



Strengthening Teachers' Digital Competence through Interactive Multimedia: A Holistic Strategy for Sustainable Educational Transformation

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ABSTRACT

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This study aims to formulate effective strategies for enhancing teachers' digital competence, particularly in developing and implementing interactive multimedia-based learning materials to address educational challenges in the digital era. This study employed a library research method using a qualitative-descriptive approach. Data were obtained through an analysis of indexed scientific literature published between 2021 and 2026, focusing on teachers' digital competence, interactive multimedia, professional development, and technology integration in education. The findings indicate that improving teachers' digital competence requires a systematic and continuous process rather than short-term training. Three key strategies were identified: project-based continuous professional development, the establishment of professional learning communities to facilitate collaboration and knowledge sharing, and the provision of adequate technological infrastructure and institutional support. Furthermore, interactive multimedia, including videos, animations, and interactive quizzes, can enhance student engagement when designed according to sound pedagogical principles. The findings imply that successful digital transformation in education depends on the synergy between effective school management, continuous teacher development, collaborative professional environments, and teachers' intrinsic motivation to adopt technology meaningfully.

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INTRODUCTION

Digital transformation has become a major societal issue because education increasingly depends on technology to prepare learners for work, communication, and civic life. The central point is that teachers' digital competence determines whether technological investment produces meaningful learning rather than merely adding devices to classrooms (Bhagwat & Shivnath,

2026; Delianti et al., 2026). This matters because students encounter multimedia, interactive platforms, and digital information daily, creating expectations for learning experiences that are accessible, engaging, and relevant. Contemporary educational practice increasingly uses videos, animations, simulations, online assessments, and interactive learning environments. However, access to technology alone does not guarantee educational improvement; its value depends on teachers' capacity to select, design, and integrate appropriate digital resources (Ahmed, 2025; Bernsteiner et al., 2025). Therefore, strengthening teachers' digital competence is not simply a professional requirement but a broader educational priority. It can help schools convert technological change into inclusive, meaningful, and sustainable learning opportunities for students while supporting teachers in responding to evolving educational demands.

The importance of this issue also extends to educational equity. The main point is that unequal teacher readiness can widen differences in learning quality even when schools receive similar technological resources. The reason is that digital tools require pedagogical judgment: teachers must determine which media, activities, and forms of interaction support particular learning objectives and student characteristics (Fernández-Otoya et al., 2024; Makrakis, 2024). Technology can increase engagement and support flexible learning when intentionally integrated into instruction, whereas poorly designed digital materials may cause distraction, cognitive overload, or passive consumption. This contrast demonstrates that technological progress must be accompanied by professional capacity. Consequently, society needs educational systems that develop teachers as capable digital learning designers, not merely technology users (Farisia & Syafi'i, 2024; Fernández-Otoya et al., 2024). Improving this capacity can strengthen classroom instruction, support students' learning needs, and ensure that investments in educational technology contribute to broader improvements in educational participation, engagement, and learning outcomes.

A general problem is that many teachers are expected to use digital technologies without sufficiently continuous, practical, and pedagogically oriented support. The challenge involves transforming subject knowledge into interactive learning experiences aligned with curriculum objectives and students' cognitive needs (Annisa & Syafril, 2025; Muslichuddin et al., 2025). In practice, teachers may rely on slides, recorded lectures, or digital worksheets because these formats are familiar, while interactive functions remain underused. Others experiment with videos, animations, quizzes, or learning platforms but struggle to connect them with learning objectives and assessment strategies. Differences in confidence, preparation time, technical support, and infrastructure can further affect technology adoption. Consequently, the presence of digital tools does not necessarily indicate effective digital transformation. Teachers need opportunities

to create multimedia products, receive feedback, collaborate with colleagues, and refine materials through classroom use. Addressing this problem requires an integrated strategy connecting teacher learning, collaborative support, pedagogical design, and institutional conditions and sustained classroom improvement.

Previous research has established that teacher digital competence is multidimensional and should integrate technological knowledge with pedagogical and content knowledge. These contributions provide an important foundation because they demonstrate that effective technology integration depends on both teacher capacity and instructional design. Nevertheless, existing discussions often treat professional development, teacher collaboration, infrastructure, and multimedia production as separate components. Research also frequently emphasizes technology adoption or teacher attitudes without sufficiently examining how sustained training can lead to tangible interactive learning products. Another limitation is that recommendations may remain general, offering few strategies for moving teachers from basic technology use toward pedagogically purposeful multimedia development. This gap is important because schools need practical approaches that connect competence development with actual instructional products and institutional support. The present study addresses this need by synthesizing relevant literature into a coherent strategic framework for strengthening teachers' digital competence and meaningful technology integration.

The literature indicates that interactive multimedia can support attention, visualization, active participation, and flexible learning when its elements are designed. Research has explored videos, animations, simulations, interactive quizzes, and platforms, while studies of teacher development have highlighted mentoring, collaboration, and learning. However, findings do not fully explain how supports can operate together as a strategy for strengthening teachers' digital competence (Firmansyah et al., 2025; Soim et al., 2026). Existing studies provide limited synthesis of how project-based professional development, professional learning communities, and school infrastructure can reinforce one another. Consequently, a research gap concerns the design of a strategy linking teacher competence, interactive multimedia production, collaborative learning, and managerial support. This gap matters because isolated interventions may improve skills without producing lasting changes in teaching practice (Dewantara et al., 2025; Karim et al., 2025). This research contributes by integrating findings across these areas and identifying strategic relationships that can guide digital transformation in schools and teacher development programs. Such integration can provide a stronger foundation for sustainable educational innovation.

The novelty of this study lies in proposing an integrated strategy for developing teachers' digital competence through the production and application of interactive multimedia learning materials. The study positions digital competence as a continuous process involving pedagogical decision-making, technological practice, collaboration, reflection, and institutional support. This perspective connects project-based continuous professional development with professional learning communities and school. Teachers are expected to learn by producing multimedia materials, testing them in instructional contexts, receiving feedback, and improving their designs. Collaborative communities can sustain peer assistance, knowledge exchange, and reflective practice, while school management supports experimentation and innovation. This integrated approach is important because sustainable digital transformation requires alignment between individual capability and organizational support. By bringing these dimensions together, the study offers a strategic direction for educational stakeholders seeking to strengthen digital instructional practices and meaningful technology integration while maintaining alignment with curriculum goals and student need.

Based on the identified problem and research gap, this study addresses how teachers' digital competence can be strengthened for developing interactive multimedia-based learning materials. The central argument is that competence is more likely to develop when professional learning is continuous, product oriented, collaborative, and supported by institutional conditions. Project-based professional development can provide opportunities for teachers to create and refine digital materials, while professional learning communities can sustain peer assistance, knowledge exchange, and practice. School management can reinforce these processes through adequate infrastructure, time allocation, recognition, and performance expectations. The expected answer is therefore not a single training model or technology platform, but a coordinated strategy connecting teacher motivation with organizational support. This argument guides the study in synthesizing literature to identify practical mechanisms for strengthening digital competence and enabling teachers to transform technology into pedagogically meaningful interactive learning experiences that enhance engagement and support effective learning and sustainable professional growth across digital environments.

RESEARCH METHODS

This study employed a qualitative descriptive library research design to systematically examine and synthesize existing knowledge concerning teachers' digital competence and the development of interactive multimedia-based learning materials infrastructure (Aimicheva et al., 2025; Laksmi &

Fadhilawati, 2026). A library research design was selected because the study aimed to identify, compare, and interpret concepts, strategies, and findings reported in relevant scientific literature rather than collect empirical data directly from participants. The qualitative descriptive approach was considered appropriate for presenting patterns and relationships identified across the literature in a systematic and contextual manner. The study focused on scientific publications and relevant educational documents published between 2021 and 2026. The selection of this period was intended to capture recent developments in digital education, teacher competence, professional development, and interactive multimedia. This design enabled the researchers to construct a comprehensive understanding of strategies that can support sustainable improvement in teachers' digital competence within contemporary educational contexts.

As a library research study, the research did not involve a specific geographical research site or direct observation of a particular institution. Instead, the research setting was defined by the scope of literature and educational documents examined. The sources consisted of relevant national and international scientific journal articles, academic books, research reports, and educational policy documents published between 2021 and 2026. These sources were selected because they provided conceptual, empirical, and policy-based information related to teachers' digital competence, technological pedagogical integration, professional development, professional learning communities, and interactive multimedia. Data were collected using documentation techniques by systematically searching, identifying, screening, and recording information from relevant sources (Damayanti et al., 2025; Koca et al., 2026). The literature selection emphasized relevance to the research objectives, publication quality, and substantive discussion of digital competence and multimedia-based learning. This approach allowed the study to obtain diverse perspectives while maintaining consistency with its research focus and objectives.

Data analysis was conducted through four interconnected stages: data condensation, data display, and verification. First, data condensation involved selecting, simplifying, categorizing, and organizing information obtained from the identified literature according to the research focus. Irrelevant information was excluded, while findings related to teacher digital competence, professional development, collaborative learning, infrastructure, and interactive multimedia were retained (Albion, 2026; Sotalin et al., 2026). Second, the condensed data were displayed in thematic categories and comparative summaries to identify similarities, differences, patterns, and relationships across the selected sources. Third, the researchers interpreted the emerging patterns to develop a coherent understanding of effective strategies for strengthening teachers' digital

competence. Finally, verification was conducted by repeatedly examining the synthesized evidence, comparing findings across sources, and ensuring that the conclusions were logically supported by the available literature. This analytical process facilitated the formulation of an integrated strategy for sustainable teacher digital competence development and meaningful interactive multimedia implementation.

RESULTS AND DISCUSSION

Results

The analysis of the selected literature identified three main components of a holistic strategy for strengthening teachers' digital competence in developing interactive multimedia-based learning materials. These components are presented in Figure 1 and consist of project-based professional development, professional learning communities, and managerial and infrastructure support. The three components were identified as interconnected elements in the development and implementation of teachers' digital competence.



Figure 1. Holistic Strategy for Strengthening Teachers' Digital Competence

Figure 1 presents the holistic strategy for strengthening teachers' digital competence through three interconnected pillars: Project-Based Professional Development, Professional Communities (KKG/MGMP), and Managerial and Infrastructure Support. The first pillar focuses on strengthening teachers' competence through continuous project-based activities and pedagogical practice. The second pillar emphasizes collaboration among teachers through professional communities. The third pillar concerns institutional support, including managerial policies and infrastructure that facilitate the implementation of digital learning.

The first finding concerns Project-Based Professional Development. The literature synthesis identified a development process consisting of four sequential stages. The first stage involves needs analysis and pedagogical design, in which teachers identify learning competencies that require support from interactive multimedia and develop an initial storyboard or learning design. The second stage involves integrated technical workshops, where teachers develop multimedia prototypes using appropriate digital applications. The third stage involves classroom implementation and peer observation, during which teachers use the developed media and observe student responses. The fourth stage consists of reflection, revision, and dissemination of the completed multimedia products.

The second finding concerns the formation of professional learning communities through KKG and MGMP. The analysis identified three main activities within this component: reverse mentoring, shared digital resource repositories, and reflective evaluation. Reverse mentoring involves teachers with stronger digital skills assisting colleagues in developing and implementing digital learning materials. Shared repositories provide access to templates, presentation materials, assessment instruments, educational videos, digital games, and question banks. Reflective evaluation involves reviewing the implementation of digital media based on technical experiences, student responses, and the achievement of learning objectives.

The third finding concerns managerial and infrastructure support. The analysis identified several forms of institutional support required for the implementation of interactive multimedia. These include school leadership in coordinating digital innovation, the establishment of digital support teams, adequate internet connectivity, technical assistance, access to digital devices, and policies that support teachers' experimentation with digital learning media. The findings also identified professional recognition, workload-related incentives, professional development opportunities, and the integration of digital learning products into teacher performance evaluation as forms of organizational support.

The overall results indicate that the three components form a holistic strategy for strengthening teachers' digital competence. Project-based professional development provides a structured process for developing interactive multimedia, professional communities provide collaborative learning and peer support, and managerial and infrastructure support provides the conditions necessary for implementation. The findings therefore identify these three components as interconnected elements in the development, implementation, evaluation, and sustainability of teachers' digital competence in interactive multimedia-based learning.

Discussion

The findings of this study indicate that strengthening teachers' digital competence requires a holistic strategy consisting of three interconnected pillars: project-based professional development, professional learning communities, and managerial and infrastructure support (Marnoko, 2025; Ramírez Márquez et al., 2026). This finding is consistent with literature emphasizing that teacher digital competence develops through continuous learning rather than one-time training. However, the present findings extend this perspective by positioning the three elements as mutually dependent components rather than separate interventions. Project-based development provides opportunities to produce and test interactive multimedia, while professional communities provide ongoing peer support and school management creates conditions for implementation. The alignment with previous literature is evident in the emphasis on continuity, collaboration, and institutional support (Althubyani, 2024; Sulaimanova & Egamberdieva, 2025). The difference lies in the integrated structure of the proposed strategy, which connects individual competence development with collective learning and organizational readiness within one framework for digital transformation practice consistently.

The findings also reinforce the view that interactive multimedia should be developed through the integration of technology, pedagogy, and content rather than through technical skills alone. Earlier literature has emphasized meaningful technology integration, and this study confirms that teachers need to connect multimedia features with learning objectives, student needs, and instructional strategies. At the same time, the findings highlight a practical dimension that is less visible when digital competence is discussed only as knowledge or skill: teachers should demonstrate competence through instructional products that can be implemented, evaluated, and revised. This shifts attention from operating digital applications toward knowing when, why, and how to use them pedagogically (Haryanti et al., 2025; Sain & Suwondo, 2026). The implication is that professional development should evaluate not only teachers' technological abilities but also the instructional quality, relevance, usability, and learning potential of the multimedia products they create for effective classroom use.

Theoretically, this study contributes to understanding teacher digital competence by conceptualizing it as an ecosystem rather than an individual attribute. The findings suggest that technological knowledge, pedagogical knowledge, collaborative learning, leadership, infrastructure, and motivation interact in the development of effective digital practice. This perspective strengthens technology integration frameworks by emphasizing the organizational conditions surrounding classroom implementation. Practically,

the findings imply that schools should design professional development around authentic projects, establish functioning peer-learning communities, and provide adequate technological infrastructure and technical assistance. School leaders can support sustainability through recognition, collaboration, and performance measures that value meaningful digital instructional products. For teachers, the strategy provides a pathway from experimentation to classroom implementation and reflection (Chifla-Villón et al., 2025; Kiryakova & Kozhuharova, 2024). Thus, the findings have implications beyond training delivery because they address the professional and organizational conditions required to sustain digital innovation in everyday teaching practice effectively and sustainably.

The state of the art of this study lies in formulating a holistic strategy that links three dimensions often addressed separately: teacher professional development, peer-based professional learning, and managerial and infrastructure support. The visual model in Figure 1 represents these dimensions as connected components rather than isolated activities. The first component develops teachers' capacity through project-based and pedagogically oriented practice; the second sustains learning through collaboration and knowledge exchange; and the third provides the institutional environment needed for implementation. This configuration represents the central novelty because it moves beyond recommending digital training or providing technology alone. The strategy emphasizes alignment between what teachers learn, how they collaborate, and the conditions in which they work. Consequently, digital transformation is presented as a continuous process involving individual competence, collective professional learning, and institutional readiness rather than a simple process of technology adoption.

The contribution of this research is the synthesis of these dimensions into a practical framework for improving teachers' capacity to develop interactive multimedia learning materials. The framework provides a logical relationship between professional learning activities and supporting conditions. Teachers are positioned as active designers who create, implement, evaluate, and improve multimedia products (Bernsteiner et al., 2025; Bhagwat & Shivnath, 2026). Professional communities function as spaces for mentoring, resource sharing, peer feedback, and reflection, while school management supports access, infrastructure, time, recognition, and technical assistance. This contribution is relevant for schools seeking to translate technological investment into meaningful instructional practice. It also offers a basis for evaluating digital competence through observable practices and products rather than relying solely on training participation. In this sense, the research contributes by connecting competence development with classroom application and institutional support, creating a basis for sustainable improvement in digital learning practices across educational settings.

Overall, the findings suggest that digital transformation depends on synergy among teachers, peers, and school management. The three pillars shown in Figure 1 should therefore be implemented as a coordinated system rather than

as independent programs. Professional development without collaboration may limit continued learning, collaboration without infrastructure may restrict implementation, and technology provision without teacher preparation may not produce meaningful pedagogical change (Delianti et al., 2026; Marnoko, 2025). The study consequently positions holistic coordination as the central principle for strengthening teachers' digital competence and developing interactive multimedia. Its practical value lies in providing stakeholders with guidance for implementation and improvement. Its theoretical value lies in connecting individual and organizational dimensions of digital competence within a single framework. The contribution is not a new technology platform, but an integrated strategy for ensuring that technology, pedagogy, professional learning, and institutional support work together to strengthen sustainable digital practice.

CONCLUSION

This study concludes that strengthening teachers' digital competence in developing interactive multimedia requires a holistic strategy that integrates continuous professional development, professional learning communities, and managerial and infrastructure support. The main lesson is that meaningful digital transformation cannot depend solely on individual teacher initiatives but requires sustained opportunities to develop, implement, reflect on, and improve technology-based learning practices. The scholarly contribution of this study lies in synthesizing these three dimensions into an integrated framework that connects teacher competence, collaborative professional learning, and institutional support in the development of interactive multimedia. However, this study is limited by its reliance on literature-based evidence and does not directly examine the implementation of the proposed strategy in specific educational settings. Future research should therefore validate the framework through empirical studies, classroom implementation, and longitudinal evaluation to examine its effectiveness and sustainability in strengthening teachers' digital competence and supporting interactive learning.

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