JIPS 7 (3) (2026)

Jurnal Inovasi Pendidikan dan Sains

E-ISSN 2721-9119

https://ejournal.unwmataram.ac.id/index.php/JIPS

Analysis of Teachers' Needs for Interactive Science Multimedia Based on an Ethno-Inquiry Approach in Elementary Schools

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Accepted: July 06th 2026. Approved: November 02th 2026. Published: November 14th 2026

ABSTRACT

Elementary science education requires interactive media to effectively teach abstract concepts, yet teachers predominantly rely on conventional, teacher-centered resources. This study analyzes the needs of upper-grade elementary teachers for interactive science multimedia integrated with an Ethno-Inquiry approach, a pedagogical model that combines scientific investigation with local cultural wisdom. Employing a quantitative descriptive method within the analysis phase of the ADDIE development model, data were collected via an online questionnaire from 31 upper-grade teachers in Pekalongan, Indonesia. The findings reveal that educators face significant barriers, including limited ICT infrastructure and a lack of contextually appropriate digital media. Consequently, there is a unanimous demand for technology-based tools featuring dynamic animations, virtual simulations, and educational games to visualize complex phenomena. Furthermore, all respondents expressed strong interest in adopting Ethno-Inquiry multimedia to foster contextual, meaningful, and culturally responsive learning experiences. Ultimately, this study provides crucial empirical evidence and a foundational reference for developing innovative science multimedia that addresses actual classroom challenges, preserves local wisdom, and enhances student engagement in elementary schools.

Keywords: interactive multimedia, ethno-inquiry, elementary science

INTRODUCTION

Science education in elementary schools is fundamental for developing students' analytical thinking and their understanding of natural phenomena. Aligning with the *Merdeka* Curriculum, science learning must be relevant to daily life and facilitate meaningful educational experiences [1]. At this educational level, students are in a cognitive development phase that requires concrete, comprehensive, and relatable learning materials to construct conceptual understanding rather than mere memorization [2], [3].

Despite these educational ideals, science instruction in elementary schools often remains conventional and lacks pedagogical innovation. Many teachers predominantly rely on teacher-centered methods, such as lectures and printed textbooks, as their primary instructional resources [4]. This overreliance on conventional materials results in a one-way learning process that fails to promote active student participation and optimal conceptual understanding [5], [6].

A significant challenge in this conventional setting is the delivery of abstract science concepts, such as energy, light, and sound waves. These topics require visualization and interactive experimental activities to be comprehensible to young learners [7], [8]. Without adequate visual aids, students frequently develop misconceptions, particularly in physics-related materials that cannot be directly observed [9]. Consequently, there is an urgent need for learning media that can bridge the gap between abstract theories and concrete understanding.

To contextualize abstract concepts, educators can integrate local wisdom through an ethnoscience approach. Ethnoscience connects scientific principles with cultural practices and community values, making learning more meaningful and culturally relevant [10], [11]. For instance, the abstract concept of sound waves can be tangibly explored through local cultural artifacts, such as the traditional musical instruments used in the *Babalu* dance from Batang [12]. This interdisciplinary approach not only enhances conceptual understanding but also fosters scientific literacy and character building [13].

Building upon ethnoscience, the inquiry approach can be integrated to form the ethno-inquiry model, which emphasizes active student involvement in scientific investigations. This approach guides students to identify problems, formulate hypotheses, and draw conclusions based on observations of local cultural phenomena [14], [15]. By acting as scientists exploring their own cultural environment, students engage in

constructivist learning that develops critical thinking and problem-solving skills aligned with 21st-century competencies [16].

To effectively implement the ethno-inquiry approach, interactive multimedia serves as a crucial technological vehicle. Multimedia integrates various representation channels, such as animations, simulations, and interactive quizzes, allowing students to visualize abstract phenomena and interact directly with the material [17]. Interactive multimedia has been proven to overcome the limitations of physical laboratory tools in elementary schools, significantly boosting student motivation, engagement, and conceptual mastery [18], [19].

Although the integration of ethno-inquiry and interactive multimedia holds immense potential, its development must be grounded in empirical field needs. Currently, there is a lack of comprehensive data regarding teachers' readiness, obstacles, and specific feature requirements for such integrated media. Therefore, this study aims to analyze the needs of upper-grade elementary school teachers for interactive science multimedia based on an ethno-inquiry approach. The findings will serve as a foundational reference for developing contextually relevant, interactive, and culturally responsive science learning media.

RESEARCH METHODS

The research was a research and development (RnD) study using the ADDIE (analysis, design, development, implementation, and evaluation) model (Sugiono, 2015). The research and development stages are shown in Figure 1.

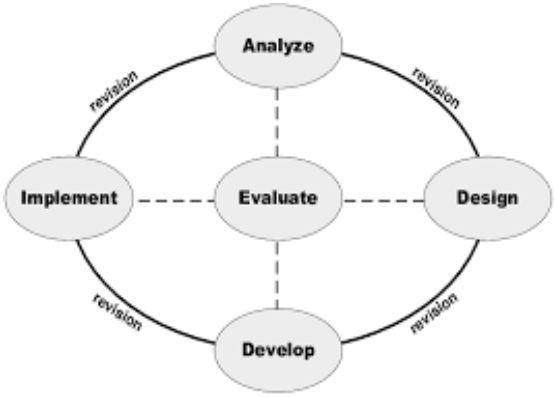


Figure 1. Model ADDIE

However, the study only conducted the analysis stage to determine the needs of teachers in science teaching at the elementary school. This analysis phase used quantitative descriptive analysis, which aims to provide an in-depth description of teachers' perceptions and experiences in teaching, as well as the need for interactive science multimedia following the needs. The subjects were 31 upper-grade teachers (grades IV-VI) in Pekalongan. They were selected using purposive sampling techniques, considering certain criteria, such as active upper-grade teachers, having at least three years of teaching experience, and being willing to participate. The choice of purposive sampling aligns with Patton's (2015) perspective, in which this technique is used to select informants who can provide rich and in-depth data.

Data collection was conducted using a questionnaire on the Google Forms platform. The instrument has several open-ended questions designed to explore teachers' needs, learning challenges, and perspectives on the use of interactive multimedia in science learning using the Ethno-Inquiry approach. Google Forms was used as it was considered practical, accessible across multiple devices, and more flexible. The results of the analysis are presented in frequency and percentage form to illustrate the actual needs of teachers for interactive science multimedia using the Ethno-Inquiry approach. The teacher needs an analysis questionnaire instrument, presented in Table 1.

Table 1. The Teacher Needs an Analysis Questionnaire Instrument

Aspect	Question	Response Type	Item Number
Learning Facilities	Does the school already have adequate ICT facilities (LCD projectors, computers, and other supporting devices) to support IPA learning?	Multiple chice	1
Effectiveness of Learning Media	Have the learning media used do far been able to improve students interest and understanding of IPA materials?	Likert scale	2
Need for Technology Based Media	Do you need technology-based learning media for the IPA subject?	Likert scale	3
Difficulties in Teaching IPA Materials	Do you experience difficulties in the teaching IPA materials?	Likert scale	4
Challenges in Using Learning Media	What are the main challenges you face when using learning media?	Checkbox	5
Learning Media Used by Teachers	What learning media do you usually use in IPA learning?	Checkbox	6
Desired Features	What features would you like to have in interactive multimedia learning materials?	Checkbox	7
Interest in Ethno-Inquiry Multimedia	If interactive IPA multimedia integrated with ethno-inquiry (connecting IPA content with local culture) were available, would you be interested in using it in IPA learning?	Likert scale	8

The needs analysis began by identifying the availability of ICT facilities in each school. Then, it identifies the types of media commonly used in schools. After identifying the types of media commonly used by upper-grade teachers, the next step was to analyze the challenges of teachers in using digital learning media in schools. Next, the needs analysis focused on features in interactive media to facilitate and increase effectiveness, engagement, and meaningfulness for students. Also, an analysis was conducted to determine upper-grade teachers' interest in integrating the Ethno-Inquiry approach into their interactive media. The integration of the Ethno-Inquiry approach in interactive science multimedia is expected to connect science concepts and local cultural contexts that are close to students' daily lives.

RESULT AND DISCUSSION

1. Availability and Utilization of ICT Infrastructure in Elementary Schools

The integration of technology in elementary science education requires adequate ICT infrastructure as a fundamental prerequisite. This study examined the availability of ICT facilities across 31 elementary schools in Pekalongan to understand the technological readiness for implementing interactive multimedia. The findings reveal a mixed landscape regarding digital infrastructure availability in participating schools. While slightly more than half of the schools possess adequate facilities, a significant portion still struggles with insufficient technological support for modern learning approaches.

The data indicates that 17 teachers (54.8%) reported their schools have adequate ICT facilities, including LCD projectors, computers, and other supporting devices necessary for digital learning implementation. Conversely, 14 teachers (45.2%) stated that their school facilities remain inadequate for supporting digital-based learning activities. This nearly even distribution suggests that while progress has been made in equipping schools with technology, substantial gaps persist that could hinder the widespread adoption of interactive multimedia in science instruction.

Table 2. Availability of ICT Facilities in Elementary Schools

Response Category	Number of Teachers	Percentage (%)
Adequate	17	54.8
Inadequate	14	45.2
Total	31	100

The distribution of ICT facility availability demonstrates that elementary schools in Pekalongan are at a transitional stage regarding technological infrastructure development. The 54.8% adequacy rate indicates that more than half of the schools have made investments in essential digital learning equipment, which aligns with government initiatives to modernize education infrastructure. However, the 45.2% inadequacy rate reveals a persistent digital divide that could exacerbate educational inequalities if not addressed through targeted interventions and resource allocation.

The implications of these findings extend beyond mere infrastructure availability to encompass the practical feasibility of implementing interactive multimedia-based learning. Schools with adequate facilities can potentially support the deployment of ethno-inquiry based interactive multimedia, enabling teachers to visualize abstract science concepts through animations, simulations, and interactive elements. Conversely, schools with inadequate facilities face significant barriers that may require alternative strategies, such as offline-capable multimedia applications or shared resource models among neighboring schools.

This infrastructure disparity reflects broader challenges in educational technology implementation documented in recent literature. According to Robandi et al., ICT competency and infrastructure remain significant barriers to digital learning implementation at the elementary school level in Indonesia [20]. The findings underscore the necessity for comprehensive planning that addresses both hardware provision and sustainable maintenance systems to ensure long-term functionality of ICT investments in elementary education.

2. Current Practices in Science Learning Media Usage

The examination of current learning media practices reveals the predominant reliance on conventional teaching resources among upper-grade elementary school teachers in Pekalongan. The data collection employed a checkbox format allowing teachers to select multiple media types they frequently utilize in science instruction. This approach provided comprehensive insights into the diversity and frequency of media usage patterns across participating schools, highlighting both traditional and emerging trends in educational resource utilization.

Table 3. Types of Science Learning Media Used by Teachers in Elementary Schools

Type of Learning Media	Number of Teachers	Percentage (%)
Textbooks	23	74.2
Student Worksheets (LKS)	22	71.0
Visual Media (pictures/posters)	26	83.9

Type of Learning Media	Number of Teachers	Percentage (%)
Audio Media (voice recordings, songs)	11	35.5
Audiovisual Media (videos, films)	21	67.7
Computer-Based Interactive Media	13	41.9
Interactive Media	1	3.2

The analysis reveals that visual media in the form of pictures and posters dominates science learning practices, utilized by 83.9% (26 teachers) of respondents. This is followed by textbooks at 74.2% (23 teachers) and student worksheets (LKS) at 71.0% (22 teachers). These conventional media types continue to serve as primary instructional resources, reflecting a teacher-centered approach where information delivery occurs primarily through static, one-way communication channels. The prevalence of these traditional media suggests that while teachers recognize the need for instructional support materials, they predominantly rely on readily available, low-technology resources that require minimal technical expertise to implement.

Audiovisual media, including videos and instructional films, demonstrates moderate adoption at 67.7% (21 teachers), indicating a gradual shift toward more dynamic content delivery methods. This finding suggests that teachers are beginning to recognize the pedagogical value of multimedia presentations in enhancing student engagement and facilitating conceptual understanding. Computer-based interactive media shows lower utilization at 41.9% (13 teachers), while purely interactive media registers minimal usage at only 3.2% (1 teacher). This significant gap between audiovisual and interactive media adoption reveals that while teachers are incorporating digital content, they have not yet fully embraced interactive, student-centered learning technologies that enable active exploration and manipulation of scientific concepts.

The dominance of conventional media aligns with findings from Adamu et al., Al Darasi et al., and Zhang et al., who observed that most elementary school teachers continue to rely on teacher-centered methods and printed materials as primary instructional resources [21], [22], [23]. This pattern raises concerns about the effectiveness of science instruction in developing students' analytical thinking and conceptual understanding, particularly for abstract concepts that require visualization and interactive exploration. According to Akmam et al., Funa, and Marisda et al., the overreliance on conventional media results in suboptimal learning processes that fail to promote active student participation and deep conceptual understanding, potentially contributing to the development of misconceptions in fundamental science topics [24], [25], [26].

The limited use of interactive multimedia, despite its proven effectiveness in science education, represents a significant opportunity for pedagogical innovation. Research by Mansour et al., and Wu et al., demonstrates that interactive multimedia can facilitate the visualization of abstract phenomena and overcome the limitations of physical laboratory resources in elementary schools [27], [28]. The current practices indicate that while teachers recognize the need for instructional media, they face various barriers—whether infrastructural, technical, or pedagogical—that prevent the full integration of interactive technologies into their teaching repertoire. This gap between current practices and optimal instructional strategies underscores the necessity for targeted professional development and resource development initiatives.

3. Challenges and Barriers in Implementing Digital Learning Media

The successful integration of digital learning media in elementary science education is contingent upon addressing multiple interconnected challenges that teachers encounter in their daily instructional practices. This study identified and categorized the primary obstacles faced by upper-grade teachers in Pekalongan when attempting to utilize technology-based learning media. Understanding these barriers is essential for developing targeted interventions and support systems that can facilitate the effective implementation of interactive multimedia in science instruction.

Table 4. Teacher Obstacles in Using Science Learning Media

Challenges Faced by Teachers	Number of Teachers	Percentage (%)
Limited Facilities (equipment, projectors, internet)	20	64.5
Limited Skills in Operating Learning Media	4	12.9
Limited Teaching Time	12	38.7
Lack of Learning Media Appropriate to Subject Matter	11	35.5
Others	3	9.7

The findings reveal that limited facilities, encompassing equipment availability, projector access, and internet connectivity, constitute the most significant barrier, affecting 64.5% (20 teachers) of respondents. This infrastructural constraint directly impacts teachers' ability to implement digital

learning solutions, regardless of their pedagogical intentions or technical competencies. The second most prevalent challenge involves limited teaching time, reported by 38.7% (12 teachers), which reflects the practical difficulties of integrating technology-enhanced activities within existing curriculum timeframes and instructional schedules. The lack of appropriate learning media aligned with specific subject matter characteristics affects 35.5% (11 teachers), indicating a gap between available resources and curriculum requirements.

Interestingly, limited skills in operating learning media emerged as a relatively minor concern, affecting only 12.9% (4 teachers) of respondents. This finding suggests that while technical competency remains a consideration for some educators, it is not the primary barrier to digital media implementation in this context. The relatively low percentage of teachers reporting skill limitations may indicate that professional development initiatives have been somewhat effective in building basic digital literacy, or that contemporary multimedia tools have become sufficiently user-friendly to minimize technical barriers. However, this does not diminish the importance of ongoing technical support and professional development, as effective technology integration requires more than basic operational skills—it demands pedagogical-technological knowledge that enables teachers to strategically select and implement digital resources.

The predominance of facility-related challenges aligns with broader patterns documented in educational technology research. Batamuliza et al., Lubis, Praja et al., and Xu et al., noted that limited laboratory facilities and ineffective learning media significantly hinder the explanation of abstract science concepts in elementary education [29], [30], [31], [32]. The infrastructure deficit creates a cascading effect: even when teachers possess the motivation and skills to implement interactive multimedia, inadequate facilities prevent translation of these intentions into classroom practice. This situation is particularly problematic for science education, which requires visualization tools and interactive simulations to make abstract concepts such as energy, sound waves, and light phenomena accessible to elementary students [33], [34].

The challenge of limited teaching time reflects structural constraints within the educational system that extend beyond individual teacher control. Teachers must balance curriculum coverage requirements, assessment obligations, and administrative duties, leaving limited flexibility for experimenting with new instructional approaches or managing the additional time requirements of technology-enhanced learning activities. This temporal constraint interacts with facility limitations, as technical difficulties or setup requirements for digital media can consume valuable instructional time, creating disincentives for technology adoption. The lack of appropriate learning media (35.5%) indicates a mismatch between commercially available or freely accessible resources and the specific pedagogical needs of elementary science instruction, particularly regarding the integration of local cultural contexts and inquiry-based approaches.

These interconnected barriers suggest that addressing digital media implementation challenges requires comprehensive, multi-faceted strategies rather than isolated interventions. Solutions must simultaneously address infrastructure deficits, provide curriculum-aligned resources, and create structural conditions that enable teachers to experiment with and refine technology-enhanced instructional practices. The development of interactive multimedia based on ethno-inquiry approaches, as proposed in this study, must therefore consider these contextual constraints, ensuring that resulting products are not only pedagogically sound but also practically feasible within the resource and time limitations characteristic of Indonesian elementary schools.

4. Teachers' Needs for Interactive Multimedia Features

The analysis of teachers' needs for interactive multimedia features provides critical insights into the specific characteristics and functionalities that educators consider essential for effective science instruction. All 31 participating teachers (100%) expressed a definite need for technology-based learning media in science education, indicating unanimous recognition of the potential value of digital resources in addressing the challenges of teaching abstract scientific concepts. This universal demand underscores the urgency of developing high-quality, contextually appropriate interactive multimedia that can support elementary science teachers in their instructional practice.

Table 5. Interactive Science Multimedia Features Needed by Teachers

Interactive Multimedia Feature	Number of Teachers	Percentage (%)
Animations/Simulations of Science Phenomena	28	90.3
Experiment Videos	25	80.6
Audio/Voice Recordings	7	22.6
Interactive Practice Exercises	24	77.4
Educational Games	25	80.6
Others	1	3.2

The feature analysis reveals that animations and simulations of science phenomena represent the most highly desired multimedia component, with 90.3% (28 teachers) indicating this need. This

overwhelming preference reflects teachers' recognition that dynamic visualizations are essential for making abstract scientific concepts concrete and comprehensible for elementary students. Concepts such as energy transformation, sound wave propagation, and light behavior cannot be directly observed in their fundamental forms, requiring representational tools that can make invisible processes visible and manipulable. The high demand for animations and simulations aligns with cognitive theories of multimedia learning, which suggest that dynamic visual representations can reduce cognitive load and facilitate deeper conceptual understanding when appropriately designed and integrated with instructional content [35], [36].

Experiment videos and educational games share equal prominence, each selected by 80.6% (25 teachers) of respondents. The strong preference for experiment videos indicates teachers' desire to provide students with access to scientific investigations that may be impractical to conduct in classroom settings due to equipment limitations, safety concerns, or time constraints. Video demonstrations of experiments can serve multiple pedagogical functions: modeling scientific inquiry processes, illustrating phenomena that occur over extended time periods or at scales inaccessible to direct observation, and providing visual reinforcement of theoretical concepts. The equal emphasis on educational games reflects growing recognition of gamification's potential to increase student engagement, motivation, and active participation in learning activities. Games can transform abstract scientific concepts into interactive challenges that require students to apply knowledge, test hypotheses, and receive immediate feedback, thereby promoting deeper cognitive processing and retention.

Interactive practice exercises, selected by 77.4% (24 teachers), represent another highly valued feature that supports formative assessment and self-regulated learning. The integration of practice exercises within multimedia environments enables students to immediately apply newly acquired knowledge, receive feedback on their understanding, and identify areas requiring further study. This feature supports the inquiry-based learning approach by providing structured opportunities for students to test their conceptual understanding and refine their mental models through iterative practice and feedback. In contrast, audio or voice recordings emerged as a lower priority, with only 22.6% (7 teachers) indicating this need, suggesting that while auditory elements may enhance multimedia presentations, they are not considered essential features compared to visual and interactive components.

The pattern of feature preferences reveals important insights about teachers' pedagogical priorities and their understanding of how technology can enhance science learning. The emphasis on visualization (animations/simulations), demonstration (experiment videos), engagement (educational games), and assessment (interactive exercises) indicates that teachers view interactive multimedia not merely as information delivery systems but as comprehensive learning environments that can support multiple dimensions of the learning process. This perspective aligns with contemporary understandings of effective technology integration, which emphasize the importance of creating interactive, student-centered learning experiences rather than simply digitizing traditional instructional materials [37], [38].

The high demand for these specific features has important implications for multimedia development initiatives. Developers must prioritize creating high-quality animations and simulations that accurately represent scientific phenomena while remaining accessible to elementary students' cognitive development levels. Experiment videos should be professionally produced, clearly narrated, and explicitly connected to curriculum objectives and inquiry processes. Educational games must balance entertainment value with educational rigor, ensuring that game mechanics reinforce rather than distract from learning objectives. Interactive practice exercises should provide meaningful feedback that helps students understand not only whether their answers are correct but also why, supporting conceptual development rather than mere memorization.

5. Teacher Interest in Ethno-Inquiry Based Interactive Multimedia

The investigation of teachers' interest in interactive science multimedia incorporating an ethno-inquiry approach yielded remarkably positive results, indicating strong receptivity to this innovative pedagogical integration. The ethno-inquiry approach combines scientific inquiry methodologies with local cultural contexts and wisdom, creating learning experiences that are simultaneously scientifically rigorous and culturally relevant. This dual orientation addresses both the cognitive needs of students to understand scientific concepts and the affective needs to see their cultural heritage valued and integrated into formal education.

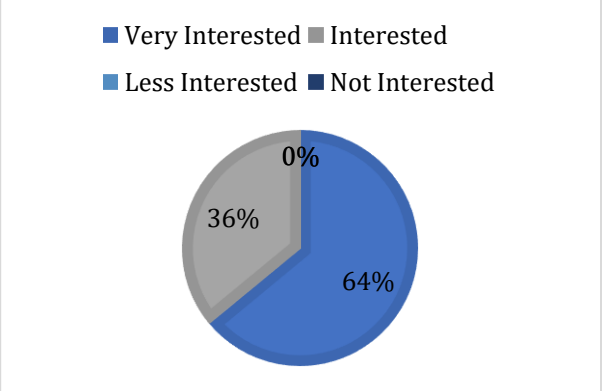


Figure 2. Teachers' Interest in Interactive Science Multimedia Using the Ethno-Inquiry Approach

The data reveals that 20 teachers (64%) expressed being "very interested" in using interactive multimedia integrated with ethnoscience and inquiry approaches, while 11 teachers (36%) indicated they were "interested." Notably, no respondents reported being "less interested" or "not interested" in this type of learning media, resulting in 100% positive interest among participants. This unanimous positive response represents an exceptionally strong endorsement of the ethno-inquiry approach and suggests that teachers recognize its potential to address multiple educational objectives simultaneously. The distribution between "very interested" and "interested" categories indicates varying degrees of enthusiasm, with nearly two-thirds of teachers demonstrating particularly strong commitment to implementing this approach in their science instruction.

The overwhelmingly positive interest in ethno-inquiry based multimedia can be attributed to several factors that align with contemporary educational priorities and challenges. First, teachers recognize that connecting science concepts to local cultural contexts can make abstract scientific principles more concrete and relatable for students. For example, the study of sound waves through traditional musical instruments used in the Babalu dance from Batang provides a tangible, culturally meaningful context for exploring physics concepts that might otherwise seem distant from students' everyday experiences [12]. This contextualization supports constructivist learning theories by building new knowledge upon students' existing cultural understanding and lived experiences.

Second, the ethno-inquiry approach addresses the dual imperative of maintaining scientific rigor while preserving and transmitting local cultural knowledge. In an era of rapid globalization and cultural homogenization, many educators feel a responsibility to ensure that formal education does not inadvertently contribute to the erosion of local cultural heritage. By integrating ethnoscience into science instruction, teachers can demonstrate that scientific thinking and cultural wisdom are not mutually exclusive but rather complementary ways of understanding the natural world [39], [40]. This integration can foster students' appreciation for both modern science and traditional knowledge systems, developing bicultural scientific literacy that values diverse epistemological perspectives.

Third, the inquiry component of the ethno-inquiry approach aligns with 21st-century learning competencies that emphasize critical thinking, problem-solving, and active knowledge construction. The ethno-inquiry model engages students in authentic scientific practices: observing local phenomena, formulating questions, investigating cultural practices, analyzing data, and drawing evidence-based conclusions [41], [42], [43]. This process develops not only scientific understanding but also transferable skills in research, analysis, and communication that are essential for success in contemporary society. The combination of cultural relevance and inquiry-based pedagogy creates powerful learning experiences that can increase student engagement, motivation, and achievement in science education.

The strong teacher interest in ethno-inquiry multimedia has significant implications for educational development initiatives. It suggests that teachers are ready and willing to adopt innovative instructional approaches that integrate technology, culture, and inquiry-based pedagogy. However, interest alone is insufficient; teachers will require appropriate resources, professional development, and ongoing support to effectively implement ethno-inquiry based multimedia in their classrooms. The development of such multimedia must therefore be accompanied by comprehensive teacher training programs that build pedagogical-technological-cultural knowledge, enabling teachers to strategically integrate these resources into their instructional practice.

Furthermore, the positive reception of ethno-inquiry approaches indicates a broader shift in Indonesian science education toward more contextualized, culturally responsive pedagogy. This shift aligns with the Merdeka Curriculum's emphasis on meaningful, relevant learning experiences that connect school knowledge to students' lives and communities [44], [45]. The development of ethno-inquiry based interactive multimedia can thus serve as a catalyst for broader educational transformation, demonstrating how technology can be leveraged not to impose standardized, decontextualized content but to enrich and diversify learning experiences in ways that honor local knowledge while developing scientific literacy.

The integration of ethnoscience values into inquiry-based multimedia represents a promising strategy for addressing multiple educational challenges simultaneously: improving conceptual understanding of abstract science concepts, increasing student engagement and motivation, preserving and transmitting local cultural knowledge, and developing 21st-century competencies. As Putri et al., Setiyadi, and Wibowo & Susanto noted, ethnoscience learning in elementary school science makes learning more meaningful while introducing students to local culture, creating educational experiences that are both academically rigorous and culturally sustaining [46], [47], [48]. The strong teacher interest documented in this study provides a solid foundation for development efforts, suggesting that well-designed ethno-inquiry multimedia will find ready adoption among elementary science teachers seeking to enhance their instructional practice.

6. Implications for Interactive Multimedia Development

The comprehensive needs analysis conducted in this study yields critical implications for the development of interactive science multimedia based on the ethno-inquiry approach. The findings collectively paint a picture of elementary science education at a crossroads: teachers recognize the need for innovative, technology-enhanced instructional resources, yet they face significant barriers that prevent effective implementation. The development of ethno-inquiry based multimedia must therefore be strategically designed to maximize pedagogical impact while minimizing practical barriers to adoption.

The infrastructure constraints identified in this study—particularly the 64.5% of teachers reporting limited facilities—necessitate that multimedia products be designed with flexibility and accessibility as core principles. Developed resources should function effectively across a range of technological environments, from schools with robust ICT infrastructure to those with minimal resources. This might involve creating multimedia that can operate offline after initial download, optimizing file sizes to accommodate limited bandwidth, and ensuring compatibility with various devices and operating systems. Additionally, multimedia should be designed to function with minimal equipment requirements, perhaps offering alternative viewing modes for classrooms without projectors or interactive displays.

The feature preferences revealed in the needs analysis provide a clear roadmap for multimedia development priorities. The overwhelming demand for animations and simulations (90.3%) indicates that development efforts should prioritize creating high-quality dynamic visualizations of abstract science phenomena. These animations must be pedagogically sound, accurately representing scientific concepts while remaining accessible to elementary students' cognitive development levels. The animations should not merely illustrate concepts but should enable students to manipulate variables, observe cause-and-effect relationships, and develop mental models of invisible processes. For example, animations of sound wave propagation could allow students to adjust frequency and amplitude parameters, observing how these changes affect wave characteristics and perceived sound.

The strong interest in experiment videos (80.6%) and educational games (80.6%) suggests that multimedia should incorporate multiple representational formats to address diverse learning preferences and objectives. Experiment videos should be professionally produced with clear narration, explicit connections to inquiry processes, and opportunities for students to predict outcomes, observe phenomena, and draw conclusions. Educational games should be carefully designed to ensure that game mechanics reinforce learning objectives rather than distract from them, providing engaging contexts for students to apply scientific concepts, test hypotheses, and receive immediate feedback. The integration of interactive practice exercises (77.4%) should provide formative assessment opportunities with diagnostic feedback that helps students understand their misconceptions and refine their understanding.

The ethno-inquiry integration requires particular attention to ensure authentic, meaningful connections between scientific concepts and local cultural practices. Rather than superficial cultural references, multimedia should deeply engage with local wisdom, demonstrating how traditional practices embody scientific principles and how scientific inquiry can illuminate cultural phenomena. For instance, multimedia exploring sound concepts through the Babalu dance should not simply mention the dance as a cultural example but should engage students in investigating how traditional instruments produce sound, how rhythm and pitch are controlled, and how these acoustic principles relate to broader physics concepts. This deep integration requires collaboration with cultural experts, careful documentation of local practices, and thoughtful pedagogical design that respects cultural knowledge while developing scientific understanding.

The development process must also address the temporal constraints reported by 38.7% of teachers by creating multimedia that integrates seamlessly into existing curriculum structures rather than requiring extensive additional time. Resources should be modular, allowing teachers to incorporate specific components into their lessons without disrupting overall instructional flow. Clear implementation guides, aligned lesson plans, and assessment tools can reduce preparation time and increase teachers' confidence in using the multimedia effectively. Additionally, multimedia should be designed to support both teacher-facilitated instruction and independent student exploration, providing flexibility in implementation based on available time and resources.

Professional development represents another critical component of successful multimedia implementation. While only 12.9% of teachers reported limited skills as a barrier, effective integration of ethno-inquiry multimedia requires more than basic technical competency—it demands pedagogical understanding of how to leverage technology for inquiry-based, culturally responsive instruction. Development initiatives should therefore include comprehensive teacher training programs that build technological, pedagogical, and cultural knowledge simultaneously. Training should provide opportunities for teachers to experience the multimedia as learners, analyze its pedagogical features, practice implementation strategies, and collaborate with colleagues to adapt resources to their specific contexts.

The development of interactive science multimedia based on the ethno-inquiry approach thus represents not merely a technical endeavor but a comprehensive educational innovation that requires attention to pedagogical design, cultural authenticity, technological accessibility, and teacher support. By addressing the needs, preferences, and constraints identified in this study, developers can create resources that have genuine potential to transform elementary science education making abstract concepts concrete, connecting school learning to students' lives, preserving cultural heritage, and developing scientific literacy for the 21st century. The strong teacher interest documented in this study provides both motivation and mandate for such development efforts, suggesting that well-designed ethno-inquiry multimedia can catalyze meaningful improvement in elementary science education quality.

CONCLUSION

This study identified a substantial need for interactive science multimedia integrating an Ethno-Inquiry approach among upper-grade elementary school teachers in Pekalongan. Based on responses from 31 teachers, the findings revealed that 45.2% reported inadequate ICT facilities, while limited infrastructure (64.5%), teaching time (38.7%), and the availability of subject-appropriate learning media (35.5%) were the primary barriers to technology integration. Although teachers commonly used visual media (83.9%), textbooks (74.2%), and student worksheets (71.0%), all respondents expressed a need for technology-based science learning media. The most frequently requested features were animations and simulations (90.3%), experimental videos (80.6%), educational games (80.6%), and interactive exercises (77.4%). Furthermore, all respondents expressed positive interest in Ethno-Inquiry-based multimedia, with 64% reporting being very interested and 36% interested. These findings establish an empirical basis for developing interactive science multimedia that integrates local cultural knowledge with scientific inquiry while accommodating classroom infrastructure and instructional constraints. Future development should prioritize accessible, potentially offline-compatible multimedia with culturally relevant investigations and interactive learning features, followed by systematic evaluation of its usability, feasibility, and effectiveness in supporting students' science learning. As this study was limited to a descriptive needs analysis involving purposively selected teachers, its findings should be interpreted as context-specific evidence of perceived needs and preferences rather than proof of multimedia effectiveness or broader teacher readiness.

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