TEKNODIKA
e-ISSN: 2656-6621
http://jurnal.uns.ac.id/Teknodika

Exploring Teachers' Needs for Technology-Based Learning in Elementary Education

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Abstract: The integration of 21st-century skills, such as critical thinking, collaboration, and digital literacy, into elementary science education remains suboptimal. Preliminary observations in Purwantoro indicate that traditional teaching methods dominate, with limited use of interactive media, restricting the development of essential student competencies. This study addresses the need for innovative learning tools by exploring the potential of Smart Apps Creator (SAC) in enhancing IPAS (science and social studies) education. Employing a qualitative descriptive approach, data were gathered from five elementary school teachers through interviews, observations, and document analysis, meanwhile, the data analysis technique in this research uses descriptive analysis techniques. Findings reveal that SAC-based media effectively meet teachers' needs by providing interactive features that promote engagement and independent learning. However, challenges such as limited infrastructure and teacher training were identified. The study underscores the significance of aligning educational practices with the demands of the digital era by integrating interactive media into the curriculum. It highlights the role of SAC in fostering 21st-century skills, offering practical recommendations for professional development and curriculum enhancement. It is hoped that the results of this research will have implications for innovative and technology-based learning as a step to accommodate learning in elementary schools more optimally.

Keywords: 21st-Century Skills, Interactive Media, Smart Apps Creator, Elementary Education, Science Education

Abstrak: *Integrasi keterampilan abad ke-21, seperti berpikir kritis, kolaborasi, dan literasi digital, dalam pembelajaran IPAS di sekolah dasar masih belum optimal. Observasi awal di wilayah Purwantoro menunjukkan bahwa metode pembelajaran tradisional masih mendominasi, dengan pemanfaatan media interaktif yang terbatas, sehingga membatasi pengembangan kompetensi esensial siswa. Penelitian ini bertujuan untuk mengatasi kebutuhan alat pembelajaran inovatif dengan mengeksplorasi potensi Smart Apps Creator (SAC) dalam meningkatkan pembelajaran IPAS. Dengan pendekatan kualitatif deskriptif, data dikumpulkan dari lima guru sekolah dasar melalui wawancara, observasi, dan analisis dokumen, sementara itu Teknik analisis data pada riset ini menggunakan Teknik analisis desrkiptif. Hasil penelitian menunjukkan bahwa media berbasis SAC mampu memenuhi kebutuhan guru dengan menyediakan fitur interaktif yang mendorong keterlibatan dan pembelajaran mandiri siswa. Namun, penelitian ini juga mengidentifikasi tantangan seperti keterbatasan infrastruktur dan pelatihan guru. Penelitian ini menegaskan pentingnya menyelaraskan praktik pendidikan dengan tuntutan era digital melalui integrasi media interaktif ke dalam kurikulum. SAC berperan dalam mendukung pengembangan keterampilan abad ke-21 dan menawarkan rekomendasi praktis untuk pelatihan profesional serta peningkatan kurikulum. Diharapkan melalui hasil riset ini dapat berimplikasi pada pembelajaran yang inovatif dan berbasis teknologi sebagai Langkah untuk mengakoomodasi pembelajaran di sekolah dasar dengan lebih optimal.*

Kata Kunci: *Keterampilan Abad Ke-21, Media Interaktif, Smart Apps Creator, Pendidikan Dasar, Pembelajaran IPAS*

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Submitted: January 2025	Accepted: January 2025	Published: March 2025

INTRODUCTION

The teaching of integrated science and social studies (IPAS) in elementary schools under the Merdeka Curriculum requires creative instructional approaches that prioritize inductive reasoning (Sutimah & Tyas, 2024). However, preliminary observations in Purwantoro reveal that many teachers rely heavily on traditional lecture-based methods and printed textbooks, which fail to engage students and restrict their development of critical thinking, collaboration, and creativity. Current lesson plans (RPP) lack explicit integration of 21st-century skills, such as digital literacy, problem-solving, and creativity, which are essential for preparing students to navigate complex modern challenges.

Research undertaken in Indonesia indicates that the 4C abilities (creativity, critical thinking, collaboration, and communication) of Indonesian students require enhancement. Research indicates that the critical and creative thinking abilities of Indonesian students are comparatively worse than those of students from other nations with a Malay ethnic demographic (Saimon et al., 2023). The study recommended the implementation of STEAM-based learning (Science, Technology, Engineering, Art, Mathematics) to enhance these competences, demonstrating a considerable improvement in students' critical and creative thinking skills relative to control classes (Barus, 2024). A study revealed that the implementation of the Critical Literacy Approach (CLA) in literary appreciation, utilizing Indonesian short stories, effectively enhanced students' critical thinking skills and critical awareness in comparison to expository strategies (Frèrejean et al., 2021). To facilitate the integration of 4C capabilities in education, scientific educators in Indonesia utilize several resources, including professional development initiatives, teacher cooperation, curriculum frameworks, and open-access materials. The Teacher Professional Education Program (PPG) is regarded as the most successful in promoting the integration of 4C (Haryani et al., 2021). Consequently, sustained efforts are essential to enhance the 4C competencies of Indonesian students via diverse creative pedagogical methods and teacher professional advancement.

Interactive digital media, such as Smart Apps Creator (SAC), provide an innovative solution for addressing the challenges in elementary education by enabling teachers to design engaging and dynamic learning experiences (Braun & Clarke, 2006; Suhartati, 2021). With features such as animations, quizzes, and offline functionality, SAC is particularly suited for areas with limited technological infrastructure (Jannah & Atmojo, 2022). Recent studies underscore the significant potential of SAC-based tools in enhancing 21st-century skills, such as critical thinking and creativity, while also increasing student motivation and improving learning outcomes across various subjects (Husna, 2022; Suhartati, 2021; Panggalih & Handayani, 2023). Moreover, interactive multimedia and e-learning platforms have been shown to facilitate contextual learning and foster critical thinking skills (Ifliadi et al., 2024; Widiyatmoko et al., 2021). Despite these advantages, challenges remain, including limited infrastructure and the need for enhanced teacher competencies in digital media usage. In the context of the Industrial Revolution 4.0, digital literacy and technology-based learning media are essential for equipping students with the skills necessary to thrive in the modern world (Rifa Hanifa Mardhiyah et al., 2021). For instance, Android-based learning media have demonstrated their effectiveness in improving early reading competencies and supporting higher-order thinking skills (P. et al., 2023; Antara & Dewantara, 2022). These findings highlight the transformative potential of integrating digital tools like SAC into elementary education.

The 21st-century learning paradigm underscores the importance of the 4C competencies as essential skills for preparing students to navigate complex global challenges (Jannah & Atmojo, 2022). These competencies are particularly vital in IPAS (social studies and natural sciences) education,

where students are encouraged to analyze real-world problems, synthesize solutions, and develop adaptive capabilities (Sutimah & Tyas, 2024). Studies highlight that the effective integration of these skills into the curriculum not only enhances academic performance but also equips students with the lifelong learning skills required to adapt to rapid technological advancements (Aslamiah et al., 2021; Rindiana et al., 2022). Scientific approaches, such as inquiry-based and problem-based learning, are particularly effective in fostering critical and creative thinking within IPAS education (Daga, 2022). Furthermore, teachers' pedagogical competencies play a pivotal role in nurturing these skills through innovative teaching models and the use of digital media, including educational games, videos, and augmented reality (Rindiana et al., 2022; Thaariq, 2020). Developing these competencies through IPAS education is essential for producing high-quality human resources capable of addressing the challenges of the 21st century and contributing to global progress (Aprilia et al., 2017).

Recent research on IPAS (Integrated Science and Social Studies) in elementary schools highlights various approaches to enhance 4C competencies. Project-Based Learning (PjBL) has been shown to improve critical thinking skills (Asrizal et al., 2022), while the ICARE model significantly influences cognitive learning outcomes (Estrada Oliver et al., 2020). Computational thinking implementation contributes to improved learning outcomes and skill development (Chang et al., 2023). Teacher competence, particularly in pedagogy, plays a crucial role in enhancing students' critical thinking abilities (Saad & Zainudin, 2022). Authentic assessment techniques covering cognitive, affective, and psychomotor aspects are essential in IPAS learning (Ella et al., 2024).

Critical thinking skills are essential for elementary school students in the 21st century, as they prepare children to face modern challenges and participate effectively in society (Barus, 2024). These skills, along with communication, collaboration, and creativity, form the core of 21st-century competencies (Anggraeni et al., 2022). However, research indicates that critical thinking skills among elementary students are often low (Sarwanto et al., 2021). To address this, various strategies have been proposed, including the use of high-order questions, open-ended questions, and STEM-based digital classroom learning models (Widya Karmila Sari Achmad & Unga Utami, 2023)(Zainil et al., 2022). Problem-solving approaches in mathematics can also foster critical and creative thinking (Ida et al., 2021). Teachers play a crucial role in developing these skills by implementing innovative learning models and creating supportive classroom environments.

This study bridges the gap between traditional teaching practices and modern educational demands by exploring the feasibility and effectiveness of SAC-based media in IPAS education. Unlike previous studies focusing solely on general media usage, this research emphasizes localized needs and the strategic embedding of 21st-century skills into instructional design (Hasibuan et al., 2024; Aslamiah et al., 2021). Therefore, the purpose of this study is to describe the needs for SAC-based interactive learning media in elementary IPAS education, assess its feasibility, and evaluate its effectiveness in enhancing students' critical thinking skills. These goals are grounded in the broader mission of fostering a more engaging, equitable, and skill-oriented educational environment for elementary students.

RESEARCH METHODS

A descriptive design and a qualitative methodology are employed in this study. The qualitative technique was selected to thoroughly comprehend primary school science instructors' perspectives on interactive learning media developed with Smart Apps Creator. Descriptive design aims to depict the phenomenon as it exists, without intervening or changing the researched variables (Creswell, 2014).

This approach enables researchers to attain a comprehensive understanding of teachers' experiences, perspectives, and requirements about the generated learning medium.

The study's subjects comprised five science teachers employed at various elementary schools in the Purwantoro District. Educators were chosen through purposive sampling methods based on certain criteria, including a minimum of three years of expertise in science instruction, proficiency in information technology, and participation in the creation or utilization of interactive learning resources. This strategy was selected as it enables researchers to concentrate on informants pertinent to the research subject (Patton, 2002). The selection of this sample is based on the research needs and competencies of the subjects who are considered truly relevant to the data to identify the design and development needs of a digital learning product innovation.

Data was collected using three main methods: semi-structured interviews, observation, and document analysis (Denzin, 2012). Semi-structured interviews were conducted to investigate instructors' perspectives, experiences, and expectations regarding technology-based learning media. Observations were made to monitor the science learning process in the classroom, particularly the usage of learning media. The syllabus, instructional materials, and teachers' daily lesson plans (RPP) were all reviewed during the document analysis process. Data collecting tools included interview rules, observation sheets, and document analysis formats (Braun & Clarke, 2006). The interview parameters included questions meant to elicit instructors' perspectives on the effectiveness of interactive learning media in helping students develop 21st century abilities. The instrument grid was created to guarantee that each instrument was relevant to the research aims, as indicated in Table 1.

Table 1. Data Collection Instrument Grid

Technique	**Indicator**	**Number of Items**	**Data Type/Technique**
Interview	Teachers' views on the effectiveness of learning media	5	Qualitative data / Semi-structured interviews
	Suitability of media to students' learning needs	3	Qualitative data / Semi-structured interviews
Observation	Student interaction in the learning process	4	Qualitative data / Direct observation
	Utilization of technology-based interactive media	3	Qualitative data / Direct observation
Document	Lesson plan alignment with 21st century skills	3	Qualitative data / Document analysis
	Utilization of technology in learning materials	2	Qualitative data / Document analysis

Adapt from (Budiarto et al., 2021; Rejekiningsih et al., 2023; Sari et al., 2024)

To ensure the validity of the instrument, content validity was conducted through consultation with three experts in the field of educational technology and research methodology. Input from the experts was used to refine the interview questions, observation indicators, and document analysis format. Data reliability was tested through triangulation techniques, namely comparing data obtained from interviews, observations, and documents to ensure consistency of information (Chauvette et al., 2019). The following is table 2 containing an illustration of the results of the analysis related to the validity and reliability of the instrument.

Table 2. Results of Instrument Validity and Reliability Analysis

Instrument	Validity (Average Score out of 5)	Validity Category	Reliability (Data Conformity %)	Reliability Category
Interview Guidelines	4.8	Very High	88%	Very Good
Observation Sheet	4.7	Very High	85%	Good
Document Analysis Format	4.6	High	83%	Good

The data were analyzed utilizing the thematic descriptive analysis approach (Bhangu et al., 2023). The analytical procedure had six stages: iterative data reading, initial topic identification, thematic coding, theme consistency evaluation, theme definition, and the formulation of descriptive narratives derived from the identified themes. The analysis was performed iteratively to guarantee that the research findings accurately represented the phenomenon. The research implementation process comprised the planning phase, data gathering, data analysis, and outcomes reporting. During the planning phase, the researcher created the instrument and secured authorization from the school. Data collection occurred over a two-month period, involving direct interviews and inspections at the school. Following the data collection, the analysis was conducted methodically until valid and reliable results were achieved.

RESULTS AND DISCUSSION

Observation of the Learning Process and Use of Media in Science-Social Material in Elementary Schools

Observations were carried out to delineate the science learning process in multiple elementary schools within Purwantoro District. The primary emphasis of the observation was the interaction between students and teachers during the learning process and the degree to which technology-based learning medium was employed. The observations revealed that science learning activities were predominantly teacher-centered, with the lecture technique as the primary strategy for material delivery.

At the outset of instruction, educators typically commence the class by offering motivation and a succinct apperception pertinent to the subject matter to be taught. Nonetheless, student engagement during the learning process was rather minimal. Direct observations indicated that merely 20% of pupils had the fortitude to respond to the teacher's inquiries, with an even smaller fraction offering questions during the discussion. The majority of students appeared inert, merely listening without much engagement in class activities. Collaborative activities, including group work, were infrequently conducted, hence hindering students' ability to cultivate 21st-century abilities, such as teamwork and communication.

The data indicated that educators predominantly depended on printed textbooks as the primary resource for science instruction. Teachers primarily source supplementary information from the internet; nevertheless, their use remains confined to references for educators and is not directly integrated into the classroom learning process. During the observation, no utilization of interactive digital learning material, including technology-based applications or software, was observed. In numerous instructional sessions, educational resources such as photos, films, or digital animations intended to enhance students' comprehension of scientific concepts were not employed. The limited utilization of digital

learning material is attributed to various issues observed during the observation. Initially, educators disclosed that the technological resources accessible in schools remain inadequate. Computer laboratories, when available, are predominantly utilized for specific disciplines like information technology and are infrequently incorporated into science and natural science curricula. Secondly, the majority of educators lack adequate expertise or training in utilizing technology-based learning resources. This leads to educators feeling more at ease employing traditional techniques like lectures and basic conversations. The findings from the study of the observational data are encapsulated in Table 3.

Table 3. Analysis of Observation Findings of the Science Learning Process

Observation Aspect	Indicator	Findings	Description
Student and teacher interaction	Student involvement in discussions	20% of students actively answered teacher questions.	Interaction is still low.
	Student participation in assignments	30% of students were enthusiastic about working on group assignments.	Collaboration activities are still minimal.
	Courage to ask questions	Only 2 students actively asked questions during class.	Need encouragement for involvement.
Observation Aspect	Use of printed books	All teachers used textbooks as the main source.	Dominance of traditional media.
	Use of digital media	No teachers used interactive applications.	Minimal innovation in learning media.
	Access to materials from the internet	Teachers used the internet to search for references.	Not integrated with learning.

The table above indicates that the limited utilization of interactive digital learning resources in science education is a primary issue recognized. Traditional media, like textbooks, can only present information in a static manner and do not facilitate the enhancement of student competencies, like critical thinking, creativity, and digital literacy. Interactive technology-based learning media, such as Smart Apps Creator (SAC), possess significant potential to enhance science education through technology-driven visualizations, simulations, and activities. Regrettably, inadequate technological resources in educational institutions and insufficient instructor proficiency in employing digital media provide considerable challenges. To address this issue, innovation is required in the creation of accessible learning media for educators, alongside comprehensive training to enhance their technological proficiency in the educational process.

Teachers' Views and Readiness for Smart Apps Creator (SAC) Learning Media Innovation for Science-Social Learning

Semi-structured interviews were done to investigate teachers' preferences for Smart Apps Creator (SAC)-based learning media to promote science and science education in elementary schools. The interviews focused on instructors' perspectives on the need for technology-based media, challenges to existing learning, and the readiness of teachers and schools to utilize the technology. According to the data, the majority of instructors believe that more interactive and technology-based learning media innovations are needed to promote science and science education. Most teachers said that using technology-based interactive media, such as SAC, might help to address the constraints of the learning media they currently employ. Teachers believed that traditional learning media, such as

textbooks and printed materials, were less appealing to students and unable to promote the development of 21st century abilities. One teacher stated:

"We need media that can make students more interested, especially for abstract science concepts, interactive visuals are very helpful."

Teachers also emphasized the importance of learning resources that are freely accessible to pupils and allow for autonomous learning. They believe SAC has the ability to address this requirement, particularly given its characteristics that allow for the combination of text, images, animations, and interactive quizzes. Despite the increased demand for media such as SAC, teachers encounter challenges in implementing the technology. The primary barrier is a lack of technical training, which prevents teachers from completely understanding how to use and build SAC-based media. One teacher stated:

"We have never been trained to use such applications. So, even though they look interesting, we don't know how to create them or use them in learning."

In addition, the readiness of schools to support the implementation of technology is another challenge. Facilities such as computers and limited internet networks hinder teachers from adopting technology-based media optimally. Meanwhile, in general, the interview findings were successfully analyzed in the following table 4.

Table 4. Coding Analysis of Interview Findings

Finding Code	Frequency of Appearance	Teacher Quote Examples	Interpretation
Interactive media needs	15	"We need media that can attract students' interest."	Teachers need technology-based media to support learning.
		"Students are often bored with printed books, they need interesting visuals."	Traditional media is less effective.
Training constraints	10	"There is no training for such applications."	Teachers need technical training to use SAC.
		"If you don't know how, it will be difficult to implement."	Teachers' technological competence is still limited.
Infrastructure readiness	8	"Computers in schools are very limited."	School facilities are inadequate for SAC-based technology.
		"Internet is often slow and unstable."	Technological infrastructure is a barrier.

The interview results showed that teachers have a significant demand for interactive learning media such as SAC. Teachers recognize SAC's potential to improve science learning, particularly in helping students understand abstract concepts and increase their enthusiasm in studying. However, important barriers to overcome include a lack of technical training and insufficient school infrastructure. To address the needs of instructors, an extensive training program is required that focuses on the development of SAC-based media and the improvement of technology facilities in schools. With these procedures, teachers will be better equipped to use interactive media into science curriculum and promote the development of students' 21st century competencies. Meanwhile, document analysis was

carried out to determine the extent to which learning documents, such as the Lesson Implementation Plan (RPP) and teaching materials, reflect the requirement for technology-based learning media and the incorporation of 21st century skills into science education. Documents from five science teachers in Purwantoro District were reviewed, with an emphasis on the content's fit for 21st century skills, the use of technology in learning, and relation to media developments such as Smart Apps Creator (SAC).

The results of the analysis show that most lesson plans do not fully reflect the integration of 21st-century skills, such as digital literacy, critical thinking, and creativity. Learning objectives in the documents focus more on basic cognitive aspects, such as understanding concepts or memorizing facts, while developing skills such as collaboration and problem solving have not been a primary concern. One example of the lesson plan analysis shows that learning activities are more centered on teacher lectures and simple discussions, without any project-based activities or use of technology. This indicates that learning documents do not yet support the development of skills needed in the digital era. In terms of technology utilization, most of the teaching materials and learning tools used by teachers are still in the form of printed media, such as textbooks and student worksheets. There was no evidence of the use of technology-based media such as interactive applications or simulations in teaching materials. One document noted the use of sources from the internet, but only as additional references for teachers, not as part of student learning activities. The document also shows that teachers have not utilized digital applications to deliver material or engage students interactively. This is evidence that technology-based learning media such as SAC have not been integrated into learning planning. The results of the document analysis are summarized in Table 5.

Table 5. Analysis of Learning Document Findings

Analysis Aspect	Indicators	Findings	Interpretation
Integration of 21st century skills	Digital literacy	Not stated in the learning objectives.	Need explicit integration in lesson plans.
	Critical and creative thinking	Learning activities do not include problem solving.	Focus on basic cognitive aspects.
Utilization of technology	Use of digital applications/media	There is no use of applications such as SAC in learning.	Technology-based learning media has not been utilized.
	Additional sources from the internet	The internet is used for teachers, not students.	Technology is not integrated with student activities.

Document analysis found that teachers had not actively incorporated 21st century skills and technology into their lesson plans. Although teachers recognize the value of 21st century abilities, this is not reflected in learning documents such as lesson plans and teaching materials. Furthermore, teachers' learning methodologies have not included technology-based learning media, such as SAC. To address this, teachers must be trained on how to incorporate 21st century skills into lesson plans, and students must have access to technology and digital-based learning apps. This phase will help teachers construct instruction that is more relevant to students' requirements in the digital era.

The research shows poor student interest in science learning, little instructor usage of interactive digital media, and insufficient 21st century skill integration in learning documents. In elementary schools, science is still taught via lecture, with just 20% of students actively answering questions and little daring to ask questions or collaborate. Teachers mostly use printed textbooks and use the internet for teacher references without student activities. In modern learning, teamwork, communication, and

digital literacy are crucial, yet this condition hampers their development (Rawal, 2024). Technology-based learning media like Smart Apps Creator (SAC) can boost student engagement and help them understand abstract topics (Dahri et al., 2023), making it a promising science learning tool.

The limited application of technology-based learning resources in elementary science education suggests that the incorporation of 21st-century learning principles is suboptimal. The 21st-century learning paradigm underscores the necessity of digital literacy, critical thinking, cooperation, and creativity as essential competencies for students to navigate the challenges of the digital age (Aslamiah et al., 2021)(Husna, 2022). Technology-driven educational media, including interactive applications, possess significant potential to enhance engagement in learning, facilitate comprehension of abstract concepts, and promote both independent and collaborative student learning (Chuang & Jamiat, 2023). Nevertheless, data indicate that educators continue to depend on conventional media, such as printed textbooks, which are less effective in fostering the development of these skills. Prior research indicates that technology utilisation in education enhances student engagement and learning efficacy, particularly for topics necessitating dynamic visualisation (Dahri et al., 2023; Fatimah & Nugroho, 2023). Consequently, the incorporation of technology in science education is imperative to provide students with skills pertinent to contemporary demands.

The quality of learning in elementary education has been enhanced by interactive media and clever applications, as demonstrated by recent studies. Numerous studies indicate that Android-based educational applications can markedly enhance student performance across diverse subjects, including martial arts (Hasibuan et al., 2024) and mathematics (Widiyatmoko et al., 2021). Applications of artificial intelligence in e-learning have demonstrated enhancements in students' academic performance in science disciplines (Alneyadi et al., 2023), whereas augmented reality applications have been found to elevate students' motivation and learning efficacy (Afnan et al., 2021). Furthermore, multimedia interactive reading programmes have demonstrated efficacy in fostering early literacy in children (Chuang & Jamiat, 2023). Adaptive game-based applications in mathematics education demonstrate significant potential for enhancing learning outcomes and student engagement, particularly among kindergarten and first-grade children (Greipl et al., 2020). Educators are increasingly demonstrating significant interest in advanced technologies, such as the metaverse, as effective instructional instruments (Tlili et al., 2022). The findings indicate that interactive media employing intelligent applications possess significant potential to enhance the learning experience in primary education.

The study's findings demonstrate that educators possess a significant demand for technology-driven learning tools, such as Smart Apps Creator (SAC), to enhance science education. Media like SAC fulfil this requirement by offering interactive elements, like animation, video, and quizzes, which facilitate teachers in conveying abstract topics and enhance student involvement. Moreover, the adaptability of SAC enables educators to modify the content according to learning requirements, while students can utilise this medium for independent or collaborative study. This aligns with the objectives of 21st-century education, which prioritise digital literacy, critical thinking, creativity, and collaboration (Suhartati, 2021). Consequently, SAC not only facilitates a more engaging and dynamic learning experience but also aids students in acquiring skills pertinent to the requirements of the digital age.

The document analysis shows that basic science lesson plans (RPP) do not properly integrate 21st-century abilities like digital literacy, critical thinking, cooperation, and creativity. These qualities are crucial to educating pupils for the digital age and globalisation, according to literature. Numerous studies emphasise 21st-century skills, especially in elementary science. The 4C abilities are necessary for future difficulties (Boyles, 2012). Digital media like instructional games and augmented reality improve science students' critical thinking (Anastasiadis et al., 2018; Agustini et al., 2020).

Modern instructional paradigms also support the integration of 21st-century skills. For instance, the Inquiry-Based Learning approach, embedded within the Merdeka Curriculum, fosters critical and creative thinking, improving both student engagement and learning outcomes (Sutimah & Tyas, 2024). Similarly, the RADEC (Read-Answer-Discuss-Explain-Create) framework has been shown to effectively cultivate higher-order thinking skills (HOTS) in social studies (Rindiana et al., 2022). These educational strategies demonstrate the potential of integrating 21st-century skills into curriculum design, enabling students to develop the competencies needed to navigate the complexities of the 21st century and the Fourth Industrial Revolution (Husna, 2022). Incorporating these competencies into lesson plans for elementary science education is crucial for fostering well-rounded learners equipped to address future societal and technological challenges.

The challenges of teacher training and infrastructure for effective education, particularly in specialised areas like gifted education and technology integration, have been recently highlighted by recent research. Common difficulties include limited resources, inadequate training, and insufficient cooperation from stakeholders (Kalobo & Setlalentoa, 2024; Akram et al., 2022). To resolve these difficulties, research indicates the necessity of augmenting professional development opportunities, expanding resource funding, and fostering collaboration among stakeholders (García et al., 2021). It is advised to implement practice-oriented teacher education overseen by seasoned educators and to establish benchmarks for digital proficiency (Rawal, 2024). Mobile-based training frameworks demonstrate potential in enhancing teachers' professional growth (Dahri et al., 2023). Furthermore, the incorporation of sustainability and technology in teacher training is consistent with international educational objectives (Puertas-Aguilar et al., 2021). Collaborative research initiatives and the focus on particular learning requirements in domains such as music education are essential for enhancing instructional quality and student performance (Bautista et al., 2024).

This study finds major gaps in primary science education's 21st-century abilities and digital technology integration. Traditional teaching techniques and limited usage of interactive digital media impede students' critical thinking, teamwork, and digital literacy. Innovative solutions like Smart Apps Creator (SAC) can fill these gaps by delivering interactive elements that boost engagement and skill development. Insufficient alignment of lesson plans with 21st-century capabilities emphasises the need to deliberately include these skills within curriculum design. These findings highlight the need for targeted professional development to increase teachers' technological skills and improved infrastructure to support digital media in education. The study supports technology-based learning by emphasising the importance of incorporating 21st-century competencies and digital technologies into curriculum frameworks. The small sample size of five teachers and focus on a specific geographical region may limit the application of this research. To confirm and expand these findings, future research should use larger, more diverse populations and different educational contexts.

CONCLUSIONS AND RECOMMENDATIONS

The study concludes that the incorporation of 21st-century skills and digital technology in elementary scientific education is inadequate, as traditional teaching techniques and resources prevail in the learning process. Educators necessitate novel resources, such as Smart Apps Creator (SAC), and improved infrastructure to cultivate critical thinking, teamwork, and digital literacy in students. This underscores the necessity for professional development initiatives to enhance educators' technology proficiency and curriculum structures that clearly incorporate 21st-century capabilities. Future researchers are urged to broaden their investigation by incorporating a bigger and more diverse cohort

of educators and examining the efficacy of certain interactive media, such as SAC, across varied educational settings to corroborate and augment the findings of this study.

REFERENCES

Afnan, Muhammad, K., Khan, N., Lee, M.-Y., Imran, A., & Sajjad, M. (2021). School of the Future: A Comprehensive Study on the Effectiveness of Augmented Reality as a Tool for Primary School Children's Education. *Applied Sciences*, *11*(11), 5277. https://doi.org/10.3390/app11115277

Agustini, M., Yufiarti, & Wuryani. (2020). Development of learning media based on android games for children with attention deficit hyperactivity disorder. *International Journal of Interactive Mobile Technologies*, *14*(6). https://doi.org/10.3991/IJIM.V14I06.13401

Akram, H., Abdelrady, A. H., Al-Adwan, A. S., & Ramzan, M. (2022). Teachers' Perceptions of Technology Integration in Teaching-Learning Practices: A Systematic Review. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.920317

Alneyadi, S., Wardat, Y., Alshannag, Q., & Abu-Al-Aish, A. (2023). The effect of using smart e-learning app on the academic achievement of eighth-grade students. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(4), em2248. https://doi.org/10.29333/ejmste/13067

Anastasiadis, T., Lampropoulos, G., & Siakas, K. (2018). Digital Game-based Learning and Serious Games in Education. *International Journal of Advances in Scientific Research and Engineering*, *4*(12), 139–144. https://doi.org/10.31695/ijasre.2018.33016

Anggraeni, P., Sunendar, D., Maftuh, B., Sopandi, W., & Puspita, R. D. (2022). Why 6 Cs? The Urgency of Learning at Elementary School. *Proceedings of the 4th International Conference on Educational Develop Ment and Quality Assurance (ICED-QA 2021)*. https://doi.org/10.2991/assehr.k.220303.008

Antara, I. G. W. S., & Dewantara, K. A. K. (2022). E-Scrapbook: The Needs of HOTS Oriented Digital Learning Media in Elementary Schools. *Journal for Lesson and Learning Studies*, *5*(1), 71–76. https://doi.org/10.23887/jlls.v5i1.48533

Aprilia, T., Sunardi, S., & Djono, D. (2017). Penggunaan Media Sains Flipbook dalam Pembelajaran IPA di Sekolah Dasarr. *Teknodika*, *15*(2), 75. https://doi.org/10.20961/teknodika.v15i2.34749

Aslamiah, A., Abbas, E. W., & Mutiani, M. (2021). 21st-Century Skills and Social Studies Education. *The Innovation of Social Studies Journal*, *2*(2), 82. https://doi.org/10.20527/iis.v2i2.3066

Asrizal, A., Yurnetti, Y., & Usman, E. A. (2022). ICT Thematic Science Teaching Material with 5E Learning Cycle Model to Develop Students' 21st-Century Skills. *Jurnal Pendidikan IPA Indonesia*, *11*(1), 61–72. https://doi.org/10.15294/jpii.v11i1.33764

Barus, R. A. (2024). 4C SKILLS OF THE 21ST CENTURY: THEIR NATURE AND IMPORTANCE IN PRIMARY SCHOOL LEARNING. *Multidisciplinary Indonesian Center Journal (MICJO)*, *1*(2), 689–696. https://doi.org/10.62567/micjo.v1i2.88

Bautista, A., Yeung, J., Mclaren, M. L., & Ilari, B. (2024). Music in early childhood teacher education: raising awareness of a worrisome reality and proposing strategies to move forward. *Arts Education Policy Review*, *125*(3), 139–149. https://doi.org/10.1080/10632913.2022.2043969

Bhangu, S., Provost, F., & Caduff, C. (2023). Introduction to qualitative research methods - Part i.

Perspectives in Clinical Research, *14*(1). https://doi.org/10.4103/picr.picr_253_22

Boyles, T. (2012). 21 st century knowledge, skills, and abilities and entrepreneurial competencies: A model for undergraduate entrepreneurship education. *Journal of Entrepreneurship Education*, *15*(1), 41–64. https://www.abacademies.org/articles/jeevol152012.pdf

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Budiarto, M. K., Rejekiningsih, T., & Sudiyanto, S. (2021). Students' opinions on the need for interactive multimedia development for entrepreneurship learning. *International Journal of Evaluation and Research in Education (IJERE)*, *10*(4), 1290–1297. https://doi.org/http://doi.org/10.11591/ijere.v10i4.21411

Chang, C.-Y., Du, Z., Kuo, H.-C., & Chang, C.-C. (2023). Investigating the Impact of Design Thinking-Based STEAM PBL on Students' Creativity and Computational Thinking. *IEEE Transactions on Education*, *66*(6), 673–681. https://doi.org/10.1109/TE.2023.3297221

Chauvette, A., Schick-Makaroff, K., & Molzahn, A. E. (2019). Open Data in Qualitative Research. *International Journal of Qualitative Methods*, *18*. https://doi.org/10.1177/1609406918823863

Chuang, C., & Jamiat, N. (2023). A systematic review on the effectiveness of children's interactive reading applications for promoting their emergent literacy in the multimedia context. *Contemporary Educational Technology*, *15*(2), ep412. https://doi.org/10.30935/cedtech/12941

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (4th (ed.)). Sage Publications.

Daga, A. T. (2022). Penerapan Pendekatan Saintifik dalam Kurikulum 2013 untuk Mengembangka n Keterampilan Abad 21 Siswa Sekolah Dasar. *JIRA: Jurnal Inovasi Dan Riset Akademik*, *3*(1), 11–28. https://doi.org/10.47387/jira.v3i1.137

Dahri, N. A., Al-Rahmi, W. M., Almogren, A. S., Yahaya, N., Vighio, M. S., & Al-Maatuok, Q. (2023). Mobile-Based Training and Certification Framework for Teachers' Professional Development. *Sustainability*, *15*(7), 5839. https://doi.org/10.3390/su15075839

Denzin, N. K. (2012). *The Sage handbook of qualitative research* (4th (ed.)). Sage Publications.

Ella, A. F., Faathira, A., & Andhiena, R. C. (2024). The Importance of Teacher Competence in The 21st Century in Improving The Critical Thinking Skills of Elementary School Students in IPAS Learning. *Social, Humanities, and Educational Studies (SHES): Conference Series*. https://doi.org/10.20961/shes.v7i3.91618

Estrada Oliver, L., Rodriguez, L., & Pagan, A. (2020). Tales from PE: Using Project-Based Learning to Develop 21st-Century Skills in PETE Programs. *Strategies*, *33*(4), 45–48. https://doi.org/10.1080/08924562.2020.1764305

Fatimah, & Nugroho, D. A. (2023). Strengthening Digital Citizenship Values in Pancasila dan Civics Learning in the 21st Century. *ASSEHR 768*, 948–954. https://doi.org/10.2991/978-2-38476-096-1

Frèrejean, J., Geel, M. v., Keuning, T., Dolmans, D., Merriënboer, J. J. G. van, & Visscher, A. J. (2021). Ten Steps to 4c: Training Differentiation Skills in a Professional Development Program for Teachers. *Instructional Science*, *49*(3), 395–418. https://doi.org/10.1007/s11251-021-09540-x

García, J. M. G.-V., García-Carmona, M., Trujillo Torres, J. M., & Moya-Fernández, P. (2021). Teacher

Training for Educational Change: The View of International Experts. *Contemporary Educational Technology*, *14*(1), ep330. https://doi.org/10.30935/cedtech/11367

Greipl, S., Moeller, K., & Ninaus, M. (2020). Potential and limits of game-based learning. *International Journal of Technology Enhanced Learning*, *12*(4), 363. https://doi.org/10.1504/IJTEL.2020.110047

Haryani, E., Coben, W. W., Pleasants, B. A.-S., & Fetters, M. K. (2021). Analysis of Teachers' Resources for Integrating the Skills of Creativity and Innovation, Critical Thinking and Problem Solving, Collaboration, and Communication in Science Classrooms. *Jurnal Pendidikan IPA Indonesia*, *10*(1), 92–102. https://doi.org/10.15294/jpii.v10i1.27084

Hasibuan, B. S., Ilham, Z., Bangun, S. Y., Sunarno, A., Suganda, M. A., & Suryadi, D. (2024). Interactive learning media for martial arts using smart apps creator: A development study for pencak silat training. *Fizjoterapia Polska*, *24*(3), 303–310. https://doi.org/10.56984/8ZG020AH7F

Husna, E. A. (2022). PROJECT-BASED 21S- CENTURY THEMATIC LEARNING MEDIA DEVELOPMENT USING SAC FOR ELEMENTARY SCHOOL STUDENTS. *EduHumaniora | Jurnal Pendidikan Dasar Kampus Cibiru*, *14*(1), 75–82. https://doi.org/10.17509/eh.v14i1.39090

Ida, S., Aziz, R., & Irawan, W. H. (2021). CRITICAL AND CREATIVE THINKING SKILLS TO SOLVING MATH STORY PROBLEMS IN ELEMENTARY SCHOOL STUDENTS. *Jurnal Tatsqif*, *19*(2), 98–113. https://doi.org/10.20414/jtq.v19i2.4069

Ifliadi, I., Suhaidi, Prasetyo, I., Mendrofa, L. I., & Hendrawati, E. S. (2024). UTILIZATION OF DIGITAL-BASED LEARNING MEDIA IN THE INDEPENDENT CURRICULUM IN ELEMENTARY SCHOOLS. *Proceedings of International Conference on Education*, *2*(1), 706–715. https://doi.org/10.32672/pice.v2i1.1348

Jannah, D. R. N., & Atmojo, I. R. W. (2022). Media Digital dalam Memberdayakan Kemampuan Berpikir Kritis Abad 21 pada Pembelajaran IPA di Sekolah Dasar. *Jurnal Basicedu*, *6*(1), 1064–1074. https://doi.org/10.31004/basicedu.v6i1.2124

Kalobo, L., & Setlalentoa, W. (2024). Navigating Challenges in Gifted Education: A Teacher's Perspective on Overcoming Barriers. *Athens Journal of Education*, *11*(4), 269–288. https://doi.org/10.30958/aje.11-4-1

P., D. I., J., J., T., S., & Enjang, Y. A. (2023). Developing Android-Based Learning Media to Enhance Early Reading Competence of Elementary School Students. *Pegem Journal of Education and Instruction*, *13*(4). https://doi.org/10.47750/pegegog.13.04.06

Panggalih, R. H., & Handayani, D. E. (2023). PENGEMBANGAN MEDIA PEMBELAJARAN MATERI SISTEM PERNAPASAN MANUSIA BERBANTUKAN APLIKASI SAC UNTUK SEKOLAH DASAR. *JURNAL TARBIYAH*, *30*(1), 176. https://doi.org/10.30829/tar.v30i1.2693

Patton, M. Q. (2002). *Qualitative Research & Evaluation Methods* (3rd (ed.)). Sage Publications.

Puertas-Aguilar, M.-Á., Álvarez-Otero, J., & de Lázaro-Torres, M.-L. (2021). The Challenge of Teacher Training in the 2030 Agenda Framework Using Geotechnologies. *Education Sciences*, *11*(8), 381. https://doi.org/10.3390/educsci11080381

Rawal, D. M. (2024). Mapping of school teachers' digital competency in the context of digital infrastructure: a systematic review and empirical study of India. *Journal of Professional Capital and Community*, *9*(3), 173–195. https://doi.org/10.1108/JPCC-01-2024-0016

Rejekiningsih, T., Maulana, I., Budiarto, M. K., & Qodr, T. S. (2023). Android-based augmented reality in science learning for junior high schools: Preliminary study. *International Journal of Evaluation and Research in Education*, *12*(2). https://doi.org/10.11591/ijere.v12i2.23886

Rifa Hanifa Mardhiyah, Sekar Nurul Fajriyah Aldriani, Febyana Chitta, & Muhamad Rizal Zulfikar. (2021). Pentingnya Keterampilan Belajar di Abad 21 sebagai Tuntutan dalam Pengembangan Sumber Daya Manusia. *Lectura : Jurnal Pendidikan*, *12*(1), 29–40. https://doi.org/10.31849/lectura.v12i1.5813

Rindiana, T., Arifin, M. H., & Wahyuningsih, Y. (2022). MODEL PEMBELAJARAN RADEC UNTUK MENINGKATKAN HIGHER ORDER THINGKING SKILL DALAM PEMBELAJARAN IPS DI SEKOLAH DASAR. *Autentik : Jurnal Pengembangan Pendidikan Dasar*, *6*(1), 89–100. https://doi.org/10.36379/autentik.v6i1.186

Saad, A., & Zainudin, S. (2022). A review of Project-Based Learning (PBL) and Computational Thinking (CT) in teaching and learning. *Learning and Motivation*, *78*, 101802. https://doi.org/10.1016/j.lmot.2022.101802

Saimon, M., Lavicza, Z., & Dana-Picard, T. (Noah). (2023). Enhancing the 4Cs among college students of a communication skills course in Tanzania through a project-based learning model. *Education and Information Technologies*, *28*(6). https://doi.org/10.1007/s10639-022-11406-9

Sari, D., Hidayasari, N., & Elfa, F. (2024). Need Analysis of Making of Mobile Assisted Language Learning (MALL), an Android Based Application for English for Tourism and Hospitality (Etority), for Vocational Students. *Proceedings of the 11th International Applied Business and Engineering Conference, ABEC 2023*. https://doi.org/10.4108/eai.21-9-2023.2342988

Sarwanto, S., Fajari, L. E. W., & Chumdari, C. (2021). Open-Ended Questions to Assess Critical-Thinking Skills in Indonesian Elementary School. *International Journal of Instruction*, *14*(1), 615–630. https://doi.org/10.29333/iji.2021.14137a

Suhartati, O. (2021). Flipped Classroom Learning Based on Android Smart Apps Creator (SAC) in Elementary Schools. *Journal of Physics: Conference Series*, *1823*(1), 012070. https://doi.org/10.1088/1742-6596/1823/1/012070

Sutimah, S., & Tyas, D. N. (2024). Implementasi Model Pembelajaran Inquiry Based Learning pada Mata Pelajaran IPAS dalam Konteks Kurikulum Merdeka di Sekolah Dasar. *Jurnal Basicedu*, *8*(4), 2941–2952. https://doi.org/10.31004/basicedu.v8i4.8307

Thaariq, A. (2020). The Use of Social Media as Learning Resources to Support the New Normal Zahid Zufar At Thaariq, 1. *Teknodika*, *18*(2), 80–93.

Tlili, A., Huang, R., Shehata, B., Liu, D., Zhao, J., Hosny, A., Metwally, S., Wang, H., Denden, M., Bozkurt, A., Lee, L. H., Beyoglu, D., Altinay, F., Sharma, R. C., Altinay, Z., Li, Z., Liu, J., Ahmad, F., Hu, Y., & Salha, S. (2022). Is Metaverse in education a blessing or a curse : a combined content and bibliometric analysis. *Smart Learning Environments*. https://doi.org/10.1186/s40561-022-00205-x

Widiyatmoko, A., Utaminingsih, S., & Santoso. (2021). Android-based math learning to improve critical thinking. *Journal of Physics: Conference Series*, *1823*(1). https://doi.org/10.1088/1742-6596/1823/1/012091

Widya Karmila Sari Achmad, & Unga Utami. (2023). High-Order Questions Improve Students' Critical

Thinking Skills In Elementary Schools. *International Journal of Elementary Education*, *7*(2), 196–203. https://doi.org/10.23887/ijee.v7i2.61607

Zainil, M., Kenedi, A. K., Rahmatina, Indrawati, T., & Handrianto, C. (2022). The Influence of a STEM-Based Digital Classroom Learning Model and Hig h-Order Thinking Skills on the 21st-Century Skills of Elementary Schoo l Students in Indonesia. *Journal of Education and E-Learning Research*, *10*(1), 29–35. https://doi.org/10.20448/jeelr.v10i1.4336

How to cite: Istiqomah, S., Murwaningsih, T., & Sukarno. (2025). Exploring Teachers' Needs for Technology-Based Learning in Elementary Education. *Teknodika, 23 (1)*, 52-66. DOI: https://dx.doi.org/10.20961/teknodika.v23i1.98043