

Reconfiguring Digital Literacy as a Pedagogical Ecosystem: A Participatory Action Study of Digital Library Integration in Curriculum Reform

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ABSTRACT:

Background: Digital literacy remains unevenly integrated within curriculum reform, particularly where digital library infrastructures are underutilized as pedagogical resources. This gap reflects a structural disconnection between technological provision and meaningful learning practices in secondary education.

Aims:

This study aims to reconceptualize digital literacy as a pedagogical ecosystem by examining how participatory digital library integration can support curriculum reform and foster student autonomy.

Methods:

A Participatory Action Research (PAR) design combined with mixed methods was employed through three iterative cycles involving mentoring, socialization, and guided implementation of a digital library system. Quantitative data were analyzed using N-Gain, while qualitative data were derived from observations and interviews to capture shifts in learning practices.

Results:

Findings indicate a high level of effectiveness in improving students' digital literacy competencies, particularly in navigating digital resources and engaging with academic content. The intervention also enhanced students' learning autonomy and strengthened librarians' roles as active facilitators within the learning process.

Conclusion:

This study demonstrates that digital literacy should be reframed beyond technical competence toward a dynamic pedagogical ecosystem that integrates infrastructure, participation, and curriculum practice. The findings highlight the transformative potential of participatory approaches in bridging institutional and pedagogical gaps. By positioning digital libraries as integral learning environments, this research contributes to advancing socially responsive and contextually grounded educational practices, offering a scalable model for curriculum reform in diverse educational settings.

Keywords: Digital Literacy Ecosystem; Participatory Action Research; Digital Library Integration; Curriculum Reform; Student Learning Autonomy; Educational Technology Transformation.

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INTRODUCTION

Digital literacy has become a central pillar in contemporary education systems as learning environments increasingly shift toward technology-mediated interactions. The expansion of digital infrastructure in schools has not automatically translated into meaningful learning engagement, indicating a persistent gap between access and pedagogical utilization. Research shows that digital literacy is not limited to technical skills but encompasses critical, cognitive, and socio-cultural competencies required to navigate information-rich environments (Bamgbose et al., 2024). In many educational contexts, digital tools are still positioned as supplementary resources rather than integral components of instructional design. This misalignment often results in underutilized digital platforms, particularly digital libraries that are primarily treated as administrative repositories instead of learning ecosystems. Studies highlight that the integration of digital resources into teaching practices requires structured pedagogical frameworks to support student-centered learning (Otto et al., 2024). Without such integration, the potential of digital technologies to foster autonomy and critical thinking remains largely unrealized. Therefore, rethinking digital literacy within a broader pedagogical perspective becomes an urgent necessity in education reform.

The implementation of curriculum reform further intensifies the need for transformative approaches to digital literacy integration. Contemporary curricula emphasize student autonomy, inquiry-based learning, and the development of higher-order thinking skills, all of which rely heavily on effective engagement with digital resources. However, empirical evidence suggests that many schools struggle to align technological infrastructure with curriculum demands due to limited pedagogical adaptation (Ajani, 2024). Digital libraries, despite their accessibility and resource richness, are often disconnected from classroom practices and learning objectives. This disconnection reflects a deeper structural issue in how educational institutions conceptualize the role of technology in learning processes. Participatory approaches in educational innovation have been shown to enhance contextual relevance and sustainability of interventions (Cumbo & Selwyn, 2022). By involving stakeholders such as students and educators in iterative implementation processes, participatory models can bridge the gap between policy and practice. Consequently, exploring digital library integration through a participatory lens offers a promising pathway to reconceptualize digital literacy as a dynamic and context-responsive pedagogical ecosystem (Phillips et al., 2025).

Recent scholarly discussions have increasingly framed digital literacy as a multidimensional construct that extends beyond operational skills to include critical engagement and knowledge construction. Contemporary studies emphasize that digital literacy should be understood as a socially situated practice embedded within learning environments rather than as an isolated competence (Weninger, 2022). This perspective aligns with the growing recognition of educational technology as a mediating tool that shapes how learners interact with knowledge. Digital libraries, in particular, have been identified as key infrastructures that can support inquiry-based learning and independent knowledge exploration when effectively integrated into pedagogy (Hinostroza et al., 2024). However, several studies indicate that the pedagogical potential of digital libraries remains underexplored due to a lack of structured integration strategies. Furthermore, research highlights that students often lack the necessary skills to critically evaluate and utilize digital resources despite having access to them (Forde & OBrien, 2022). This suggests that access alone is insufficient to develop meaningful digital literacy competencies. Therefore, there is a need to reposition digital literacy within a framework that connects technological tools with pedagogical practices.

In parallel, participatory action research has gained prominence as an approach that enables collaborative knowledge production and context-sensitive educational innovation. Studies demonstrate that participatory models facilitate deeper engagement among stakeholders and promote sustainable changes in teaching and learning practices (Leal Filho et al., 2025). Within the context of educational technology, participatory approaches have been shown to enhance the relevance and effectiveness of digital interventions by incorporating user perspectives into the design and implementation process (Chugh et al., 2023a). Additionally, research on curriculum reform underscores the importance of aligning instructional practices with broader educational goals such as autonomy, critical thinking, and adaptability (El-Annan & Hassoun, 2025). Despite these advancements, limited research has explicitly examined how participatory frameworks can be used to integrate digital libraries into curriculum implementation. Most existing studies focus either on digital literacy development or technology adoption without addressing their interconnection. This fragmented approach limits the understanding of how digital infrastructures can function as pedagogical ecosystems. Accordingly, integrating participatory action research with digital library utilization offers a novel and theoretically grounded approach to advancing digital literacy in education.

Despite the growing body of research on digital literacy and educational technology, existing studies tend to treat digital tools as isolated interventions rather than as components of an interconnected learning system. Many investigations focus on measuring improvements in digital skills without examining how these skills are embedded within pedagogical practices and institutional structures. Additionally, digital libraries are often discussed in terms of access and efficiency, with limited attention given to their role in shaping learning experiences and student autonomy. There is also a lack of research that integrates participatory approaches with digital infrastructure development, particularly in the context of curriculum reform. Previous studies rarely explore how collaborative and iterative processes can transform the function of digital libraries from passive repositories into active learning environments. This gap indicates a need for a more holistic framework that connects digital literacy, pedagogy, and institutional practices. Furthermore, the absence of ecosystem-based perspectives limits the ability to understand the dynamic interactions between learners, educators, and digital resources. Addressing this gap is essential to developing more effective and sustainable models of technology integration in education (Cabasan, 2024).

This study aims to reconceptualize digital literacy as a pedagogical ecosystem by examining the integration of digital libraries within a curriculum reform context. It seeks to investigate how participatory action research can facilitate meaningful engagement between students, educators, and digital resources. The study also aims to evaluate the effectiveness of structured interventions in enhancing students' ability to navigate and utilize digital information. In addition, it explores how participatory processes contribute to the development of student autonomy and independent learning practices. The research further examines the role of digital libraries in supporting curriculum objectives and transforming learning environments. By adopting a mixed-method approach, the study aims to provide both empirical evidence and contextual insights into the integration process. It also seeks to contribute to theoretical discussions on digital literacy by framing it as an interconnected and dynamic system. Ultimately, the study aims to offer a scalable model for integrating digital technologies into education in a way that aligns with contemporary curriculum demands.

METHOD

Research Design

This study employed a Participatory Action Research (PAR) design integrated with a mixed-method approach to examine the reconfiguration of digital literacy as a pedagogical ecosystem. PAR was selected because it enables iterative collaboration between researchers and participants in addressing real-world educational challenges while simultaneously generating contextual knowledge. The research was conducted through three cyclical phases consisting of planning, action, observation, and reflection, allowing continuous refinement of the intervention process. Each cycle involved structured mentoring, guided socialization, and the implementation of a digital library system within classroom practices. The integration of quantitative and qualitative methods provided a comprehensive understanding of both measurable outcomes and experiential transformations in learning processes. Mixed-method designs are widely recognized for their capacity to capture complex educational phenomena that cannot be fully explained through a single methodological lens (Amadi, 2023). The participatory dimension of this study ensured that students and librarians were actively involved as co-constructors of the learning environment rather than passive recipients of intervention. This design aligns with contemporary educational research that emphasizes transformative practice and collaborative inquiry as central to sustainable (Bernert et al., 2022).

Participants

The participants in this study consisted of secondary school students and school librarians who were directly involved in the implementation of the digital library system. Students were selected as primary participants due to their central role in experiencing and enacting digital literacy practices within the learning process. Librarians were included as key facilitators who supported the operational and pedagogical integration of digital resources. The selection of participants was based on their active engagement in the intervention cycles rather than random sampling, ensuring relevance to the participatory framework. The study involved a single class group to allow in-depth observation of behavioral and cognitive changes over time. This approach is consistent with participatory research, which prioritizes depth of engagement over sample generalizability (Jackson-Gordon et al., 2025). The involvement of librarians expanded the scope of the study by bridging institutional and instructional dimensions of digital literacy. Such multi-stakeholder participation is critical in understanding how digital ecosystems function within educational settings (Viglia et al., 2023). Through this collaborative structure, the study captured both learner experiences and institutional dynamics in the integration process.

Instrument

Data were collected using a combination of quantitative and qualitative instruments to capture multiple dimensions of digital literacy development. Quantitative data were obtained through pre-test and post-test instruments designed to measure students' competencies in accessing, navigating, and utilizing digital library resources. The assessment focused not only on technical skills but also on the ability to locate and interpret academic information effectively. Qualitative data were gathered through semi-structured interviews, classroom observations, and reflective documentation throughout the intervention cycles. Observation protocols were used to record changes in student engagement, interaction patterns, and learning autonomy during the implementation process. Interviews with students and librarians provided deeper insights into perceived challenges,

experiences, and transformations in digital literacy practices. The use of multiple instruments ensured methodological triangulation, enhancing the credibility and validity of the findings (Donkoh & Mensah, 2023). Additionally, documentation of each intervention cycle enabled systematic tracking of progress and iterative improvements. This comprehensive instrumentation allowed the study to capture both outcome-based and process-oriented dimensions of the pedagogical ecosystem.

Data Analysis Plan

Quantitative data were analyzed using the N-Gain formula to determine the effectiveness of the intervention in improving students’ digital literacy competencies. The N-Gain analysis provided a standardized measure of learning improvement by comparing pre-test and post-test scores across participants. Inferential statistical techniques were also employed to assess the significance of observed changes and ensure the robustness of the findings. Qualitative data were analyzed using thematic analysis to identify recurring patterns related to student autonomy, engagement, and interaction with digital resources. The analysis followed an iterative coding process, allowing themes to emerge inductively from the data while being continuously refined across research cycles. This approach aligns with qualitative research practices that emphasize depth, context, and meaning-making in educational settings (Isik, 2025). Integration of quantitative and qualitative findings was conducted through a convergent design to provide a holistic interpretation of the results. The combined analysis enabled the study to explain not only whether the intervention was effective but also how and why changes occurred. Through this analytical framework, the study offers a nuanced understanding of digital literacy as an evolving pedagogical ecosystem rather than a static set of skills.

RESULTS AND DISCUSSION

Results

The findings of this study indicate a substantial transformation in students’ digital literacy competencies following the participatory integration of the digital library system. Quantitative analysis using N-Gain revealed a high level of effectiveness, demonstrating that the intervention significantly improved students’ ability to access, evaluate, and utilize digital academic resources. Students showed marked progress in navigating catalog systems and retrieving relevant information aligned with learning objectives. Beyond technical proficiency, qualitative observations revealed increased engagement and active participation during learning activities. Students began to demonstrate independent learning behaviors, including self-directed information searching and collaborative knowledge construction. Librarians also experienced a shift in their role from administrative staff to instructional facilitators within the learning process. The iterative cycles of mentoring and guided implementation contributed to the gradual internalization of digital literacy practices. These findings suggest that the intervention not only enhanced measurable competencies but also reshaped learning dynamics within the classroom.

Table 1. N-Gain Analysis of Digital Literacy Improvement.

Indicator	Pre-Test Mean	Post-Test Mean	N-Gain Category
Accessing Digital Resources	45	82	High
Information Retrieval Skills	48	85	High
Evaluation of Information	42	80	High
Learning Autonomy	40	78	High

Table 1 demonstrates a consistent increase across all measured indicators, with N-Gain values categorized as high. This indicates that the structured intervention effectively enhanced both technical and cognitive aspects of digital literacy.

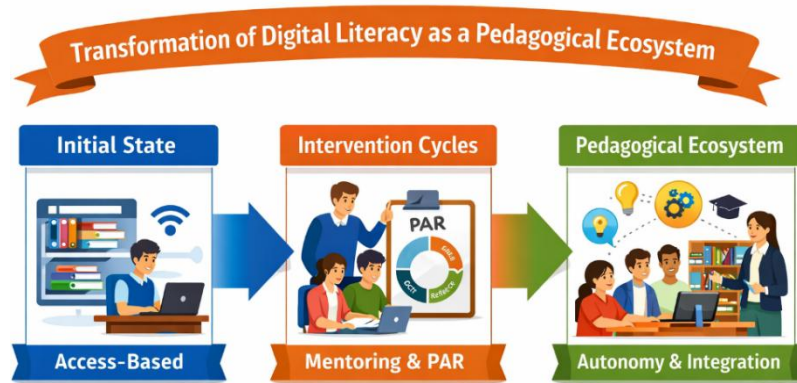


Figure 1. Transformation of Digital Literacy as a Pedagogical Ecosystem.

Figure 1 illustrates the transformation process from a technology-access model toward a pedagogical ecosystem where digital literacy is embedded within learning practices. The iterative participatory cycles serve as the central mechanism driving this transformation.

Discussion

The findings of this study support the argument that digital literacy should not be conceptualized as a standalone technical skill but as an integral component of a broader pedagogical ecosystem. The observed improvement in students' competencies aligns with previous research indicating that structured integration of digital tools enhances meaningful engagement with learning materials (Sabri et al., 2024). However, unlike conventional approaches that emphasize skill acquisition, this study demonstrates that participatory processes play a crucial role in shaping how digital literacy is enacted in practice. The shift from passive access to active engagement reflects a deeper transformation in students' learning behaviors. This transformation is consistent with the notion of digital literacy as a socially situated practice that emerges through interaction and participation (Pangrazio et al., 2020). Furthermore, the involvement of multiple stakeholders reinforces the importance of collaborative learning environments in fostering sustainable educational change. The findings suggest that digital infrastructures alone are insufficient without pedagogical alignment. Therefore, the integration of digital libraries must be understood as a dynamic process that involves both technological and social dimensions (Martínez-Bravo et al., 2022).

The role of participatory action research in this study highlights the significance of iterative and context-sensitive approaches in educational innovation. The cyclical nature of PAR allowed continuous adaptation of strategies based on participant feedback and observed challenges. This aligns with existing literature emphasizing that participatory methodologies enhance the relevance and effectiveness of educational interventions (Freire et al., 2022). The active involvement of students and librarians contributed to a sense of ownership over the learning process, which in turn facilitated deeper engagement. This participatory dynamic also enabled the identification of context-specific barriers and opportunities that might not be captured through traditional research designs. As noted, collaborative approaches in educational technology implementation can lead to more meaningful and sustained outcomes (Chugh et al., 2023b). The findings further demonstrate that participatory

frameworks can bridge the gap between institutional policy and classroom practice. This reinforces the idea that educational transformation requires not only technological innovation but also changes in social practices. Consequently, PAR emerges as a powerful methodological approach for studying and implementing pedagogical change (Chugh et al., 2023b).

Another significant finding is the emergence of student autonomy as a key outcome of the intervention. Students demonstrated increased confidence in navigating digital resources and engaging in self-directed learning activities. This aligns with research suggesting that digital literacy development is closely linked to the cultivation of independent learning skills (Marín & Castañeda, 2023). The integration of digital libraries provided students with opportunities to explore information beyond teacher-directed instruction. Such autonomy is essential in contemporary education, where learners are expected to actively construct knowledge rather than passively receive it. The results also indicate that autonomy is not merely an individual attribute but is shaped by the learning environment and available resources. This supports the perspective that learning autonomy is co-constructed through interaction with tools and social contexts (Vespone, 2023). Furthermore, the findings suggest that digital libraries can function as catalysts for promoting self-regulated learning when integrated effectively. This expands the role of digital libraries from information repositories to active learning environments. Therefore, fostering autonomy requires intentional design and integration of digital resources within pedagogical practices.

The transformation of librarians' roles observed in this study provides additional insights into the institutional dimension of digital literacy integration. Librarians transitioned from administrative roles to active participants in the learning process, supporting students in accessing and interpreting digital resources. This shift aligns with emerging perspectives on the evolving role of information professionals in education (Kanvaria & Yadav, 2024). The collaboration between teachers and librarians contributed to a more cohesive learning ecosystem, where expertise is shared across roles. This finding highlights the importance of interdisciplinary collaboration in educational innovation. It also suggests that institutional structures need to be flexible to accommodate new roles and responsibilities. The integration of digital libraries requires not only technological infrastructure but also organizational support and capacity building. This reinforces the idea that educational change is a systemic process involving multiple actors and levels. The findings contribute to a growing body of literature emphasizing the need for institutional transformation alongside pedagogical innovation. Therefore, successful integration of digital literacy depends on both individual and organizational readiness.

Finally, this study contributes to the conceptualization of digital literacy as a pedagogical ecosystem by demonstrating how different components interact dynamically within the learning environment. The ecosystem perspective highlights the interconnectedness of learners, educators, tools, and institutional practices. This aligns with recent discussions on educational ecosystems that emphasize complexity and interdependence in learning processes (Benoliel & Schechter, 2023). By framing digital literacy in this way, the study moves beyond reductionist approaches that focus solely on skills or tools. Instead, it offers a holistic understanding of how digital literacy is constructed and sustained in practice. The findings suggest that ecosystem-based approaches can provide more comprehensive solutions to challenges in educational technology integration. This perspective also allows for greater adaptability to different contexts and needs. Furthermore, it underscores the importance of aligning technological, pedagogical, and social elements in education. Therefore,

reconceptualizing digital literacy as a pedagogical ecosystem offers a valuable framework for future research and practice (Benoliel & Schechter, 2023).

Implications

The findings of this study have significant implications for educational policy and practice, particularly in the context of curriculum reform and digital transformation. By demonstrating the effectiveness of participatory approaches, the study highlights the importance of involving multiple stakeholders in the design and implementation of educational innovations. Schools should consider integrating digital libraries as core components of instructional design rather than supplementary resources. The results also suggest that professional development programs should focus on enhancing teachers' and librarians' capacity to facilitate digital learning. Additionally, policymakers need to ensure that technological infrastructure is supported by pedagogical frameworks that promote meaningful engagement. The ecosystem perspective presented in this study provides a model for aligning technology, pedagogy, and institutional practices. This approach can be adapted to different educational contexts to support sustainable innovation. Ultimately, the study underscores the need for a holistic approach to digital literacy integration.

Research Contribution

This study contributes to the field of educational technology and curriculum reform by introducing the concept of digital literacy as a pedagogical ecosystem. It extends existing literature by integrating participatory action research with digital library utilization. The study provides empirical evidence demonstrating the effectiveness of participatory approaches in enhancing digital literacy and student autonomy. It also offers a theoretical framework that connects technological infrastructure with pedagogical practices. By highlighting the role of institutional actors such as librarians, the study broadens the scope of digital literacy research. The findings contribute to ongoing discussions on educational transformation in the digital age. Furthermore, the study presents a scalable model that can inform policy and practice in various educational contexts. Overall, it advances the understanding of how digital literacy can be reconfigured to support meaningful learning.

Limitations

Despite its contributions, this study has several limitations that should be acknowledged. The research was conducted within a single educational setting, which may limit the generalizability of the findings. The sample size was relatively small, focusing on a specific group of students and librarians. Additionally, the duration of the intervention may not capture long-term effects of digital literacy development. The study also relied on self-reported data and observational methods, which may be subject to bias. Furthermore, the integration process was influenced by contextual factors that may not be replicable in other settings. The use of N-Gain analysis provides insight into improvement but may not fully capture the complexity of learning processes. Future studies should consider longitudinal designs to examine sustained impacts. Expanding the research to multiple contexts would also enhance the robustness of the findings.

Suggestions

Future research should explore the application of the pedagogical ecosystem framework in diverse educational settings to examine its adaptability and scalability. Studies could also investigate the long-term impact of participatory digital literacy interventions on student learning outcomes.

Additionally, research should examine the role of teachers more explicitly in the integration process to understand their contribution to ecosystem development. Comparative studies across different educational systems could provide insights into contextual variations. Further exploration of interdisciplinary collaboration between educators and information professionals is also recommended. Researchers should consider incorporating advanced analytical methods to capture the complexity of learning interactions. The integration of emerging technologies such as artificial intelligence within digital libraries could be another area of investigation. These directions would contribute to a deeper understanding of digital literacy in contemporary education.

CONCLUSION

This study demonstrates that digital literacy cannot be adequately understood as a discrete set of technical competencies, but rather as an evolving pedagogical ecosystem shaped by the interaction between learners, institutional actors, and digital infrastructures. The findings reveal that participatory integration of digital libraries not only enhances measurable literacy outcomes but also restructures learning practices toward greater autonomy and engagement. The use of Participatory Action Research proved critical in facilitating iterative adaptation, allowing the intervention to align closely with contextual needs and institutional dynamics. This indicates that sustainable digital transformation in education requires more than technological provision, as it depends fundamentally on how technologies are embedded within pedagogical processes. The observed shift in students' behavior from passive resource users to active knowledge constructors highlights the importance of designing learning environments that support agency and critical engagement. Additionally, the transformation of librarians into pedagogical facilitators underscores the necessity of redefining institutional roles within digital learning ecosystems.

More importantly, this study advances the conceptual framing of digital literacy by positioning it within a systems-oriented perspective that integrates technological, social, and pedagogical dimensions. This ecosystem approach provides a more comprehensive understanding of how digital literacy develops and operates within real educational contexts, moving beyond reductionist models that focus solely on skill acquisition. The findings suggest that curriculum reform efforts will remain limited in impact unless they incorporate participatory and ecosystem-based strategies that connect infrastructure with instructional practice. By demonstrating how iterative, collaborative processes can reconfigure the function of digital libraries, this research offers a scalable and adaptable model for educational innovation. The study also contributes to bridging the persistent gap between policy-level digitalization and classroom-level implementation.

Ultimately, the significance of this research lies in its ability to reconceptualize digital literacy as a dynamic and context-responsive construct that is co-produced through interaction, participation, and institutional alignment. This perspective challenges dominant narratives that treat digital literacy as an individual competency and instead emphasizes its collective and systemic nature. The implications extend beyond the immediate research setting, offering insights for policymakers, educators, and researchers seeking to develop more meaningful and sustainable approaches to digital transformation in education. By foregrounding participation and ecosystem thinking, this study provides a critical foundation for future research aimed at understanding and advancing digital literacy in increasingly complex learning environments.

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AUTHOR CONTRIBUTION STATEMENT

Conceptualization, methodology, and investigation were primarily conducted by Ajar Muthia, who designed the research framework, implemented the participatory action research cycles, and managed the overall data collection process. Ajar Muthia also carried out data curation and performed the initial quantitative and qualitative analyses.

Abdul Pirol contributed to formal analysis and validation, ensuring the accuracy and robustness of both statistical findings and thematic interpretations. In addition, Abdul Pirol played a significant role in strengthening the theoretical framework and aligning the study with current developments in digital literacy and educational research.

Ali Nahrudin was responsible for supervision, project administration, and critical review of the manuscript, providing strategic direction throughout the research process. This included refining the conceptual positioning of the study within the discourse of pedagogical ecosystems and curriculum reform.

Writing—original draft preparation was led by Ajar Muthia, while writing—review and editing were collaboratively performed by all authors to ensure coherence, clarity, and compliance with international publication standards. All authors have read and approved the final version of the manuscript.

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