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Computational Thinking and Problem Solving in Science Class: A Need Analysis for Innovative Instructional Materials

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Abstract. The 21st-century learning paradigm demands mastery of complex skills such as Computational Thinking (CT) and Problem Solving (PS) to prepare students for the digitalization era. However, global and local data indicate a significant competency gap where students' logical and systematic reasoning remains underdeveloped. This study aims to describe the preliminary findings related to the needs analysis of adaptive instructional materials for ecosystem topics in Grade V elementary school as an effort to stimulate CT and PS skills. This research adopts a descriptive qualitative approach, specifically the analysis phase within the ADDIE development model. Data were collected through questionnaires, interview protocols, and diagnostic tests involving fifth-grade students and teachers at SDN Percobaan 1, Malang City. The findings revealed that students' PS and CT skills reached low averages of only 46% and 44%, respectively. Needs assessment data showed that 81% of students require instructional materials for ecosystem topics, with 76% preferring concise, "handy" media, and 72% showing high acceptability for the booklet format. Additionally, 85% of students are proficient in operating mobile phones, providing a strong foundation for technology-integrated media. In conclusion, there is a critical need for developing innovative, systematic, and practical learning tools, such as technology-integrated instructional materials to fill the learning gap and facilitate mastery of scientific concepts.

Keywords: Instructional materials; Computational Thinking; Problem Solving; Elementary School; 21st-century skill.

1. Introduction

The 21st-century learning paradigm has undergone a systematic shift from mere character and knowledge formation toward the mastery of 21st-century skills (González-Pérez & Ramírez-Montoya, 2022). The objective of cultivating these skills is to equip students as successful human resources prepared for the digitalization era. This era, dominated by the rapid advancement of Artificial Intelligence (AI) and information technology, demands that students be highly adaptive. Students are no longer positioned as passive recipients of information but as creators and executors capable of deconstructing complex problems through the framework of Computational Thinking (CT) (Hurt et al., 2023; Wang et al., 2022). Science education in the 21st century is no longer solely oriented toward cognitive accumulation through the transfer of knowledge; instead, it has transformed into a vehicle for developing scientific skills and critical thinking (Hebebci & Usta, 2022).

Through science, students are expected to possess the proficiency to solve real-life problems. The urgency of mastering Problem-Solving (PS) skills within the scientific domain is linked to the development of human resources capable of contributing meaningfully to society and the environment (Rowe, 2024). The importance of mastering science and technology has become a primary pillar of Indonesia's national development. The government's strategic vision, as outlined in Asta Cita No. 4, explicitly emphasizes the strengthening of human resources, science, technology, and quality education. This commitment was further solidified by the Academic Paper released in February 2025 by the Ministry of Basic and Secondary Education, which mandates the transformation of the primary education system through the deep internalization of digital literacy, coding, and the introduction of AI. This policy aims to produce a competitive generation in the Society 5.0 era while maintaining technological ethics.

1.1. Problem Statement

The researcher is confronted with a critical competency gap in scientific literacy among Indonesian students, which is manifesting as a failure to meet both global and local academic benchmarks. National PISA data, showing only 34% of students reaching basic science proficiency compared to the 76% OECD average, is reflected locally at SDN Percobaan 01 Malang, where Problem-Solving (PS) and Computational Thinking (CT) scores sit at a meager 46% and 44%, respectively. According to Riyadi (2021), students' problem-solving skills still need to be developed because they are currently at a fairly low level. The primary cause of this crisis is a lack of structured, adaptive learning instruments current teaching materials are overly narrative-based and fail to bridge abstract concepts with practical application (Simon & Zeng 2024). Consequently, students are unable to reason through phenomena or apply logic systematically, leaving their cognitive development stagnant under conventional, non-stimulating learning processes.

To investigate and mitigate these issues, the researcher should develop and test "handy" instructional booklets specifically focused on ecosystem topics, as 81% of students have identified a need for this subject matter. Since 72% of students are already comfortable with the booklet format, this investigation should focus on whether these concise, accessible materials can effectively integrate CT and PS stimulation into the elementary curriculum. Researching this is vital because scientific literacy and algorithmic reasoning are foundational skills in the modern world without an intervention that aligns instructional design with student preferences and teacher needs, the gap between governmental aspirations and student reality will continue to widen, leaving students ill-equipped for real-world challenges.

Instructional materials play a vital role in helping students construct knowledge (Chisunum & Nwadiokwu 2024). Given that elementary school students are in the concrete operational stage of development, science learning must involve interactive media that serves as a learning facilitator (Hayat et al., 2024). Previous research underscores the importance of needs analysis concerning science learning media in elementary schools. Studies suggest that adaptive learning media are essential for elementary students to master scientific concepts more effectively. It has been argued that these students still require interactive materials to assist in knowledge acquisition. Based on prior research, it can be generalized that instructional materials are instrumental in science education, aimed at facilitating the management of knowledge for students.

Responding to this urgency, this study aims to describe the preliminary findings related to the needs analysis of adaptive learning media for ecosystem topics in Grade V elementary school as an effort to develop CT and PS skills. The scope of the analysis includes the current state of science learning in elementary schools, a review of existing teaching materials and media, an analysis of student characteristics, and a needs assessment for science instructional materials. The results of this study are expected to serve as a foundation for further research capable of providing alternative solutions to these pedagogical challenges.

1.2. Related Research

A comprehensive analysis of science education literature reveals a significant disconnect between the widespread digitalization of teaching materials and the effective internalization of Problem-Solving (PS) and Computational Thinking (CT) in elementary schools (Arslantaş 2025; Saad & Zainudin 2024). To date, research in elementary science has remained polarized, focusing either on conventional printed materials or purely digital applications. While some studies have identified the potential synergy between these formats, a notable research gap remains: the lack of a cohesive integration between physical practicality and digital accessibility. This study addresses this gap by developing a hybrid instructional tool that merges the convenience of a printed booklet with digital technology via QR codes. Furthermore, existing developments in teaching materials often prioritize technical formats while neglecting the integration of robust pedagogical approaches.

This oversight is critical, as a structured pedagogical framework is essential for elementary students who are still in the concrete operational stage of cognitive development. This research fills that void by implementing the Socio-Scientific Issues (SSI) approach to foster a learning environment that is both meaningful and engaging. A final discrepancy is found in research outcomes previous studies have largely focused on validating materials to improve general cognitive scores and conceptual understanding (Shi 2023; Agya & Meisuri 2023). There is a distinct lack of resources specifically engineered to stimulate systematic problem-solving and algorithmic thinking. Unlike prior research, this innovation shifts the focus from mere cognitive mastery toward the measurable acquisition of Computational Thinking and Problem-Solving skills. Based on this needs analysis, the study provides a strong foundation for developing interactive and adaptive science materials designed to enhance computational and problem-solving competencies in elementary education.

1.3. Research Objectives

Based on the aforementioned review, the researcher identifies a critical need to enhance the effectiveness of science education through the development of adaptive instructional materials, specifically focusing on ecosystem topics. This study aims to delineate the results of a needs analysis for developing adaptive teaching resources tailored for fifth-grade elementary school students. The proposed materials will integrate the Socio-Scientific Issues (SSI) approach and QR Code technology to align with 21st-century learning demands. Ultimately, the findings of this research are expected to contribute significantly to the body of knowledge within the field of elementary education.

2. Theoretical Framework

2.1. Instructional Materials

Instructional materials are systematically structured learning instruments designed to facilitate interaction between teachers and students in achieving measurable educational goals (Asrori et al., 2025). Far more than a mere collection of information, these materials serve as mediators that organize scientific facts, concepts, and procedures into a language appropriate for the students' cognitive development. Through a clear structure, instructional materials create a focused learning environment, minimize misconceptions, and empower students to independently construct knowledge in alignment with constructivist principles.

The primary functions of instructional materials include delivering content concisely, providing learning guidelines for students, and supporting the development of competencies synchronized with the curriculum (Choppin et al., 2022). In practice, these materials must adhere to the principles of relevance and consistency to serve as a guide for the students' reasoning processes. Their presence ensures the standardization of educational quality and assists educators in managing classroom teaching and learning activities more effectively and efficiently.

Amidst the digital transformation, the format of instructional materials has evolved beyond conventional print media, such as modules or student worksheets. The integration of technology has enabled the emergence of digital, audio-visual, and interactive teaching aids that are more contextual and engaging for the digital native generation (Samala et al., 2024). This diversity of formats ranging from e-books to virtual simulations provides educators with the flexibility to transform abstract concepts into visual representations, thereby enhancing student motivation and comprehension throughout the learning process.

2.2. Problem Solving Skills

Problem solving is a higher-order thinking process involving identification, critical analysis, and the discovery of creative solutions to complex obstacles (Yapatang & Polyiem 2022). Psychologically, this skill demands the mobilization of executive functions to discern the nature of a problem while integrating prior knowledge with new information within the working memory. As a core 21st-century competency, it serves as a foundation for critical thinking, training students to navigate unstructured situations independently through logical reasoning and creativity.

Operationally, problem-solving is not merely a routine activity but a systematic art of reasoning that encompasses metacognitive abilities to monitor the effectiveness of employed strategies (Pradana, 2024). Success in this cognitive process is characterized by an individual's proficiency in gathering valid information and their flexibility in selecting a resolution approach. Notably, "problem framing" during the initial phase is considered the most crucial aspect, as errors in defining the problem often lead to a failure in determining an effective final solution.

A primary reference in developing these skills is Polya (2014) with a four-stage systematic model: understanding the problem, devising a plan, carrying out the plan, and looking back. Through these stages, students are guided to identify problem constraints, establish relationships between data points, implement solution steps meticulously, and evaluate the arguments used. By mastering these indicators, students are expected to achieve the intellectual maturity required to manage uncertainty through a structured, evaluative, and data-driven approach.

2.3. Computational Thinking Skills

Computational Thinking (CT) is a problem-solving methodology that involves organizing data and formulating logical solutions capable of being effectively represented by an information-processing agent. Popularized by Jeannette Wing (2006), the concept does not intend for humans to think like computers; rather, it emphasizes the use of human intellectual capacity to dissect complex problems through abstraction and algorithmic modeling. This skill is now regarded as a fundamental literacy, comparable to reading, writing, and arithmetic, due to its ability to transform abstract problems into ordered, systematic sequences of instructions. The defining characteristic of computational thinking is its conceptual and fundamental nature, transcending mere technical or programming skills. It enables individuals to manage complexity through decomposition and critical evaluation, ensuring that formidable, large-scale problems are resolved through measurable and efficient steps. In the era of digital transformation, the urgency of developing CT skills is paramount, empowering students to evolve from passive technology consumers into adaptive creators capable of generalizing solutions and making decisions grounded in robust data and logic (Richardo et al., 2025).

Operationally, computational thinking skills are measured through five primary indicators: decomposition, pattern recognition, abstraction, algorithm design, and evaluation. The process begins by breaking down complex problems into smaller, manageable fragments (decomposition) and identifying trends or similarities (pattern recognition). Subsequently, students filter out irrelevant details (abstraction) to construct sequential instructions (algorithm design), culminating in testing and error correction (debugging) to ensure the resulting solutions are truly effective and efficient.

3. Method

3.1. Research Design

This study adopts a descriptive qualitative approach, specifically focused on the Analysis phase within the ADDIE model. The primary objective of utilizing this approach is to provide a profound and comprehensive depiction of real-world field conditions without manipulating any variables. Through the descriptive qualitative method, the researcher is able to explore the complexity of obstacles faced by both teachers and students, as well as identify unmet learning needs in science education. This enables the researcher to capture educational phenomena holistically, serving as a fundamental basis for designing targeted solutions.

The scope of this study is strictly limited to the Needs Analysis phase to map the technical and pedagogical requirements for instructional media development. Focusing on this phase is critical to ensure that the developed teaching materials maintain high relevance to the characteristics of elementary school students and the demands of the curriculum. By mapping student proficiency profiles in Problem-Solving and Computational Thinking from the outset, the researcher can formulate specifications for learning instruments that are not only adaptive but also capable of bridging the previously identified competency gaps.

3.2. Participants

To provide a comprehensive overview of the field conditions at SDN Percobaan 1 Malang City, the research participants were selected using a purposive sampling technique. The subjects consisted of two primary groups: fifth-grade students, who serve as the primary users of the proposed instructional materials, and elementary school teachers, who provide pedagogical insight into the feasibility of the "handy" booklet integration.

The following tables detail the demographic characteristics of the participants involved in the Analysis phase. Table 1 presents the profile of student participants, including gender, age, educational level, prior experience with digital media or QR Codes, and the total number of respondents. Meanwhile, Table 2 presents the profile of the teacher participant, including gender, educational background, occupation, and teaching experience.

Table 1. Profile the Character of Students Participans

Characteristic	Category	Frequency (f)	Percentage (%)
Gender	Male	20	48%
	Female	22	52%
Age	10–11 Years Old	42	100%
Educational Level	Grade V Elementary School	42	100%
Prior Experience	Familiar with Digital Media/QR Codes	36	85%
Total		42	100%

Table 2. Profile the Character of Teacher Participans

Characteristic	Category	Frequency (f)	Percentage (%)
Gender	Female	1	100%
Educational Background	Bachelor of Education (S1 PGSD)	1	100%
Occupation	Certified Classroom Teacher	1	100%
Teaching Experience	5 -10 Years	1	100%

3.3. Data Collection

Data collection in this research was conducted through triangulation using three primary instruments to ensure the validity and depth of findings during the analysis phase. First, questionnaires were administered to students to identify their instructional material needs and specific preferences for adaptive learning resources. Second, in-depth interviews were conducted with educators to explore actual pedagogical constraints in the classroom and to map the extent to which Computational Thinking (CT) and Problem Solving (PS) stimulations have been integrated into current instructional processes.

In addition to perceptual data, this study employed diagnostic tests as a third instrument to establish an objective baseline of student competencies. These tests were specifically designed to measure students' cognitive abilities in dissecting problems logically and systematically, in accordance with CT and PS indicators. The assessment was performed to determine the current level of students' CT and PS proficiency within Science (IPA) instruction. The pre-test items provided were strictly aligned with the established indicators of CT and PS. By synthesizing the results from the questionnaires, interviews, and quantitative tests, the researcher obtained a comprehensive overview of the gap between 21st-century science learning requirements and the reality of students' field-level competencies

3.4. Data Analysis

Data analysis in this study was conducted through a rigorous triangulation approach, integrating qualitative and quantitative techniques to ensure a robust empirical foundation. Qualitative data derived from teacher interviews underwent a systematic process of data reduction, display, and conclusion drawing to extract core pedagogical constraints and institutional requirements. Simultaneously, quantitative results from diagnostic tests and questionnaires were processed to calculate mean scores and frequency distributions. This multi-methodological synthesis allows for a comprehensive cross-verification of findings, ensuring that the media specifications derived for the subsequent design phase are grounded in the actualities of the classroom environment.

Quantitative data obtained from the needs assessment questionnaires and diagnostic test instruments were analyzed using descriptive statistical techniques. This analytical layer was specifically designed to map student characteristics and establish a baseline for their Computational Thinking (CT) and Problem Solving (PS) proficiencies. By identifying these specific cognitive profiles, the researcher could pinpoint the exact dimensions where students struggle—be it in algorithmic design or problem framing thereby informing the adaptive features of the proposed instructional materials.

To ensure precision in the evaluation of these quantitative components, the data from each instrument were converted into percentage scores. This conversion facilitates a standardized interpretation of the necessity level for new media development and the severity of the competency gap. The calculation follows the percentage formula proposed by Akbar et al (2025):

$$P = \frac{f}{N} \times 100\%$$

Decription:

P: Percentage (relative frequency)

f: Frequency of responses or scores obtained by students

N: Number of Cases (total respondents or maximum possible score)

The resulting percentages are then categorized into specific criteria to determine the urgency of developing adaptive instructional materials. The results were analyzed qualitatively by converting the calculated values into descriptive explanations. The decision-making reference is based on the interpretation criteria established by Akbar (2013), as presented in Table 3.

Table 3. Needs Interpretation Categories

Achievement	Interpretation Category
81% – 100%	Very High Need
61% – 80%	High Need
41% – 60%	Moderate Need
21% – 40%	Low Need
0% – 20%	No Need

3.5. Validity and Reliability

To ensure the quality of the research findings, the validity of the data collection instruments including questionnaires, interview protocols, and diagnostic tests was rigorously assessed through expert judgment. This process ensures that each item within the instruments accurately represents the indicators of Computational Thinking (CT) and Problem-Solving (PS) while remaining aligned with the developmental characteristics of elementary school students. Content validity is paramount during the needs analysis phase to ensure that the data obtained reflects objective field requirements rather than superficial perceptions, thereby enabling a precise mapping of students' competency gaps.

The reliability of the instruments was further strengthened through a triangulation approach involving both methods and data sources, which serves to maintain the consistency of research results despite being derived from various origins. By synthesizing qualitative data from the reduction of teacher interviews with quantitative data from student diagnostic tests, the researcher can verify the stability and consistency of information regarding pedagogical barriers and cognitive profiles. This reliability ensures that the baseline data used as the foundation for instructional material development possesses a high degree of credibility and is scientifically accountable.

In practice, the integration of validity and reliability establishes a robust methodological framework that minimizes bias and error during the data collection process. The use of expert validation addresses the "truth value" of the instruments (validity), while triangulation ensures the "dependability" of the findings (reliability) across different contexts. Consequently, the resulting data provides a solid empirical springboard for the subsequent design phase, ensuring that the adaptive features of the developed science materials are based on verified pedagogical needs and measurable student performance levels.

4. Findings

Findings from diagnostic tests revealed a significant competency gap in the cognitive aspect. Data shows that the average Problem Solving (PS) skill only reached 46%, while Computational Thinking (CT) skills recorded a lower figure at 44%. This low achievement indicates that systematic, logical, and algorithmic mindsets, which are the main indicators of CT, have not been well-internalized within the students' cognitive structures. This phenomenon shows that the conventional learning applied so far has not been able to optimally stimulate students' PS and CT abilities to face complex problem-solving challenges.

The needs analysis was conducted through a needs questionnaire instrument distributed to 5th-grade students of Elementary School in SDN Percobaan 01 with a total of 42 samples. The instrument was specifically provided to determine the needs of students in elementary school Science learning. Based on the results of the questionnaire, it was concluded that a learning medium is needed to help students learn. The analysis results are presented in the following Figure 1.

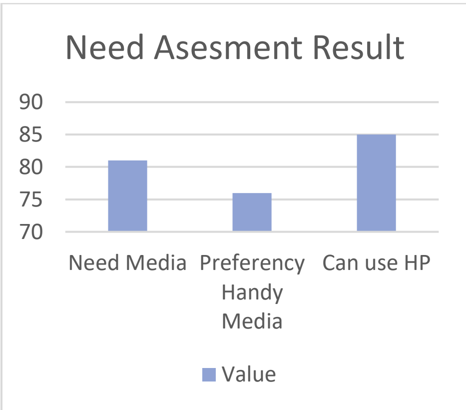

Figure 1. Need Asesment Result

The data reveals a significant demand for specialized instructional support, with 81% of students explicitly stating a need for teaching materials dedicated to ecosystem topics. This high percentage suggests that the current curriculum delivery may not be sufficient for students to grasp the complexities of ecological systems. Furthermore, 34 out of 42 students emphasized that supplementary aids are essential for constructing a clear understanding of the material. This indicates that the foundational concepts of ecosystems are perceived as challenging, requiring a more structured and supportive approach than what is currently provided in the classroom.

The primary driver for this demand is the predominantly conventional nature of current Science instruction. Students noted that learning often takes place without the involvement of engaging or interactive media, which can lead to decreased motivation and difficulty in visualizing abstract environmental processes. This gap between traditional teaching methods and the students' need for modern pedagogical tools creates a strategic opportunity. By developing innovative teaching materials, educators can move away from rote memorization toward a more dynamic model that facilitates a deeper mastery of the subject matter.

A critical finding in the preference analysis is the shift toward portability and ease of use, with 76% of students favoring "handy" or accessible teaching materials. This is further supported by the fact that 32 out of 42 students expressed a specific interest in concise content. Historically, Science textbooks have been criticized for being overly thick and heavy, which often creates a psychological barrier to learning. By transitioning to a more streamlined format, the proposed materials can reduce cognitive overload and make the study of ecosystems feel more manageable and less intimidating for elementary learners.

The high level of familiarity with the booklet format presents a significant advantage for implementation. With 72% of students already acquainted with this medium, the "learning booklet" stands out as a tool with high acceptance and low resistance. Unlike entirely new or complex platforms, a booklet offers a familiar structure that combines concise text with supportive imagery. This existing familiarity ensures that the transition to new materials will be seamless, allowing students to focus on the academic content rather than struggling to navigate the medium itself.

In alignment with the demands of adaptive learning, the integration of technology has become a necessity rather than an option. The analysis shows that 85% of students in Elementary Schools X and Y are capable of operating mobile phones, with 36 out of 42 students explicitly describing themselves as proficient. This technological literacy provides a strong foundation for developing technology-based or hybrid media. Such an approach ensures that the teaching materials are not only modern but also perfectly matched to the students' actual daily habits and digital competencies.

Ultimately, the development of these teaching materials represents a vital innovation to bridge the gap between student needs and classroom reality. By combining the conciseness of a booklet with the adaptive potential of technologynbased resources, the proposed solution addresses the limitations of conventional Science learning. This systematic approach focusing on student proficiency, preference for portability, and the need for engaging ecosystem content promises to overcome existing barriers to confidence and comprehension, significantly enhancing the quality of science education in the digital age.

To further clarify the qualitative findings, Table 4 presents the interview results with the fifth-grade teacher regarding students' learning characteristics, challenges in understanding ecosystem material, the use of instructional media, and the urgency of developing adaptive learning media to support Problem Solving and Computational Thinking skills.

Tabel 4. Interview Result

No	Question	Result
1	How are the students' learning modalities/learning styles during classroom instruction?	There are various types: visual, auditory, and kinesthetic. The approach tends to focus on visual and kinesthetic learning, incorporating videos and hands-on activities.
2	What are the students' characteristics when participating in Science (IPA) learning?	They are quite curious. However, some of them still lack confidence.
3	So far, which parts of the Science material are considered difficult for students to understand?	abstract concepts such as ecosystems
4	How is the students' overall understanding of the ecosystem material?	In the intermediate category, some students are able to handle it while

No	Question	Result
		others struggle. This is particularly true for topics related to cause-and-effect relationships in ecosystems and the impacts of ecosystem changes.
5	What efforts have been made to help students better understand the material?	video, images, discussions, contextual learning
6	Has Science learning been integrated with the goal of developing Problem Solving skills?	We have already gone through discussions and guided learning sessions, but feel that the process is not yet optimal or systematic in every learning session
7	Has Science learning been integrated with the goal of developing Computational Thinking skills?	is still limited and has not yet been explicitly implemented for computational thinking skills
8	What media are usually used during Science learning, and are they aligned with adaptive learning principles?	Books, images, videos, and PowerPoint presentations have not yet addressed the issue mentioned in point one
9	How is the selection process for those media in the Science learning process?	availability of resources, ease of use, suitability for the material
10	Are there supporting facilities available to help students understand Science material?	There are LCD screens, textbooks, and environmental resources, as well as adequate internet access and a computer lab
11	What types of media are most frequently used in Science learning, and what are the results?	Visual and audiovisual materials can help boost students' motivation to learn, but their implementation has not yet been optimal
12	In the use of media, has it been connected to specific approaches such as PBL (Problem Based Learning) or Socio-Scientific Issues?	It has been done, but it is still sporadic and has not been implemented consistently.
13	To what extent is the urgency of creating media integrated with specific approaches to help students improve 21st-century skills?	It is extremely important and urgent to help students develop critical thinking, collaboration, communication, creativity (4C), problem-solving skills, and digital literacy
14	Do you know or are you familiar with learning booklets?	in the form of printed materials, similar to learning modules but shorter (containing content, images, and activities)
15	Is there a need for media that integrates learning approaches and is based on adaptive learning principles to help students improve Problem Solving and Computational Thinking skills?	It is essential that students develop problem-solving and computational skills

Current Science (IPA) instruction in schools reveals a gap between the potential of existing facilities and the actual implementation of classroom teaching methods. Although students exhibit high curiosity and are supported by adequate facilities such as LCD projectors, computer laboratories, and internet access their understanding of abstract materials, particularly ecosystems, remains suboptimal. Students tend to struggle with understanding cause and effect relationships and the impacts of environmental changes, while the teacher's approach to addressing diverse learning modalities (visual, auditory, and kinesthetic) is not yet fully adaptive.

On the other hand, the integration of 21st-century skills, such as Problem Solving and Computational Thinking (CT), is still in its early stages and has not been applied systematically. The use of conventional media, such as textbooks and PowerPoint presentations, has proven effective in increasing student motivation, but remains insufficient in consistently sharpening critical thinking skills and digital literacy. While learning strategies like Problem-Based Learning (PBL) have been introduced, their implementation remains sporadic, preventing the goal of developing comprehensive problem-solving skills from being fully realized.

Consequently, there is a high level of urgency to develop new learning media, such as an instructional booklet, specifically designed based on adaptive learning principles. This media is expected to integrate essential content with approaches that train Problem Solving and Computational Thinking skills. By introducing more systematic and relevant media that meets modern challenges, it is hoped that students' self-confidence issues can be addressed and the quality of their understanding of complex science concepts can be significantly improved.

The results of the needs analysis are reinforced by interviews conducted with 5th-grade teachers. The reality in the field is strengthened by interview results with teachers showing that the development of problem-solving skills and computational thinking has not been implemented regularly. Teachers face obstacles in preparing appropriate learning tools due to the limited media that can connect difficult science theories with real examples for elementary school students. The teaching materials currently available are mostly just text readings without activities that trigger students to think critically. Based on the needs analysis, there is a great opportunity in learning that has not been utilized to the maximum. This indicates the need for the development of new learning tools that are more challenging and practical for students.

5. Discussion

Teaching materials serve as essential learning instruments that support the optimization of the educational process (Saputri & Asrizal 2023). The materials used by educators to assist in constructing content, whether in print or digital form, are referred to as teaching materials. They function as supporting facilities for students to facilitate conceptual mastery. Through teaching materials, students are expected to gain a profound understanding of a subject (Ribosa & Duran, 2022).

Reviewing the initial diagnostic test results for Problem Solving (PS) and Computational Thinking (CT) skills, which showed low achievement, stimulation through teaching materials is required. Teaching materials also function to shape more adequate student skills as preparation for future life. Twenty-first-century skills, such as problem-solving and computation, are vital for students to possess so they can compete in the global era (Yeni et al., 2024). Forming these skills is not easy, as it requires specific stimulation. According to Mallillin (2024) teaching materials are media devices and content specifically structured to optimize the effectiveness of the learning environment. The role of teaching materials is crucial in providing stimulation to the learning process, ensuring that every stage of learning becomes more organized, has clear objectives, and is easy to evaluate (Akbar et al., 2025).

The preparation of teaching materials must align with the curriculum to serve as a guide for students in independently constructing knowledge (Zhao et al., 2023). In line with the constructivist approach, teaching materials are designed to trigger understanding through integrated learning activities and evaluations. The primary goal is to simplify the process of internalizing concepts for learners. Therefore, the development of teaching materials must be based on student needs.

Elementary school students, who are still in the concrete operational phase, require media in the process of conceptualizing material. Based on the results of the needs analysis, 34 out of 42 students require assistance from teaching materials to help understand ecosystem topics. Consistent with Limbung & Prabowo (2022), teaching materials can improve student understanding or learning outcomes. The development of teaching materials is important as an effort to create a learning climate that makes it easier for students to acquire knowledge. Developing teaching materials is one way to fulfill students' learning facility needs.

Currently available teaching materials are dominated by static narrative texts that have not yet facilitated critical thinking activities. There is a significant opportunity to transform learning tools into more systematic and practical instruments. Therefore, developing teaching materials that integrate problem solving activities and computational thinking stimulation is a solution to fill the gap in students' learning needs while supporting teacher professionalism in managing innovative Science (IPA) instruction.

Interviews with fifth-grade teachers revealed a discrepancy between curriculum demands and the reality of classroom instruction. Currently, the development of problem-solving and computational thinking skills has not been consistently integrated into the elementary-level Science learning process. The main obstacle faced by teachers is the limited availability of teaching materials capable of bridging abstract scientific theories with real-world phenomena. According to Susanti et al, (2022) teaching materials can serve as additional supplements for students to understand material and achieve specific skills.

Innovation in the development of teaching materials is directed toward efficiency in form and ease of use. The goal of developing concise teaching materials is to increase student interest and engagement (Anggraeni et al., 2023). Based on the questionnaire, 32 out of 42 students are more interested in concise teaching materials compared to conventional textbooks, which tend to be thick and heavy. A concise format is capable of reducing students' cognitive load, making it easier for them to project the material into knowledge.

In line with the demands of adaptive learning in the digital era, teaching materials should be integrated with technology. The integration of technology in teaching materials can improve student learning outcomes because it is engaging. Analysis shows that 36 out of 42 students stated they are proficient in operating smartphones. This data provides a strong foundation that the development of technology-based teaching materials has high acceptability and matches the real conditions of the research subjects, ensuring that digital media integration can be implemented without technical hurdles.

Based on the discussion above, it can be concluded that the development of teaching materials is necessary to help stimulate the problem-solving and computational skills of elementary school students. Teaching materials represent an interactive solution that can meet student needs in science learning. The characteristics of being concise and technology-integrated form the basis for developing teaching materials for elementary students. The developed materials must meet student needs and align with learning objectives to effectively stimulate problem-solving and computational skills.

6. Conclusion

Based on the results of the needs analysis, it can be concluded that there is a competency gap among fifth-grade students in mastering Problem Solving (PS) and Computational Thinking (CT) skills. This is evidenced by test results showing average scores of 46% for PS skills and 44% for CT skills. These low scores are attributed to a learning process that has not yet been effective in stimulating critical and computational thinking abilities. Additionally, it was found that there are currently no learning instruments capable of stimulating students to develop PS and CT. The needs analysis indicates strong support for the development of learning instruments in the form of instructional materials, with 81% of students needing ecosystem-related instructional materials and 76% preferring concise (handy) instructional materials. Students' proficiency in using smartphones (85%) presents a strategic opportunity for integrating technology into instructional materials. Thus, the development of concise, technology-integrated adaptive instructional materials serves as a solution for science learning and efforts to enhance elementary students' PS and CT skills.

Limitation

This study possesses a primary limitation in its developmental scope, as it focuses exclusively on the Needs Analysis phase. While this phase provides a profound empirical foundation regarding the competency gaps in Computational Thinking (CT) and Problem Solving (PS) at the elementary level, the findings do not yet encompass large-scale product effectiveness testing across diverse classroom environments. Consequently, the results remain diagnostic and prescriptive; while highly accurate in determining media specifications, they require further validation through subsequent design, development, and formal evaluation phases to measure their actual pedagogical impact.

Furthermore, sociocultural and geographical constraints must be considered, as the research subjects were limited to a single educational institution in an urban area (SDN Percobaan 01 Malang). The characteristics of students as digital natives in an urban setting may result in technological familiarity levels that differ from students in rural areas or those with limited digital infrastructure. This limits the generalizability of the findings to the broader population of elementary students in Indonesia. Nevertheless, this research provides a valid framework for policymakers and educational practitioners in designing adaptive instructional materials based on 21st-century demands

Recommendation

Based on the findings of this needs analysis, it is recommended that educational practitioners and curriculum developers immediately integrate instructional materials that are not merely narrative but activity-based to stimulate higher-order thinking skills. Elementary school educators should begin adopting adaptive learning media that combine the practicality of print with the flexibility of digital technology, such as QR Code integration, to bridge resource gaps in the classroom. Furthermore, the implementation of a Socio-Scientific Issues (SSI) approach is highly encouraged to bring real-world phenomena into the classroom, allowing students to sharpen their Problem-Solving and Computational Thinking skills within relevant and meaningful contexts.

For future research, it is suggested that the scope be expanded into the Development and Implementation phases to empirically test product effectiveness in the field. Future researchers should conduct experimental studies involving broader and more diverse samples, encompassing different geographical regions (such as rural or underserved areas) to ensure the inclusivity and generalizability of the developed media. Moreover, subsequent studies should explore the influence of other moderating variables, such as teacher technological readiness and student learning motivation, in determining the success of internalizing algorithmic thinking and problem-solving abilities through these interactive instructional materials.

Declaration of Generative AI and AI-assisted Technologies

This manuscript was prepared with the assistance of Generative AI Gemini. The AI was used to assist in language refinement and content organization. All intellectual contributions, critical analyses, and final revisions were conducted by the authors. The authors take full responsibility for the accuracy, originality, and integrity of the content presented in this work.

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