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Defining Technology-Based Learning Media in Science Subjects for Elementary Schools

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Abstract: Current learning media devices require an update by integrating information technology to support learning needs in the digital era 4.0. The main issue faced is the lack of skills among some teachers in implementing the latest technologies, which results in a gap in the effective utilization of learning media. Based on this problem, this research aims to develop and integrate information technology into learning media in elementary schools. This study employs a qualitative approach with a collaborative method involving experts in automotive engineering and education science. The subjects of this research are elementary school teachers who were interviewed to obtain their perceptions and experiences in using learning media. The research methodology includes in-depth interviews, analysis of curriculum documents, and open-ended questionnaires to comprehensively gather data. The data analysis technique used is the Miles & Huberman model, which includes data condensation, data presentation, and conclusion drawing. The results indicate an urgent need to develop technology-based learning media, especially simulators, to stimulate students' cognitive, affective, and psychomotor abilities in the classroom. This media can support teachers in various learning activities, such as assembling, problem-solving, and innovating. The conclusion of this study emphasizes that integrating technology into learning media can enrich the learning process and help reduce the technology skills gap among teachers. The implications of this research are crucial for future curriculum development and teacher training. This study provides insights into the importance of continuous professional development for teachers to adopt and effectively implement educational technology. Additionally, the findings suggest that learning media development should include essential topics such as changes in the state of matter, energy and its transformations, and electricity and magnetism, which are fundamental components in the elementary science curriculum.

Keywords: elementary school education, science subject, technology-based learning media, qualitative research

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Introduction

In the rapidly evolving landscape of technological innovation, there's a growing imperative for both students and educators to swiftly adapt to new educational paradigms. As underscored by (Shtembari & Elgün, 2023), students are increasingly expected to grasp complex topics, essential for acquiring the knowledge and skills needed to navigate future challenges. On their end, teachers are tasked with the critical role of ensuring that students not only receive this information but can also effectively apply it. This necessitates a fusion of traditional educational methodologies with modern technological tools, creating learning environments that are more engaging and significantly more efficacious (Häkkinen et al., 2017). Expanding on this, the research by (Haleem et al., 2022) highlights that technology serves multiple roles within the educational sector, acting not only as a facilitator but also as a creator, mentor, and assessor of educational content. This multifaceted use of technology transforms traditional educational methods, enabling a more interactive and media-rich learning

experience. Such an approach enhances engagement and fosters a deeper exploration of subject matter, allowing students to gain a more comprehensive understanding of complex. However, the integration of technology into educational media is not a process that can be approached lightly. Educators must thoroughly analysehe educational content and desired outcomes (Lidyasari et al., 2022; Suyitno & Fujiastuti, 2019). This initial analysis is crucial as it informs the selection of the most suitable media formats—video, audio, or other multimedia elements. Only through careful planning and consideration can the true potential of technological advancements in education be fully realized, ensuring that both teaching and learning are optimized for the challenges and opportunities of the digital age.

As the integration of technology-based learning media progresses, understanding the multifaceted role of technology in educational contexts becomes crucial. This development phase transcends traditional teaching methodologies, requiring educators to acquire new skills that are often outside their conventional pedagogical repertoire. According to (El-Sabagh, 2021), the selection of technological tools should be grounded on robust evidence that highlights their benefits, such as enhanced efficiency, effectiveness, resilience, reliability, usability, student engagement, flexibility, and overall success in educational outcomes. However, as highlighted by (Christensen et al., 2013) and (Voogt et al., 2013), the adoption of new technologies in educational settings is frequently impulsive, with insufficient justification of their advantages over existing methods. This rash adoption can undermine the potential benefits of technological advancements. To avoid such pitfalls, any new technological implementation in education must be backed by clear evidence of its added value. This approach ensures that investments in technology directly contribute to enhanced learning outcomes. (Clark & Mayer, 2008) further emphasize that the research undertaken to evaluate the impact of technology in education should be meticulous, aiming to understand not just the functionality but also the educational gains from using new tools. By focusing on developing technological tools that specifically enhance learning outcomes, educators can ensure that the benefits of these tools are both significant and measurable. This strategy justifies the use of new technologies and promotes a more evidence-based approach to educational innovation, ensuring that technology is a robust enhancer of both teaching and learning experiences.

As the technological landscape in education continues to expand, it becomes increasingly important for educators to understand the nuanced pedagogical implications associated with the selection and use of educational technology. This encompasses a range of considerations from hardware and software choices to bandwidth, data security, and privacy concerns, as noted by (Schlosser et al., 2022). The selection process must be guided by the principles of effective learning, ensuring that the technology chosen supports diverse pedagogical methods, aligns with learning objectives, and offers the necessary flexibility to educators (Cavanagh et al., 2020). This process highlights the critical role of educators in the design and selection phases of educational technologies, pushing for pedagogical innovation rather than imposing constraints. However, many educators encounter significant hurdles in this area, often stemming from time constraints and a lack of specialized skills necessary for developing technology-based educational media. These challenges highlight the need for collaborative efforts between academic researchers and practitioners in the vocational fields. Such collaborations focus on creating learning media that seamlessly integrate physical and digital activities, which is especially crucial for elementary school-aged children. The goal is to bridge the theoretical and practical divides, ensuring that educational technologies not only meet but actually enhance the learning experience for students. This collaborative approach aims to foster environments where technology is an enabler of educational innovation, making learning more effective and engaging.

Methods

The development needs of technology-based learning media were analyzed using a qualitative research method. The qualitative research method was employed with the hope that the design of the learning media development produced can be explored from various perspectives and experiences of teachers and students in a holistic and in-depth manner (Bogdan & Biklen, 1997). The research stages conducted were explained in Figure 1.

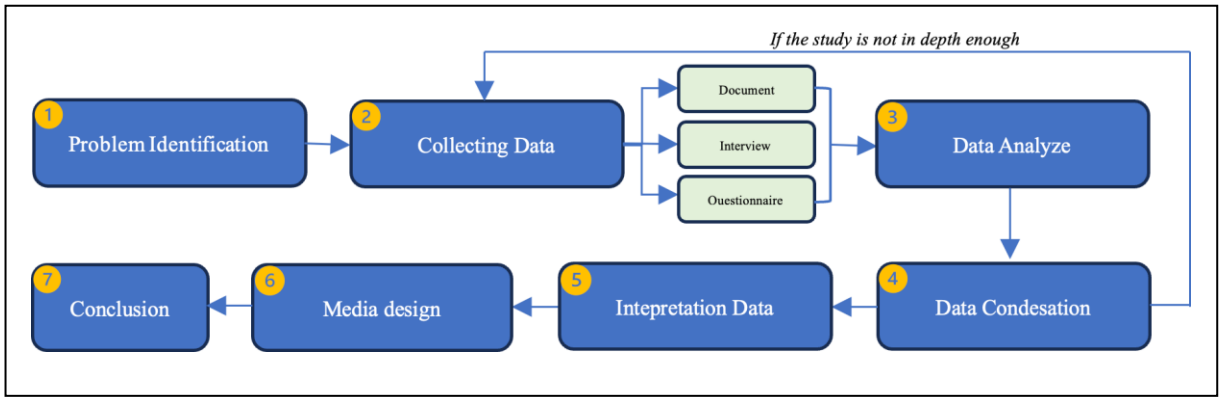

Figure 1. Research Design

In the problem identification stage, the researcher formulated the steps and objectives for identifying what needs to be explored in developing technology-based learning media for elementary school students. Subsequently, the results of this identification were grouped into three main aspects: 1) elementary school learning content, 2) elementary school learning subjects, and 3) learning outcomes. Based on these three aspects, the researcher developed several questions for interview and observation sessions. The results of the interviews and observations were then analyzed using content analysis based on the prevailing curriculum, the Merdeka Curriculum. After the data was collected and analyzed to determine the subjects and content, the researcher delves deeper into the existing media development needs through interview and observation sessions in the second stage, which focuses more on the media that will be developed. The results of the interviews and observations in the second stage were then condensed, depicting the learning media design to be developed. The subjects involved in this research were seven elementary school teachers in the Yogyakarta region, and questionnaires were distributed using the snowball sampling technique

Results and Discussion

Results

Interviews were conducted with seven elementary school teachers in the first stage to narrow the focus on media-related topics designed according to certain learning materials. The interview was conducted on June 17, 2023, via the Zoom application for 1.5 hours. The researcher's summary of the interview results was then confirmed to the respondent. After going through the sentence revision stages, the researcher re-extracted the sentences so that they were easy to understand and arranged based on the sentence structure in written language. Pseudonyms are used to maintain the confidentiality of respondents' data, following ethical standards in qualitative research (Petrova et al., 2014).

1. Teaching Experience in Elementary School (Learning Methods and Materials Involving the Use of Media)

   The results of interviews related to teachers' teaching methods so far show that lecture, assignment, and question-and-answer methods are still the methods that are often applied, even though some have used project-based learning and cooperative learning models. Explained by several teachers when researchers asked about the teaching methods that teachers have been applying to students in explaining learning material as follows:

   > "So far, I have taught learning materials in elementary school with lectures, questions, and answers so that students are provoked to think when I explain—starting from asking about students' life events and continuing by integrating them into learning. However, I don't teach all the material completely through my explanations. For example, I can't use the lecture method when teaching mathematics, so I mostly explain the method first. The students practice with the questions I give both individually and in groups. When studying science, I

usually use groups to do practical work in class, and in social studies, I usually use the cooperative learning method- G3."

While several other teachers agreed, one teacher added the following:

"I combine project-based learning following the demands of the Independent Curriculum. I usually give project-based learning when the students have gained basic knowledge at the beginning, and then I divide them into groups to work on projects at home. Later, the results will be presented in class as part of the project-based assessment. However, this method can be applied when I get the mandate to teach in high classes (4, 5, and 6 grades). Teaching in lower classes is a bit difficult because many students still need intensive guidance compared to teaching students in higher classes who are far away. They are more independent. About 40% of the time, I use the lecture method to explain; the rest is a combination of projects, assignments, project-based learning, and other varied methods-G5."

The researcher underlined the statement regarding the methods used by teachers in schools so far, which are still relatively varied. Lecture methods, guided exercises, and assignments are widely applied to lower-graders between grades 1 - 3 of elementary school. Meanwhile, project-based and cooperative learning methods are widely used by students in high classes between grades 4-6 of elementary school. These results show that the elementary school teachers who were respondents in this research have used methods that vary depending on the phases of student development. However, based on the demands of the current curriculum, problem-based learning is expected to be applied from an early age so that students can think critically in dealing with problems global challenges in the future. Meanwhile, the results of interviews regarding the use of learning media by teachers to support learning in the classroom obtained the following data:

"Following the method, the media I use usually adapts to the learning content. If the material is abstract, such as mathematics, at our school, mathematics learning kits are available, such as geometric shapes, flat shapes, scales, number cards, etc. In science lessons, I usually use the teaching aids available at school. I often combine these teaching aids with learning videos to make them more interesting for students. But again, the use of learning media in class is adjusted to the student's grade level. There is more singing and playing in lower grades, so I use songs related to the learning material. Learning will be more serious in higher classes, and I use the existing teaching aids more. - G1 & G2."

Another teacher added that:

"At my school, it is usually used for research by lecturers and students, and they develop learning media on certain materials. However, sometimes, the media is not provided to the school because the media is used for students' thesis exams. Only a few media outlets are available in schools based on the results of the research by lecturers. Otherwise, I sometimes make PPTs, download learning videos from YouTube channels, and use worksheets that I can make myself. However, according to other teachers' statements, there are also teaching aids that I sometimes use for certain learning materials. For example, when explaining electricity, the school has a science kit, including a clamp cable, a small bulb, a battery, and a battery holder. But mostly everything is damaged, Sir, because of uncontrolled student activity when using the media (laughing) - G4"

Information was obtained that the media used by teachers varied greatly depending on the content of the material being taught. However, some stated that there are teaching aids that differ in meaning and use from learning media. However, from the statements during the interview process, it is clear that not only visual and audio media but sometimes teachers also use audio-visual media to make learning more enjoyable. Science kits are also used but are susceptible to damage, so teachers prefer other media. Researchers explored more deeply the functionality of the media currently available in schools and the achievement of learning materials under the demands

of the times through the use of technology and the applicable curriculum. The results are explained in the interview narrative, in which the researcher has perfected the sentences as follows:

> "I usually use Canva and Ms.PowerPoint to create packaged learning materials to make them more interesting. I also usually use Google Classroom and the independent LMS prepared by the school. For example, in learning outcomes in the water cycle or rain cycle material, students are asked to understand the water cycle and the rain process, differentiating terms in science: evaporation, transpiration, condensation, and infiltration. Usually, I include a video that explains the flow and process of rain from the source. YouTube into a standalone LMS-G7."

Another statement was conveyed by the teacher as follows:

> "My experience is using learning media in the form of videos to help explain lesson material in meeting learning outcomes in the Merdeka Curriculum. As in the material about the senses in humans in class 4 and other learning materials, the expected learning achievement is that students can identify the functions of the five senses in humans. I made the learning video media, but sometimes I download it on the YouTube application. I also use multimodal texts (stories from quality books) displayed in front of the class using an LCD screen or projector as learning media for science and science subjects and Pancasila education. I also want to use the Quizziz application like the trainings I have attended, but no facilities are available for all students to access the application-G3."

Based on the interview results, it can be concluded that teachers have been creating their learning media with the help of graphic design tools such as Canva and Ms.PowerPoint so that material delivery is more interesting for elementary school students. The constraint factor in supporting tools in using technological devices and digital-based applications is their reason for creating simple learning media, such as multimodal texts that are set so students are more interested in reading them. They also rely on the YouTube application, which provides interesting videos with educational themes as a learning medium. However, the learning outcomes conveyed by all respondents were still at a differentiated level. This interview is inversely proportional to the results of observations made by researchers on 40 teacher respondents regarding learning achievements during teaching. However, certain materials can be developed again to the level of creation.

Moreover, 6 out of 7 respondents use learning media more when teaching science subjects. Based on this, the researcher tried to dig deeper into media use in science subjects through a second interview session. The choice of media in science subjects is because teachers often use learning media compared to other topics. However, their use is still not maximized to the level of learning achievement created. As additional information, the use of methods, learning material achievements, and learning media as a result of observations are explained in Figure 2.

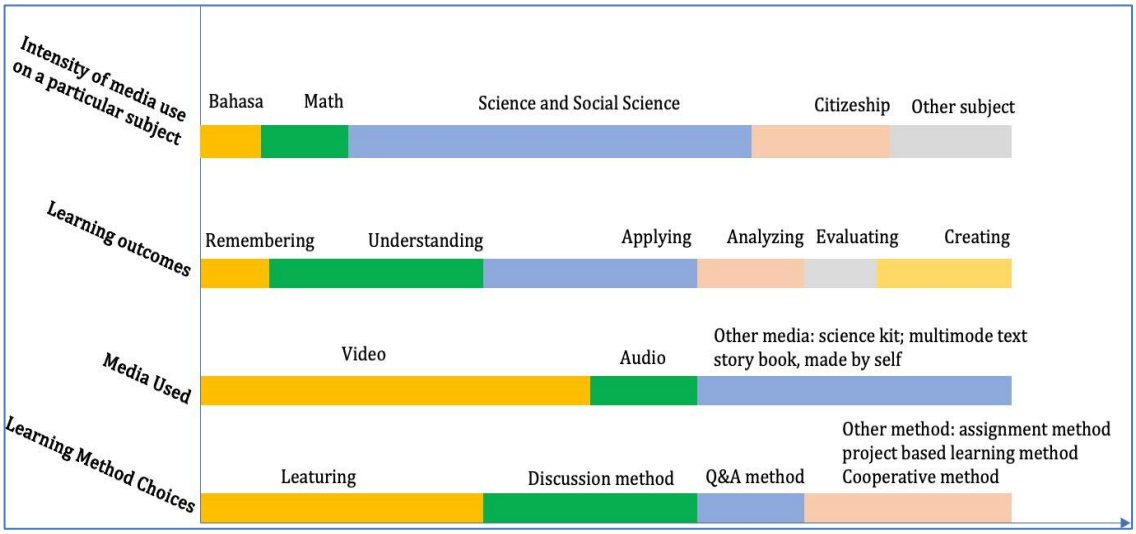

Figure 2. Demograph learning patterns in elementary school involving methods and learning media on specific subjects. The color difference indicates the size of the respondent's choice

2. Need for Learning Media Development in Science Subjects

The second interview was conducted on June 23, 2023, via the Zoom application and involved seven teacher respondents in the first stage interview for 2 hours. This second interview was conducted to dig deeper into the need for developing learning media in science subjects due to condensing interview and observation data. The main interview questions related to 1) practical activities on science learning material in high grades 4, 5, and 6; 2) experience of using learning media in materials taught by respondents; and 3) the need for developing existing learning media. The researcher summarized the three main questions in the interview results as follows:

> "I currently teach 4th grade and have taught 2nd, 3rd, and 5th grade in previous years. As far as I know, science material in class 4 consists of topics such as 1) special characteristics of animals and plants; 2) ways of reproduction of animals and plants; 3) changes in the form of objects (additional other teachers); 4) life cycle; 5) energy and its changes (additional other teachers); and 6) the earth and the universe. The use of media in science material in grade 4 is varied. When explaining material related to animals and plants, their special characteristics, how they reproduce, and the life cycle of animals, I use media in the form of PPTs and videos taken from YouTube. Explaining the material using PPT and learning videos is quite interesting for students and easy to understand. Meanwhile, I apply practical activities rather than explanations when explaining object shape and properties changes. Students are asked to bring tools such as water, ice cubes, candles, camphor, cloth, a spoon, clear glass, and a cutter. Students in groups are asked to follow each step using student worksheets. Regarding energy and its changes, I give students a project at home to observe objects that use electrical energy sources and batteries and then list the energy changes that occur. Meanwhile, I reuse learning videos and teaching kits from the school lab regarding the earth and the universe. In my opinion, the media that needs to be developed is a matter of changes in the form of substances and energy and its changes. Why? Because in my experience, students being asked to bring ice cubes is quite difficult, especially if you have to bring sharp objects to school, most likely in the future, I will use learning videos to explain this material-G1."

> Another teacher described his experience as follows:

> "I now teach in grade 3, but previously taught in grade 5. As far as I remember, the material in grade 5 was almost the same as what was taught in grade 4. The difference may be in the development of the material. If class 4 basic knowledge is taught, class 5 is more about applying science in everyday life. So the material taught in class 5 is about 1) energy and its

changes; 2) properties of light; 3) living creatures and their life processes; 4) earth and universe (additional other teachers); 5) objects and their properties, more about objects that fall into the types of conductors and insulators (additions from other teachers). Like others, when teaching material about energy and its changes, I usually ask students to observe the surrounding environment and think about how the lights can turn on, the fan can move, etc. After that, I will explain why this happened by explaining the material packaged in PPT form. Practical activities were carried out when I taught material about the properties of light and the properties of conductors and insulators. In my opinion, the media that needs to be developed is the material properties of light and the properties of conductors and insulators. Because if you ask students to bring materials such as flashlights, spoons, magnets, and so on, sometimes some students cannot bring all the equipment. So that the expected science practicum is less than optimal - G4."

The senior teacher who teaches in class 6 said that:

"I teach in 6th-grade elementary school and have held 6th grade since I first taught in 2004. Rotating to another school also still teaches 6th-grade elementary school, so I still really know the science learning material in 6th-grade elementary school (while laughing). The material in grade 6 elementary school in the previous curriculum (Kurikulum 2013) and the Merdeka Curriculum (current curriculum) is not much different. The difference is that currently, science is combined with social science subjects. But if you focus on science subjects only, then the material consists of 1) repetition of material in grades 4 and 5 (characteristics of living things and the environment in which they live, the reproduction of living things, the relationship between temperature, conductive properties and uses of objects, energy, and its changes, the solar system, the earth's rotation, the earth's revolution, and the moon's revolution, and the occurrence of lunar and solar eclipses). The use of learning media is more or less the same as other teachers, mostly using PPT and learning videos. Except for force and motion material, we have a science kit for measuring loads using a simple machine model (usually used for practical assessments other than assembling series and parallel electrical circuits). We also use the available science kit to explain the differences between electric and parallel circuits in the electrical energy material. Students in my class are very enthusiastic when conducting experiments with simple machines and assembling electric and parallel circuits. Maybe because it's something new for them, but I think development can be done on electrical energy materials. Usually, I make projects so students can make applications of electrical energy, such as making toys, electric bells, alarms, traffic light models, and house lighting models. But everyone collects works related to home lighting models (everyone laughs). Maybe because I have taught electrical energy by assembling series and parallel circuits, students can only make electrical circuits as their final project-G5".

Based on the interview results, several science learning materials need further media development. These materials include 1) changes in the state of matter, 2) energy and its changes, 3) the properties of conductors and insulators, and 4) electricity and magnet. From these results, the researchers then surveyed 40 teachers to determine priorities for developing technology-based learning media that support the knowledge and skills needed in the current era as secondary data in this research.

Discussion

The research highlights the pivotal role that suitable learning models and methods play in enhancing elementary education, particularly in fostering critical skills, creativity, motivation, social skills, and retention among students aged 7-12 years. (Halah & Patrick, 2015) and (Heard et al., 2020; Piaget, 2003) underscore the necessity for teachers to meticulously choose and adapt these strategies, considering the developmental stages of children as delineated by Piaget (2003). A diverse array of teaching methods such as lectures, question-and-answer sessions, discussions, practice exercises, contextual learning, and collaborative activities are recommended for use in elementary classrooms. Additionally, innovative learning models like project-based, problem-based, and discovery and inquiry learning have been recognized for their effectiveness in boosting active participation among students.

These models encourage a more hands-on and engaging learning experience, which is critical for comprehending and retaining knowledge. (Afikah et al., 2022) further assert the importance of integrating effective learning media into these methods and models. The adoption of such media plays a crucial role in translating theoretical knowledge into practical skills and social competencies. This integration is vital for creating learning experiences that are more attractive and understandable and interactive and relevant to students' lives. (Scott, 2023) elaborates on the outcomes of such educational enhancements, suggesting that well-integrated learning media and methods can lead to improved learning outcomes and better prepare students for the complexities of the modern world. By employing a variety of teaching methods and learning models, and complementing these with appropriate educational media, teachers can significantly enrich the learning environment, making it more conducive to student success and adaptation to future challenges.

The role of instructional media in the classroom is multifaceted and critical for enhancing learning experiences. (Lawless & Pellegrino, 2007) highlight the importance of several key aspects that educators need to consider when selecting and using instructional media: relevance of content, alignment with learning objectives, accessibility, quality of visual and audio components, and levels of engagement. These elements ensure that the media fits the educational context and actively involves students in the learning process. Educators are not just users but integral to developing and refining instructional media. Their continuous engagement with these tools allows them to tailor learning experiences to meet their students' specific needs and the classroom dynamics. This ongoing development is crucial for keeping the content relevant and aligned with the evolving educational standards and learning objectives. In environments rich in technology, educators who are more familiar with technological advancements often face unique challenges and opportunities compared to their less tech-savvy counterparts. These educators can leverage their knowledge and experience to foster educational transformation, as mentioned by (Suprianto et al., 2019). They catalyse new ideas and tools that elevate learning standards and enhance the educational landscape. Furthermore, the use of high-quality instructional media can significantly impact learning outcomes by simplifying the learning process, increasing student engagement, improving efficiency, boosting concentration, motivating learners, and facilitating a deeper understanding of the content. (Rachmadtullah et al., 2023) emphasize that these factors collectively promote active student involvement in educational activities, leading to better absorption of educational content. This approach is particularly beneficial in primary education, where aligning with the developmental stages of children is crucial for fostering genuine comprehension and ensuring that the learning experience is both effective and enjoyable.

The study sheds light on the innovative approaches primary school teachers are employing to develop instructional media, highlighting both their creativity and the various challenges they face. These challenges often stem from equipment limitations and geographical constraints that can impede the ability of some educators to fully engage in the development of sophisticated media. Despite these obstacles, the integration of modern technology remains prevalent among many educators, enhancing the learning experience and interaction with educational content. However, the necessity to adapt to available resources has led some educators to utilize simpler tools and technologies readily available in their environment. This approach aligns with the previously discussed definitions and roles of instructional media, emphasizing that effective educational tools should not only incorporate cutting-edge technology but also be accessible and practical by utilizing resources that are readily available (Corrall & Jolly, 2019; van Dulmen et al., 2023). This dual approach encourages a balance between modern and accessible technologies, allowing teachers to innovate within their means while striving to incorporate more advanced technological solutions where possible (Barakabitze et al., 2019; Ross, 2020). This strategy ensures that educational content is delivered effectively, engaging students in a contextually relevant and technologically forward-thinking manner. It highlights the importance of flexibility and adaptability in the development of instructional media, ensuring that all educators, regardless of their geographical or resource limitations, can create effective and engaging learning environments.

The research findings emphasize the transformative impact of instructional media in enhancing primary education by precisely addressing students' diverse needs, characteristics, and circumstances. According to (Arifianto & Izzudin, 2021) and (Afikah et al., 2022; Zaini et al., 2021), instructional media is notably versatile, drawing from a combination of advanced technology, simple tools, and available local resources, thereby making education more accessible and tailored to individual learning

environments. This approach underscores the necessity for primary school teachers to be adaptive and innovative, not confined by equipment availability, geographical constraints, or communication limitations. Such flexibility allows them to create a wide array of instructional media types, each suited to different pedagogical needs and contexts, thus significantly enhancing the educational experience. Moreover, the effectiveness of these media is closely linked to how well they achieve learning objectives. Afikah et al. (2022) and (Scott, 2023) suggest that the effectiveness of instructional media involves not only meeting these objectives but doing so with precision and thoroughness. It is indicated that technology-based instructional media, especially simulators and other digital tools that reflect contemporary technological use, are highly effective. These tools are particularly valued for their convenience and ease of integration into existing educational frameworks, as both students and teachers are likely already equipped with the necessary gadgets, facilitating smoother implementation. The majority of teachers appreciate the development of such technology-based instructional media and are adept at integrating these tools into their teaching practices. However, it's also noted that even in the absence of advanced technology, some teachers remain resourceful, managing to create effective instructional media with more basic tools. This adaptability ensures that all students, regardless of their technological accessibility, can benefit from enriched learning experiences designed to be effective, efficient, and engaging.

Conclusion

This study explores the educational techniques and media utilized by elementary school teachers, specifically focusing on science subjects. It reveals a dynamic range of teaching methods tailored to student development stages: younger students (grades 1-3) experience more structured methods like lectures and guided exercises, while older students (grades 4-6) engage in project-based and cooperative learning. Teachers creatively adapt available resources to enhance learning, using tools like PowerPoint, Canva, and various educational videos. Despite this ingenuity, they face challenges such as insufficient or damaged physical teaching aids, highlighting a need for more durable and effective educational resources. Furthermore, technological integration is necessary as digital platforms like Google Classroom become integral in disseminating curriculum content, suggesting a shift towards more digital solutions in education. This transition could potentially address gaps in physical media availability and quality. The study underscores the critical role of adaptable educational media and technology in modern teaching, pointing towards a future where investment in robust educational tools and teacher training in their use could significantly enrich the learning environment and outcomes for students.

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