

DEVELOPMENT OF INTERACTIVE LEARNING MEDIA BASED ON OPEN TECHNOLOGY

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Abstract: This study aims to develop interactive learning media based on open-source technology to enhance the quality of education in secondary schools. The background of this research arises from the need for innovative media that is not only visually appealing but also capable of fostering active student engagement. The research employed a Research and Development (R&D) approach with a modified Borg & Gall model, including preliminary studies, product design, expert validation, limited trials, revisions, and field testing. The findings indicate that open-source interactive media can increase learning motivation, strengthen conceptual understanding, and provide teachers with creative flexibility in adapting learning content. However, challenges such as limited digital literacy among teachers and infrastructure gaps remain significant barriers to implementation in resource-limited schools. Therefore, systematic training, stakeholder collaboration, and infrastructure support are essential for sustainable utilization of interactive media. This study concludes that open-source technology holds strong potential as a strategic instrument for educational equity and quality improvement in Indonesia.

Keywords: *interactive media, open-source technology, innovative learning, education*

Abstrak: Penelitian ini bertujuan mengembangkan media pembelajaran interaktif berbasis teknologi terbuka yang dapat meningkatkan kualitas pembelajaran di sekolah menengah. Latar belakang penelitian ini berangkat dari kebutuhan akan media inovatif yang tidak hanya menarik secara visual, tetapi juga mampu meningkatkan keterlibatan aktif peserta didik. Metode penelitian menggunakan pendekatan Research and Development (R&D) dengan model Borg & Gall yang dimodifikasi, meliputi tahap studi pendahuluan, desain produk, validasi ahli, uji coba terbatas, revisi, dan uji coba lapangan. Hasil penelitian menunjukkan bahwa media interaktif berbasis open-source dapat meningkatkan motivasi belajar, memperkuat pemahaman konsep, serta memberikan ruang kreatif bagi guru dalam menyesuaikan konten pembelajaran. Namun, keterbatasan literasi digital guru dan kesenjangan infrastruktur masih menjadi hambatan utama implementasi di sekolah berbasis sumber daya rendah. Oleh karena itu, diperlukan dukungan pelatihan sistematis, kolaborasi antar pemangku kepentingan, dan penyediaan infrastruktur agar pemanfaatan media interaktif dapat berkelanjutan. Penelitian ini menyimpulkan bahwa teknologi terbuka berpotensi menjadi instrumen strategis dalam pemerataan dan peningkatan mutu pendidikan di Indonesia.

Kata kunci: *media interaktif, teknologi terbuka, pembelajaran inovatif, pendidikan*

Introduction

The development of the digital era demands a more dynamic, adaptive, and enjoyable learning approach. Adawiyah et al. (2024) showed that interactive learning media based on technology-rich tools such as Articulate Storyline 3 supports the understanding of abstract concepts through animations, quizzes, and interactive videos, thereby increasing active student engagement and improving learning outcomes in elementary schools. However, the cost of commercial licenses is often a barrier to wider adoption, especially in schools with limited resources. Open learning

technology is believed to be a solution, by providing a platform that is easily customizable, low cost, and has an open support community for material adaptation.

Besides cost challenges, accessibility is a significant barrier to digital media adoption. Susanto et al. (2024) in the context of religious education stated that the use of interactive media such as animated videos, digital quizzes, and educational games can improve motivation, conceptual understanding, and critical thinking in elementary school students. However, the study also noted challenges related to teacher readiness and the availability of infrastructure such as devices and internet connections. This indicates the need for interactive learning media based on open technology that is lightweight, offline-friendly, and easily developed by local educators without licensing barriers.

The development of interactive media based on Android devices also shows potential for broader reach. The Adjustment Journal study (2023) developed Android-based interactive learning media for adjustment journal materials and successfully reached users more flexibly. Open technologies such as Android and open-source operating systems enable the creation of free learning applications that can be operated offline or online, and can be modified to suit local needs by teachers or educational developers.

The use of common platforms like Google Sites has also been shown to facilitate distance learning. Firmansyah et al. (2020) demonstrated that interactive media based on Google Sites enabled learning to take place anywhere, with content including text, images, videos, and quizzes, resulting in positive student feedback. Google Sites is free and easy to use, making it an open technology portal suitable for adaptation as an interactive learning tool in a variety of situations.

Lack of teacher creativity is one of the obstacles to developing effective learning media. Rijal (2020) researched web-based learning media designed to enhance teacher creativity. While focused on teachers, a similar approach to open media allows teachers to learn and produce interactive content independently and collectively. Open tools like Canva, WordPress, and similar platforms can be utilized to create engaging media without the need for complex programming, key to active and sustainable learning.

An applicable interactive design strategy is urgently needed. Ningsi & Hartono (2025) used the ADDIE model in developing interactive media for elementary school students, including needs analysis, design, implementation, and evaluation. The results showed a significant increase in learning motivation through media involving physical components such as wooden map boards and cultural cards. A similar approach using open technologies can be enriched with interactive features such as drag-and-drop, visual simulations, and automated feedback systems.

However, the effectiveness of interactive media also depends heavily on the quality of its design and underlying technology. Study et al. (2023) in an international journal explained that the use of Articulate Storyline 3 as the basis for interactive media successfully facilitated lifestyle learning across various learning styles and enhanced understanding of the topic of magnetism. However, paid tools limit inclusivity. Therefore, it is necessary to design an open media framework with interoperability across platforms and community support for sustainable development.

The use of metadata and open repositories is also essential for managing open educational content. An arXiv study on metadata-based OER quality prediction (Tavakoli et al., 2020) demonstrated the efficiency of open content quality assessment using a metadata-based system. This can be adapted for open interactive learning systems, making it easier for teachers and students to find high-quality materials, minimizing content duplication, and improving interoperability between learning resources.

User community involvement and collaboration between stakeholders are crucial elements for open media to develop and remain relevant. The Effectiveness of Interactive Learning Media... (2024) study shows that effective media development requires the involvement of teachers, students, and educational policymakers at every stage of ADDIE. Therefore, an open interactive media framework needs to include collaboration models such as learning wikis, crowd-sourced repositories, and discussion forums as part of a continuous development cycle.

Overall, open technology-based interactive learning media offers significant potential for innovation in mainstream education. However, effective development requires the integration of pedagogical design principles, lightweight technology, offline access, quality metadata, and

collaborative engagement. Key challenges emerging from the literature include teacher technical readiness, infrastructure, device access, and competency in open learning materials. With a clear conceptual framework, we can begin to identify design models, implementation strategies, and support mechanisms to make open interactive media a tangible part of future educational revitalization.

Although various studies demonstrate the effectiveness of interactive learning media, several problems persist in its practical implementation in schools. First, limited teacher competency in developing open technology-based media is often a major obstacle. Second, school infrastructure is uneven, particularly regarding the availability of devices and internet access. Third, student adaptation to new media is not always easy, especially at the elementary level. Fourth, the sustainability of media development is often overlooked due to a lack of technical and policy support. According to Prasetyo & Yuliana (2023), without teacher training, infrastructure strengthening, and collaboration between stakeholders, interactive media development cannot run optimally in schools with limited resources. This underscores the importance of designing a more comprehensive implementation framework.

Research methodology

This research uses a research and development (R&D) approach with the Borg & Gall model modified as needed. This design was chosen based on the research objective, which is to produce interactive learning media products based on open technology that can be widely used by educators and students. According to Sari (2022), the R&D method is relevant for producing innovative educational products because it combines the design, validation, and effectiveness testing processes. The research stages include preliminary studies, media design, expert validation, limited trials, revisions, and field trials.

The research locations were purposively selected in several junior high schools in Central Java, taking into account the readiness of technological infrastructure and teachers' openness to the use of open-source media. The research subjects consisted of subject teachers, students, and educational technology experts who played a role in product validation. Purposive sampling was used to ensure the subjects involved were directly relevant to the media development context. According to Rahmawati (2021), purposive sampling is effective in development research because it focuses on informants with direct experience.

Data collection techniques included in-depth interviews, participant observation, questionnaires, and documentation studies. Interviews were conducted with teachers to explore learning media needs, while observations were used to assess actual classroom conditions. Questionnaires were administered to students to gauge their acceptance and motivation to learn using the developed media. Document analysis was conducted on the syllabus, learning materials, and competency standards to ensure the media aligns with curriculum requirements. According to Putra (2020), this combination of methods allows researchers to obtain a more comprehensive picture of the effectiveness of learning media.

Data analysis was conducted using a simple qualitative and quantitative descriptive approach. Qualitative data from interviews and observations were analyzed using thematic analysis techniques, while quantitative data from questionnaires were analyzed using descriptive statistics (mean, percentage, and standard deviation) to determine the level of media effectiveness. Product validation was conducted through expert testing and field trials to ensure the media's reliability. According to Nugroho (2023), multi-layered validation is important in development research so that the resulting media is not only innovative but also feasible for practical use in real-life learning contexts.

Discussion

A. The Relevance of Open Technology in Learning Media

The use of open technology in developing learning media is increasingly relevant in the digital era due to its flexibility, accessibility, and the potential for collaboration across educational institutions. According to Kurniawan (2022), the use of open-source software provides significant opportunities for teachers to adapt learning media to curriculum needs without the constraints of paid licensing. This aligns with the principle of democratizing access to education, where open technology can bridge the gap between schools with varying levels of resources. Thus, open technology serves not only as a pedagogical tool but also as an instrument for educational equity.

The use of open-source platforms such as Odoo in learning media has proven effective in enriching interactivity and automatic evaluation systems. Putri, Harimurti, et al. (2025) reported that Odoo as an interactive media improves the learning outcomes of students at the Industrial Automation Engineering Vocational School, with high validity and positive student responses—an average score of over 90% on validation and 86% student satisfaction. This shows that open technology-based media is not only more inclusive, but also supports high pedagogical quality in the vocational and technical domains.

In addition to Odoo, the implementation of open-source e-learning has shown significant results in the context of distance learning. Musliman & Suendarti (2021) found that the use of open-source e-learning at SMP IT Bekasi Regency increased the average post-test score (85.97) compared to the control group (80.19), with a gain of 0.52 versus 0.30. This finding confirms that open-source platforms can provide more effective and affordable learning even in emergency situations like the pandemic, without having to rely on commercial solutions.

The contribution of open technology also emerged in the development of open-source programming media to support computational thinking. Ahzan, Wua Laja, & Hijriani (2021) developed open-source programming media for advanced calculus students that significantly improved learning outcomes (validation and post-test scores increased dramatically to above 90%). This demonstrates that open-source can be an effective means of introducing advanced concepts like computational thinking in a more interactive and adaptive format.

At the institutional level, Indonesian government initiatives such as IGOS support the use of open-source software in education. Gozali & Lo (2012) outlined that Linux, Moodle, WordPress, and Blender are becoming essential components of the next generation of e-learning in higher education. Although this research was conducted several years ago, its relevance remains as evidence that open infrastructure has become a crucial foundation for the national digital education system.

In the context of science education, the OSSCAR open platform offers a collaborative environment for developing interactive educational tools. Du et al. (2022) describe how OSSCAR facilitates the creation of minimalist science education applications that can be used by a broad community of teachers, students, and researchers. This approach is relevant for the development of open-source interactive learning media, as it allows local innovations to thrive in a global context without technological barriers.

Open educational resources (OER) require quality metadata to facilitate curation and recommendations. Tavakoli et al. (2021) demonstrated that metadata analysis allows predicting OER quality with up to 94.6% accuracy. In the context of open learning media, implementing this metadata ensures that teachers and students easily find valid interactive resources that meet curriculum needs.

The effectiveness of technology media has also been proven at the early childhood education level, where the combination of AR videos and interactive storybooks increases children's engagement and comprehension. Windiastuti et al. (2024) concluded that despite barriers such as screen time, technology media remains effective for early childhood education. This supports the idea that open-source interactive media can be modified and used across educational levels, including early childhood education.

Finally, the role of creativity and community collaboration is fundamental to the sustainability of open media. While not yet supported by specific research with licensed DOIs, several open-source educational initiatives (such as educational wikis) emphasize the importance of collaboration and peer

review to maintain the development and relevance of media. This indicates that open media is not just technology, but also a social practice that strengthens educational relationships.

B. Interactivity as the Key to Media Effectiveness

Interactivity is a crucial element in modern learning media because it encourages active student engagement. According to Susanto (2021), interactive media has been shown to increase motivation, participation, and conceptual understanding through direct feedback features, simulations, and educational games. In the context of open technology, interactivity can be further developed because open source code enables further innovation by teachers and the developer community. This demonstrates that open-source interactive media is not merely a static learning tool but also a creative space that supports experiential learning.

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According to Hidayat (2022), interactivity serves as a two-way communication bridge between students and the material, making the learning process more meaningful. When students can control the learning process through self-navigation or choice of learning paths, they tend to feel a sense of ownership in the learning process. Open technology-based media allows for the development of flexible navigation features that can be tailored to individual and group needs. Thus, interactive media not only presents content but also provides space for personalized learning according to students' learning styles.

Sulastris (2021) emphasized that interactivity strengthens students' cognitive engagement because clicking, dragging, and inputting answers in digital media require active mental engagement. In this context, interactive media can stimulate critical thinking and problem-solving skills. Open technology provides teachers with the opportunity to add game-based challenges, practical simulations, or freely accessible case studies. This is relevant for 21st-century education, which demands collaboration, creativity, and critical thinking.

According to Prasetyo (2023), interactivity impacts not only the cognitive domain but also the affective one, as interactive media creates a positive emotional experience during learning. Learners feel valued because they receive immediate feedback on every response. This aspect can increase intrinsic motivation and foster a positive attitude toward the learning material. Open-source media reinforces this, as the developer community can continuously refine emotional features such as animation, sound, or interactive avatars at no additional cost.

In research by Nurhayati (2022), interactivity plays a crucial role in enhancing students' collaborative skills. Interactive online media allows students to work together both synchronously and asynchronously. Through discussion features, group quizzes, or team-based projects, students learn to communicate ideas, value opinions, and solve problems together. Open technology provides the flexibility to integrate with other platforms, enabling broader collaboration across classes and schools.

Firmansyah (2023) demonstrated that interactivity is also an effective tool for formative assessment. Through interactive quiz features, teachers can monitor learning outcomes in real time, while students receive immediate feedback to correct errors. The advantage of open-source learning is that it allows for the integration of evaluation data with a learning management system (LMS), allowing for more comprehensive assessments. This helps teachers design adaptive learning tailored to students' needs.

Rahayu (2022) stated that interactive media based on open technology also strengthens students' digital skills. By using interactive features, students become accustomed to operating applications, solving technical problems, and utilizing technology to support the learning process. This experience is relevant to the needs of the 21st century, which demands digital literacy as a core competency.

Because the technology used is open, students can also be encouraged to understand the basic principles of programming or simple media development.

Research by Wahyuni (2023) confirms that interactivity contributes significantly to learning sustainability. Students tend to retain their learning interest for longer when media provides varied interactions such as simulations, interactive videos, and adaptive quizzes. Open technology allows for the continued expansion of these interactions without reliance on specific vendors. This makes open-source interactive media a sustainable solution for schools with limited budgets.

According to Santoso (2022), interactivity also has strategic value in building inclusive learning. Interactive media can be equipped with accessibility features such as automatic captions, audio narration, or digital sign language. Because it is open-source, developers can add inclusive modules according to local needs without licensing constraints. Thus, interactivity not only improves the quality of learning but also ensures access to education for all students, including those with disabilities.

C. Implementation Challenges in Schools

Despite its potential, the implementation of open technology-based learning media faces several challenges. One of these is the limited digital literacy of teachers and students in utilizing open-source platforms. Rahmawati (2023) emphasized that without systematic training support, interactive media cannot be optimally utilized because teachers tend to revert to conventional methods. Furthermore, limited infrastructure, such as hardware and internet connections, also poses a barrier in low-resource schools. Therefore, a phased implementation strategy is needed, taking into account technological readiness, human resources, and educational policy support.

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Besides limited digital literacy, resistance to change is also a significant obstacle. Teachers accustomed to lecture methods often worry that new technologies will increase their workload. According to Wulandari (2022), many educators perceive the use of interactive media as requiring longer preparation time than traditional methods, leading to reluctance to adopt them. However, with proper training, the use of open technology-based media can actually reduce teachers' administrative burden due to several automation features. This resistance challenge highlights the need for intensive mentoring to foster a positive mindset for open technology-based learning innovations.

The infrastructure gap between urban and rural schools is also a factor that cannot be ignored. According to Saputra (2021), differences in access to computer devices, stable internet connections, and technical support make the implementation of open-source media uneven. In remote areas, teachers must strive to find alternative solutions to maintain learning. This situation emphasizes the importance of affirmative policies from local and central governments to strengthen digital education infrastructure. Without such intervention, the use of open technology risks being enjoyed only by schools with adequate resources, thus widening the gap in education quality.

Data security and privacy are also significant challenges in implementing open technology-based media. According to Lestari (2023), many open-source platforms lack data protection systems as stringent as commercial applications, potentially posing a risk to student data leaks. This is a particularly serious issue in the educational context, where student personal data must be safeguarded in accordance with digital security principles. Therefore, schools require technical guidance on data management when using open technology-based media. Without sound data management policies, the use of interactive media can pose legal and ethical risks.

Limited technical support is also often a barrier for schools. According to Hidayat (2022), most schools lack technology experts who can provide quick solutions when interactive media encounters problems. This forces teachers to play the dual role of educator and technician, often hindering

learning. This lack of technical support leads many teachers to choose not to use open technology-based media, even though they recognize its potential. A possible solution is to form school- or district-based support communities that provide collective and ongoing technical assistance.

Another challenge that arises is the limited human resources required to develop learning content tailored to student needs. According to Prasetyo (2021), although open technology offers flexibility, not all teachers have the skills to design engaging, interactive content. This often results in learning media used that are less than optimal in increasing student engagement. Intensive training and workshops on instructional design are needed to enable teachers to utilize open technology optimally. This way, the resulting interactive media can support competency achievement while maintaining student learning interest.

Another obstacle lies in the limited school budget to support the implementation of open technology. According to Nugraha (2023), even though open-source applications are license-free, additional costs for hardware, internet connections, and maintenance are still required. In schools with limited funds, budget priorities are directed more towards basic needs, so technology development is often neglected. Therefore, external financial support from the government, the private sector, and corporate social responsibility (CSR) is crucial to ensure the sustainable use of open technology-based interactive media in schools.

The cultural context of learning in schools also presents a challenge. According to Aminah (2022), some students are still accustomed to passive learning methods, making them feel awkward when faced with interactive media that demands active participation. This demonstrates the need for a paradigm shift not only for teachers but also for students as media users. This shift in learning culture requires time and a gradual process with a persuasive and contextual approach. With consistent practice, students will be able to adapt and enjoy the benefits of using open technology-based media.

Finally, educational policy support is a key factor in overcoming various implementation challenges. According to Handayani (2023), without clear regulations, schools tend to struggle to systematically design open technology utilization programs. Policy support can take the form of standard regulations, incentives, and integrated training programs facilitated by the government. This is crucial to ensure that the use of open technology-based interactive media is not merely a local initiative but also becomes part of national policy. Thus, implementation challenges can be minimized through synergy between teachers, schools, and policymakers.

D. Sustainability and Collaboration Prospects

Sustainability is crucial in the development of open technology-based learning media. Nugroho (2024) stated that the success of interactive media depends heavily on a community of users and developers who actively update content and features in line with curriculum developments. In this regard, collaboration between schools, universities, and the educational technology community needs to be strengthened so that the media developed is not only useful for the immediate future but also adapts over the long term. This collaboration also encourages sustainable innovation that is relevant to student needs and the dynamics of global education.

The sustainability of open-source learning media requires alternative funding mechanisms. According to Pratiwi (2023), schools can adopt a collaborative model involving local governments, non-profit organizations, and the private sector to support the ongoing maintenance of the platform. With stable funding, developers can continuously update features to keep pace with changing times. Collaborative funding also prevents dependence on a single source, thereby minimizing the risk of stagnation. In this context, the active participation of all educational stakeholders is crucial for creating a sustainable interactive media ecosystem.

The role of universities is crucial in maintaining the sustainability of interactive learning media. According to Santoso (2022), campuses can serve as centers of innovation and testing laboratories for open technology-based media. Through research and community service, universities can help schools develop content tailored to the characteristics of local students. Furthermore, student involvement also encourages the emergence of young people ready to continue development. Thus, the sustainability of interactive media can be maintained through the regeneration of developers and continued collaboration between educational institutions.

User communities play a key role in maintaining the relevance of open-source learning media. According to Lestari (2023), communities that actively share good practices, tutorials, and feature updates will accelerate the adoption process in schools. Sharing within the community also creates a collaborative environment that supports teachers' continued learning and innovation. Thus, sustainability depends not only on technical aspects but also on the collaborative culture fostered among users. This demonstrates that communities are the backbone of the sustainability of open-source technology-based media.

The sustainability prospects of interactive media are also influenced by its ability to adapt to technological developments. According to Hakim (2022), open-source media has the advantage of adapting more quickly to software updates and integrating with new technologies, such as artificial intelligence or learning analytics. If schools and communities can capitalize on this flexibility, interactive media will remain relevant in the long term. This adaptability is why open technology is worth considering as a strategic solution for the sustainability of digital education.

Government involvement in supporting collaboration is another crucial factor. According to Wulandari (2023), the government can provide incentives in the form of standard policies, national training, and infrastructure support that facilitate schools' access to open technologies. These affirmative policies not only accelerate adoption but also ensure the continued use of interactive media in schools. Thus, the success of collaboration is determined not only by schools and communities but also by consistent adherence to digital education policies.

In addition to the government, the private sector also plays a role in promoting sustainability. According to Hidayat (2024), many technology companies have corporate social responsibility (CSR) programs that can be directed toward supporting the development of interactive learning media. Collaborating with the private sector provides not only financial resources but also the technical expertise needed for system development. This collaboration creates a synergistic ecosystem where education and industry mutually reinforce each other to create sustainable media.

Sustainability must also be viewed from a pedagogical perspective. According to Fadilah (2022), interactive learning media can only survive if it is proven effective in improving the quality of learning outcomes. Therefore, regular evaluation is necessary to ensure that open technology-based media truly supports student competency achievement. This evaluation can be conducted collaboratively between teachers, researchers, and the user community. With a sustainable evaluative approach, interactive media will not only survive but also continue to evolve in line with the real needs of education.

Finally, cross-border collaboration opens up significant opportunities for the sustainability of open-source learning media. According to Syafitri (2023), integration with the global community allows access to technological updates, multilingual content, and a broader knowledge network. This not only strengthens sustainability but also makes Indonesian education more competitive internationally. Cross-border collaboration demonstrates that the sustainability of interactive learning media is inextricably linked to the dynamics of the globalization of digital education.

Research result

The research results show that developing interactive learning media based on open technology can increase student engagement in the learning process. Limited trials in several junior high schools in Central Java demonstrated increased student motivation and participation when using the developed interactive media. Teachers also stated that the media helped them explain abstract material more concretely. This aligns with findings that open technology allows teachers to adapt content to learning needs without the constraints of software licensing.

Furthermore, research has found that teachers' acceptance of interactive media still depends on their digital literacy skills. Teachers who are accustomed to using open-source applications adapt more quickly than those without similar experience. This situation emphasizes the importance of systematic training for more equitable implementation of interactive media. According to Prasetyo & Yuliana (2023), without the support of teacher

training, infrastructure strengthening, and collaboration between stakeholders, interactive media development cannot be optimally implemented in schools with limited resources.

From the student perspective, the survey results showed that the majority felt interactive media provided a more enjoyable learning experience than conventional lecture methods. They considered the simulation features, interactive quizzes, and visualization of the material to help accelerate conceptual understanding. However, some students in schools with limited hardware and internet connections reported technical challenges that significantly disrupted the learning process. These findings confirm that media effectiveness is determined not only by content quality but also by the readiness of supporting infrastructure at the school.

Overall, this research demonstrates that interactive learning media based on open technology has significant potential for improving the quality of learning. However, its success depends on support from the broader ecosystem. Collaboration between schools, the government, universities, and the technology community is needed to build a comprehensive implementation framework. With cross-sector support, interactive media can be implemented not only in schools with adequate resources but also in schools with limited infrastructure.

Conclusion

This research confirms that the development of interactive learning media based on open technology is highly relevant in supporting modern learning processes. This media can increase student motivation, engagement, and understanding through interactive features that can be tailored to curriculum needs. Open technology also provides opportunities for teachers to develop materials flexibly without licensing constraints, thus aligning with the principle of democratizing access to education.

However, the implementation of interactive learning media is not without challenges. Research shows that teachers' limited digital literacy, gaps in school infrastructure, and technical constraints in the field can impact implementation effectiveness. This demonstrates that the success of open technology in education depends not only on the quality of the media but also on the readiness of human resources and adequate infrastructure support.

The findings also indicate that collaboration is key to the sustainable development of open-source interactive media. The involvement of schools, universities, developer communities, and the government in providing training and policy support is necessary to expand the use of open-source interactive media. This collective support is expected to reduce disparities between schools, especially those with limited resources.

Conceptually, this study concludes that the implementation framework for interactive learning media based on open technology must be comprehensive, encompassing design, teacher training, infrastructure, and cross-sector collaboration. Thus, interactive media is not merely a fleeting innovation but can become a strategic instrument for sustainably improving the quality of education, both locally and globally.

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