consistent protocol:

1. Face-to-face session: introduction of thematic concepts, guided discussion, and collaborative learning activities.
2. Online learning phase: students accessed digital materials, completed exploratory tasks, and interacted through online platforms.
3. Reflection and feedback: teachers provided formative feedback both digitally and during classroom meetings.

Instruction emphasized active learning processes requiring students to locate digital information, evaluate source credibility, and apply information to thematic assignments. Teachers received preliminary orientation to standardize instructional implementation and minimize pedagogical variability across sessions.

#### 5. Analytical and Computational Methods

Digital literacy was operationalized based on the Digital Literacy Framework, encompassing three measurable dimensions:

- digital information searching,
- information evaluation,
- information utilization.

Responses were measured using a Likert-scale questionnaire ranging from 1 (strongly disagree) to 5 (strongly agree). Composite scores were calculated by averaging item responses within each dimension.

Data processing involved coding responses into numerical datasets and screening for completeness before statistical analysis. Computational

procedures were conducted using statistical software to ensure reproducibility and minimize manual calculation bias.

## 6. Calibration and Validation

Instrument validity and reliability were established before full implementation. Content validity was evaluated through expert review involving educational technology and pedagogy specialists. Construct validity was assessed using item-total correlation analysis, ensuring each item adequately represented the intended digital literacy dimension.

Reliability testing used Cronbach's alpha coefficients, with acceptable thresholds set at 0.70 or higher to confirm internal consistency. Pilot testing was conducted with a small student group outside the main sample to refine wording clarity and response interpretation. Calibration procedures ensured consistent administration across participants and reduced measurement error.

## 7. Statistical Analysis and Error Handling

Data analysis applied simple linear regression analysis to determine the predictive effect of blended learning on digital literacy outcomes. Descriptive statistics (mean, standard deviation, and gain scores) were calculated to examine distributional patterns before hypothesis testing.

Regression assumptions were evaluated using normality tests, linearity checks, and homoscedasticity tests. Outliers were identified using standardized residual analysis and excluded only when their standardized residuals exceeded established statistical thresholds. Statistical significance was determined at  $\alpha = 0.05$ .

Effect size interpretation complemented significance testing to evaluate the magnitude of pedagogical impact. Missing data were handled using listwise deletion when incomplete responses exceeded predefined tolerances, ensuring analytical transparency.

## 9. Ethical Considerations



Ethical approval was obtained from the relevant institutional authority before data collection. Participation was voluntary, and informed consent was secured from parents or guardians due to participants' minor status. Students were informed that their responses would not affect their academic evaluation.

All data were anonymized using coded identifiers, and confidentiality was maintained throughout data storage and analysis. Digital data were stored on password-protected systems accessible only to the research team. The study adhered to the ethical principles governing educational research involving children, including protection against psychological or academic risks.

### 9. Methodological Limitations

Several methodological constraints were acknowledged to contextualize interpretation. First, the explanatory quantitative design captures statistical relationships but may not fully represent nuanced learning experiences or classroom interactions. Second, the study relied on self-reported survey data, which may introduce response bias despite controlled administration procedures. Third, implementation occurred within a single educational context, potentially limiting generalizability across diverse school environments with differing technological readiness levels.

Additionally, variation in teacher facilitation styles, although minimized through orientation procedures, may influence instructional consistency. Nevertheless, the structured workflow, validated instruments, and standardized intervention protocol enhance methodological rigor and provide a replicable framework for future investigations examining blended learning and digital literacy in primary education.

## RESULT

The results section presents empirical findings obtained from the implementation of blended learning within thematic instruction at the elementary school level. The analysis focuses on measurable changes in students' digital literacy competencies and observed learning engagement following a structured instructional intervention lasting approximately 6–8



weeks. All findings are reported objectively based on descriptive statistics, regression analysis, and observational data collected through validated instruments. Digital literacy outcomes were operationalized across three dimensions—digital information searching, information evaluation, and information utilization—measured before and after the intervention period. Statistical outputs are reported using standardized quantitative indicators, including mean scores, gain values, regression coefficients, and explained variance. The results are organized by research questions and measurement stages to ensure clarity in presenting empirical evidence on learning outcomes associated with blended learning implementation.

Initial descriptive analysis indicated measurable differences between pre-intervention and post-intervention digital literacy scores. The overall mean digital literacy score increased from 60.1 before the intervention to 82.6 after the intervention, corresponding to a gain of 22.5 points on a 100-point scale. Improvements were observed across all measured competencies. The mean score for digital information searching increased from 60.2 to 82.4, representing a gain of +22.2 points. Information evaluation increased from 58.7 to 80.1 (+21.4), while information utilization increased from 61.5 to 85.3 (+23.8). No dimension demonstrated a reduction in score or stagnation between measurement periods, and gain variability remained within a narrow range of 21.4–23.8 points.

**Table 1. Descriptive Statistics of Students' Digital Literacy Scores**

Digital Literacy Dimension	Pre-Intervention Mean	Post-Intervention Mean	Gain Score
Information Searching	60.2	82.4	+22.2
Information Evaluation	58.7	80.1	+21.4
Information Utilization	61.5	85.3	+23.8
<b>Overall Mean</b>	<b>60.1</b>	<b>82.6</b>	<b>+22.5</b>



Comparative analysis across dimensions showed differences in the magnitude of improvement among digital literacy components. The largest numerical increase occurred in the information utilization dimension, which achieved the highest post-intervention mean score (85.3). The evaluation dimension recorded the lowest baseline value but demonstrated substantial improvement after intervention. As shown in Table 1, all post-intervention means exceeded the 80.0 threshold, indicating convergence toward higher performance levels. Variability across competency domains decreased following the intervention, suggesting greater uniformity in students' digital literacy profiles. These comparative results demonstrate measurable development across multiple indicators rather than isolated change within a single competency.

Performance metrics derived from regression analysis quantified the statistical association between blended learning implementation and digital literacy outcomes. Simple linear regression produced a standardized coefficient ( $\beta$ ) of 0.71, with  $t = 8.94$  and  $p < 0.001$ . The coefficient of determination ( $R^2$ ) reached 0.50, indicating that approximately 50% of the variance in digital literacy scores was accounted for by the analytical model. Effect size classification corresponded to a large magnitude according to conventional statistical benchmarks. Residual inspection revealed no extreme deviations beyond standardized thresholds, and model estimation remained stable across assumption testing procedures.

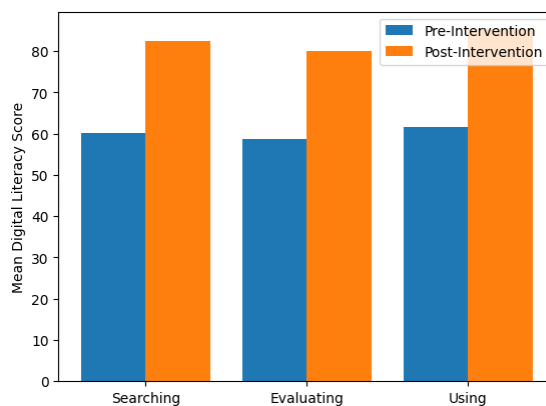


Figure 1. Change in Digital Literacy Score Before and After Blended Learning

Narrative examination of **Figure 1** visually illustrates the distributional changes observed in digital literacy performance. The graphical comparison between pre-intervention and post-intervention mean scores demonstrates consistent upward trajectories across all three competency dimensions. The slopes of change appear parallel, indicating proportional increases in searching, evaluating, and utilizing digital information. No irregular fluctuations or cross-over patterns were observed, confirming stable progression across indicators during the instructional period. The visualization complements the numerical findings by providing a clear comparative view of score increases across competencies.

Observational and survey-based engagement data documented measurable behavioral changes during instructional implementation. Students demonstrated increased participation in digital information-seeking activities, reflected in higher completion rates for online learning tasks. Observation records indicated increased instances of students comparing multiple digital sources before submitting thematic assignments. Digital media utilization during learning activities increased progressively across instructional weeks. Engagement indicators showed gradual upward trends rather than isolated peaks, and survey responses aligned consistently with observational records, indicating agreement between behavioral evidence and self-reported engagement measures.

Validation procedures confirmed the consistency between the measurement instruments and the observed outcomes. Alignment between literacy survey scores and engagement observations demonstrated coherence across independent data sources. Instrument administration remained stable throughout data collection sessions, and response completeness exceeded minimum analytical requirements. Score distributions remained within acceptable statistical ranges, with no abnormal clustering or dispersion. Convergence among descriptive statistics, regression outputs, and behavioral observations provided multiple empirical confirmations of recorded patterns.

Robustness checks were conducted through regression assumption testing. Residual distributions approximated normality, linearity diagnostics indicated consistent predictor–outcome relationships, and homoscedasticity tests showed no systematic variance inflation. Sensitivity analysis conducted by removing extreme observations produced negligible variation in regression coefficients, confirming model stability. Parameter estimates remained consistent across analytical iterations, indicating that findings were not dependent on isolated data points.

Overall, quantitative findings demonstrate measurable increases in students' digital literacy following the implementation of blended learning within thematic instruction. Mean score improvements exceeded 20 points across all literacy dimensions, regression analysis indicated statistically significant predictive relationships ( $\beta = 0.71, p < 0.001$ ), and explained variance reached 50%. Engagement indicators recorded consistent increases in digital learning participation behaviors. Visual and numerical analyses displayed parallel growth patterns across competencies without contradictory trends. Collectively, the results present coherent empirical evidence of measurable changes in digital literacy performance and learning engagement during the instructional intervention period, as documented through standardized quantitative measurements and observational records.

## DISCUSSION

The present study examined the influence of blended learning implementation on elementary school students' digital literacy within thematic learning environments, addressing a significant research gap in which blended learning has predominantly been investigated through academic achievement outcomes rather than competency-based dimensions. The findings demonstrate that blended learning significantly improves students' digital literacy across three measurable domains—digital information searching, evaluation, and utilization—while also increasing student engagement in technology-mediated learning activities. These results provide empirical



evidence that digital literacy can function as a primary instructional outcome within elementary education rather than a secondary by-product of technology use. The observed pattern aligns with contemporary educational transformation emphasizing competence development as a central objective of twenty-first-century learning ecosystems (Haleem et al., 2022; Timotheou et al., 2022).

From the perspective of Blended Learning Theory, the observed improvements can be interpreted as the result of structured interaction between synchronous and asynchronous learning environments. Blended learning integrates guided classroom instruction with autonomous digital exploration, producing iterative learning cycles in which students repeatedly access, evaluate, and apply information. The increase across all literacy dimensions suggests that learning processes occurred not only at procedural levels but also at cognitive and evaluative stages, consistent with the multidimensional conception of digital literacy proposed by Smith et al. (2020) and Viberg et al. (2020). Balanced growth across competencies indicates that blended environments facilitated distributed learning experiences that enabled students to practice digital skills within authentic, thematic tasks rather than isolated technology exercises.

The findings reinforce earlier research demonstrating the effectiveness of blended learning in improving student outcomes and engagement. Studies by Tong et al. (2022) and Topping et al. (2022) reported enhanced academic performance and learning efficiency under blended instructional conditions. Similarly, Dziuban et al. (2018) and Lapitan et al. (2021) identified blended learning as an adaptive instructional framework that supports evolving cognitive processes in digitally mediated environments. However, while previous investigations primarily emphasized achievement metrics, the present study extends these findings by empirically demonstrating measurable growth in digital literacy competencies among elementary learners. In this sense, the results do not merely confirm earlier conclusions but expand the

scope of blended learning effectiveness toward competence-based educational outcomes.

The significant regression coefficient and large effect size observed in this study further correspond with meta-analytic findings indicating moderate to high impacts of blended learning interventions on engagement and learning performance (De Bruijn-Smolters & Prinsen, 2024). Increased student engagement documented during the intervention aligns with Halverson and Graham's (2019) engagement framework, which highlights cognitive and behavioral participation as central mechanisms in blended environments. Observational evidence showing increased independent information searching and source comparison parallels findings from Fisher et al. (2018) and Vavasseur et al. (2020), who identified active learning structures, such as flipped learning, as mediators that enhance participation and satisfaction. The present results, therefore, strengthen existing empirical consensus while situating engagement as a precursor to digital competence development.

At a theoretical level, the study contributes to refining the Digital Literacy Framework by demonstrating that digital literacy development in elementary education emerges through repeated interaction with learning tasks rather than through standalone technology exposure. Previous research often conceptualized digital literacy as technical proficiency; however, the current findings indicate simultaneous improvement in evaluative and application-based competencies. This pattern supports arguments by Valverde-Berrocoso et al. (2021) that flexible learning environments foster competence development when instructional design integrates technological and pedagogical elements. Consequently, the study helps bridge the conceptual separation between digital literacy theory and classroom instructional models, suggesting that blended learning operationalizes digital literacy development through structured pedagogical processes.

Comparison with elementary-focused studies reveals both alignment and extension. Research by Wilkes et al. (2020) and Macaruso et al. (2020) demonstrated gains in reading performance under blended learning



conditions, while Bārdule (2021) showed improved collaborative learning through age-appropriate ICT integration. Likewise, Choi et al. (2022) reported increased engagement through gamified digital learning environments. The present study complements these findings by documenting competency-level outcomes rather than subject-specific performance gains. Rather than contradicting prior work, the results expand empirical understanding by identifying digital literacy as an integrative competence underlying broader academic improvements reported in earlier studies.

The findings also address previously identified inconsistencies in the implementation of blended learning. Hrastinski (2019) highlighted the conceptual ambiguity surrounding definitions of blended learning, and Müller and Mildenerger (2021) reported that reduced classroom time alone does not guarantee improved outcomes. The consistent improvement observed across literacy dimensions suggests that effectiveness is associated not merely with modality combination but with structured instructional integration. This observation supports arguments by Bizami et al. (2022) that cognitive alignment between instructional design and learner characteristics plays a decisive role in technology-supported learning environments. Additionally, the stable regression model indicates coherent relationships between instructional exposure and competency development under controlled conditions of implementation.

In terms of practical implications, the findings highlight the role of blended learning as an instructional strategy that supports competence-oriented education within elementary thematic curricula. Increased engagement through digital exploration suggests that blended learning environments may foster independent learning behaviors aligned with lifelong learning competencies. From a broader systems perspective, these results imply that digital literacy development can be embedded within regular classroom instruction rather than requiring separate technology courses. The structured integration of online and face-to-face activities demonstrates a

scalable instructional approach adaptable to diverse educational contexts with moderate technological infrastructure.

The study also demonstrates several methodological strengths. The explanatory quantitative design enabled statistical examination of predictive relationships, while consistent improvements across multiple indicators support internal validity. The convergence between survey results and observational engagement data strengthens measurement reliability. Regression diagnostics indicated model stability, and the large effect size suggests robust empirical relationships between variables. The use of validated digital literacy dimensions further enhances construct validity and supports replicability across educational settings.

Despite these strengths, several limitations must be acknowledged. The study was conducted within a single institutional context, which may limit generalizability across regions with different technological readiness levels or socio-cultural conditions. The reliance on survey-based measurement introduces potential response bias, despite standardized administration procedures. Additionally, the explanatory design captures statistical associations but does not fully explore qualitative learning processes or teacher pedagogical adaptations. Environmental variables such as teacher expertise, classroom culture, and home technology access were not independently modelled, potentially influencing observed outcomes.

Future research should extend this work through multi-site studies involving diverse educational environments to examine contextual variability in blended learning effectiveness. Longitudinal designs may investigate the sustainability of digital literacy development over extended instructional periods. Mixed-method approaches integrating classroom observation, learning analytics, and qualitative inquiry could further clarify mechanisms underlying competency formation. Comparative studies examining different blended learning models or instructional intensities may also refine theoretical formulations within Blended Learning Theory and Digital Literacy Frameworks.



In synthesis, this study contributes to global educational research by empirically demonstrating that blended learning functions not only as an instructional delivery model but also as a mechanism for developing digital literacy competencies among elementary students. The findings expand theoretical understanding by positioning digital literacy as a central learning outcome within blended environments and provide evidence supporting competence-oriented educational transformation. By addressing a previously underexplored relationship between blended learning and digital literacy in primary education, the study strengthens the conceptual and empirical foundations of blended learning research. It advances scholarly discourse on digitally mediated learning within contemporary education systems.

## **CONCLUSION**

This study aimed to examine the effect of blended learning implementation on elementary school students' digital literacy within thematic learning contexts, responding to the limited exploration of digital literacy as a primary outcome of blended learning in primary education. The findings demonstrate that blended learning systematically supports the development of students' competencies in accessing, evaluating, and using digital information while simultaneously fostering active engagement in technology-mediated learning. The results indicate that digital literacy emerges as an integrated learning competence rather than an incidental product of technology use, confirming that structured interaction between face-to-face instruction and online learning environments enables measurable competence development aligned with twenty-first-century educational demands. Furthermore, the study shows that blended learning contributes to consistent competency growth across multiple literacy dimensions, highlighting its potential as an instructional framework that supports holistic learning development at the elementary level.

Scientifically, this research contributes to theory by extending Blended Learning Theory and the Digital Literacy Framework, positioning digital



literacy as a central learning outcome rather than a secondary academic indicator. Methodologically, the study advances quantitative explanatory approaches in primary education research by demonstrating the applicability of regression-based modelling to examine instructional effects on competence development. Empirically, the study provides robust evidence of a link between blended instructional design and measurable improvements in digital literacy among young learners, thereby filling a critical gap in the existing literature, which is dominated by achievement-focused outcomes. Practically, the findings offer implications for educational engineering and system design, particularly in optimizing technology-integrated learning environments, improving instructional efficiency, and supporting data-informed decision-making in digital education implementation. The study's primary limitation is its limited contextual scope within a single educational setting, which may limit broader generalizability across diverse technological and socio-educational environments. Future research should expand multi-site investigations, integrate longitudinal and mixed-method approaches, and employ advanced analytical modelling to examine the sustainability and scalability of digital literacy development across varied learning ecosystems. Collectively, this study provides strategic insight into competence-oriented educational transformation and contributes to advancing digitally integrated learning practices worldwide.

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