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The Development of the 'Mahaga' Digital Authentic Assessment Instrument Based on the Project-Based STEM Approach to Enhance Elementary School Students' Scientific Literacy

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Abstract: This research developed a digital authentic assessment instrument based on a project-based STEM approach to enhance scientific literacy among elementary school students. This study aimed to create an instrument that is valid, practical, and effective. The research employed a Research and Development (R&D) approach, utilizing the ADDIE model. Data were collected through observation, interviews, and tests. The product's practicality was assessed by media, evaluation, and material experts using closed questionnaires. Its effectiveness was measured via a pretest–posttest design conducted with small and large groups of students. A t-test and N-Gain analysis were used to evaluate the improvement of learning outcomes. The validation results were strong, with scores of 97% from the content expert, 94.5% from the assessment expert, and 95.5% from the media expert, indicating that the instrument was very valid. The practicality test also yielded a very practical score of 93% from student and teacher responses. For the effectiveness test, average scores increased from a pre-test of 58.2 to a post-test of 83.2, resulting in a medium N-Gain score of 0.59. This finding indicates that the use of the 'MAHAGA' digital authentic assessment is highly effective. These findings affirm 'MAHAGA' as a valid, practical, and effective instrument, offering a significant contribution to promoting scientific literacy in elementary education. This instrument offers a promising, innovative solution to advance science education at the elementary level, equip students with essential 21st-century skills, and support the development of a more adaptive, critical, and innovative generation.

Keywords: Scientific Literacy, Digital Authentic Assessment, Project-Based STEM, Elementary School Students

Introduction

Science education at the elementary school level is foundational for shaping students' intellectual and character development (Nanda et al., 2024). Science, fundamentally, is not merely a collection of facts but a dynamic process for understanding the world around us (International Science Council, 2018). Effective science education stimulates critical thinking, problem-solving abilities, and innovation (Muhibbuddin et al., 2023; García-Carmona, 2023). It encourages children to observe phenomena, ask relevant questions, and systematically seek answers, which are core to logical and analytical thought (Skalstad & Munkebye, 2021). Direct engagement in experiments and observations has been shown to enhance memory and concentration skills, sharpening students' focus on important details (Tindan & Anaba, 2024).

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Beyond individual development, mastering basic science concepts at the elementary level has broader implications for national progress (Jamaris et. al., 2019). Indonesia, despite its abundant natural resources, has often been a consumer rather than a producer of technological products (Novianti & Asmara, 2023; Fernandez et al., 2022). By cultivating basic science concepts from an early age, the nation can transform into a producer, creating its own technological innovations and achieving a respected global standing (UNESCO, 2019). Science education that fosters "genius works" and the ability to conduct "simple experiments" can catalyze original innovation and technological independence (Brand, 2020). The development of instruments like 'MAHAGA', which focuses on environmental preservation in Central Kalimantan through a project-based STEM approach, directly supports this national vision (Syahmani et. al., 2023). By involving students in solving real local problems through scientific inquiry and innovation, this instrument not only imparts scientific facts but also cultivates a mindset of practical problem-solving and creative application (Karamustafaoğlu & Pektaş, 2023). This approach, even at the elementary level, lays the groundwork for a generation capable of developing local solutions and reducing reliance on external technology, thereby promoting innovation and national self-reliance consistent with the aspiration of producing original works (Tindan & Anaba, 2024). Despite the clear urgency of science education, various significant challenges hinder the optimal achievement of scientific literacy in Indonesia (Yanto et al., 2025). While PISA 2022 data showed an improved ranking for Indonesia, it also noted a global decline in average scores, indicating a persistent need for quality improvement in science education (Bilad et al., 2024).

Traditional, teacher-centered, and less innovative teaching methods contribute to student passivity (Pen & Singh, 2025). This creates a detrimental feedback loop between conventional teaching and low scientific literacy (Adnan et al., 2021; Brassil & Couch, 2019). When teachers, due to limited competence or facilities, rely on less innovative methods, students become disinterested and perceive science as difficult (Awang et al., 2025). This disinterest, coupled with a lack of active participation, further impedes the development of their scientific literacy and science process skills (Ma, 2023; Dresscher et al., 2021). In turn, underdeveloped skills and negative perceptions make it harder for teachers to effectively motivate and teach students. Limited adequate facilities and teachers' restricted competence in effective science instruction are also major obstacles (Kahveci, 2023; Timbasal Nuevo, 2024). Teachers also struggle to develop learning materials and assessment instruments that are truly aligned with the nature of science, which ultimately leads to underdeveloped science process skills among students (Steen et al., 2023). The 'MAHAGA' instrument is designed to break this negative cycle by offering a technology-enhanced, project-based, and engaging alternative that directly addresses student

Disinterest and teachers' capacity to implement authentic, inquiry-based science education (Haatainen & Aksela, 2021). The enhancement of scientific literacy and science process skills is a critical imperative in the 21st century (Turiman et al., 2012). Both are fundamental competencies that equip individuals with essential abilities to understand, apply, and communicate scientific information in daily life (Kelp et al., 2023). Beyond mere factual recall, scientific literacy demands critical thinking, analysis of complex problems, and the use of scientific methods to solve emerging challenges (Nanda et al., 2024). Science process skills, an integral component of scientific literacy, encompass a range of abilities enabling students to engage in scientific inquiry: observing phenomena, asking questions and making predictions, planning and conducting investigations, processing and analyzing data, evaluating and reflecting on findings, and effectively communicating results (Chengere et al., 2025; Gizaw & Sota, 2023).

The need for scientific literacy extends beyond knowledge acquisition; it is about cultivating a versatile set of cognitive and practical skills crucial for navigating a rapidly changing world. In an era marked by swift technological advancements, complex global issues and information overload, the ability to critically comprehend, apply, and communicate scientific information, and to solve problems, is a prerequisite for individual success, informed decision-making, and societal progress. This is particularly relevant given the global decline in PISA science scores (Aqeel, 2024). Therefore, scientific literacy, as targeted by instruments like 'MAHAGA', serves as a crucial adaptive capacity (Mulyono et al., 2024). It empowers students not just with definitive answers, but with the dynamic process of scientific inquiry itself—the ability to continuously learn, question, analyze, and adapt to new scientific and technological paradigms throughout their lives. This aligns with the nature of science, which emphasizes science as a dynamic, inquiry-based endeavor, making these adaptive skills central to its educational mission (Lederman et al., 2013).

A comprehensive needs analysis conducted on 27 fifth-grade elementary students revealed quantitative data underscoring significant challenges in science learning. The data indicated that the majority of students (77.8%) expressed low interest in learning science, and a large proportion (71.4%) perceived the subject as difficult. Furthermore, 74.0% of students felt they did not discover new things in science learning, 92.5%

experienced minimal practical activities, 96.3% had not mastered science process skills, 92.5% found the given questions unengaging, 92.5% noted that questions were confined to text with answers found directly in books, and 96.3% reported that questions lacked connection to real life and local potential in Central Kalimantan. These figures empirically validate fundamental issues that need to be addressed in elementary science education. However, the analysis also uncovered strong student preferences for innovative and interactive learning methods (Abykanova et al., 2016). A substantial 70.3% of students desired technology-integrated learning, 96.3% enjoyed game-based tests, and 92.5% wanted more practical activities. This data highlights a clear discrepancy between current science teaching practices and the learning modalities students find engaging and effective. The high demand for technology-driven, game-based, and practical learning experiences is not merely a superficial preference; it is a strong indicator that traditional pedagogical approaches are failing to capture student attention and foster deeper learning.

From the teachers' perspective, the analysis also identified an urgent requirement for technology-based test questions that can effectively enhance students' science process skills (Pacala, 2025; Katayev et al., 2023; Li, 2021). Teachers reported difficulties in conducting science practicals due to their limited ability to develop learning materials and assessment instruments aligned with the nature of science, which resulted in science process skills not being maximized (Ramadhan et al., 2020; Ismael, 2018; Irwanto, 2023). They also noted that current test questions were often derived from textbooks and lacked engaging models. The fact that teachers are simultaneously seeking technology-based tools to improve science process skills further underscores a shared recognition of this pedagogical gap and a readiness within the educational ecosystem for innovative solutions (Park et al., 2023; Boughaydi et al., 2025). The 'MAHAGA' instrument, with its integration of Kahoot (game-based technology) and a project-based approach, directly targets this critical gap, positioning itself as a highly relevant and potentially transformative intervention (Sohilait et al., 2025; Halimatussa'diah et al., 2019; Rayan & Watted, 2024).

Based on the outlined background and needs analysis results, the primary objective of this research is to develop a valid, practical, and effective 'MAHAGA' digital authentic assessment instrument based on a project-based STEM approach to enhance scientific literacy among elementary school students.

Method

This research used a Research and Development (R&D) approach, a systematic methodology used to create and validate new products or programs, or to improve existing ones, with the aim of producing effective and efficient innovations in education (Umar et al., 2023). Development in this research used the ADDIE model. The ADDIE development model consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Adeoye et al., 2024). This model is designed to solve learning problems in a gradual and systematic manner, with each stage being interconnected and not being carried out randomly. Following the ADDIE model, the stages for developing the 'MAHAGA' digital authentic assessment instrument are outlined below.

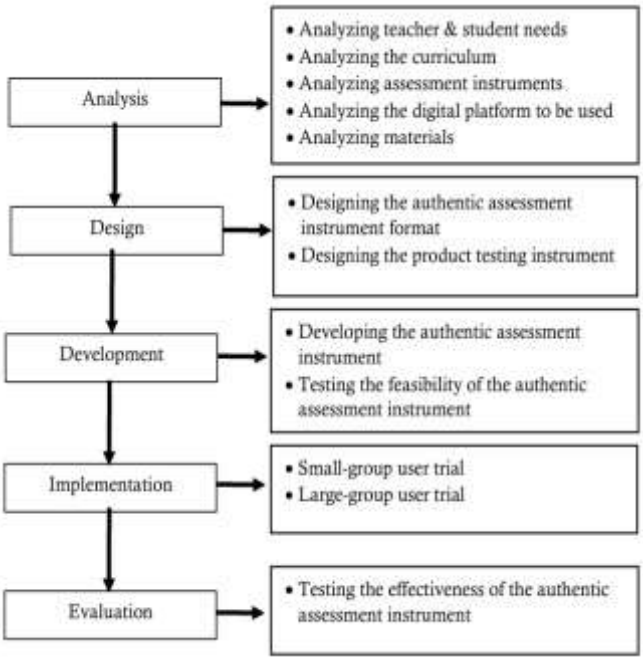

Figure 1. Research model

Data collection techniques were conducted through observation, interviews, and tests. Data analysis was carried out through qualitative and quantitative approaches. A qualitative approach was used throughout several key phases of the project. First, in the analysis stage, qualitative data were collected to inform the product's development through a literature review, analysis of software and hardware requirements, and an assessment of expected skills. This was followed by the design stage, which involved gathering qualitative reference data to create the initial product design and its assessment instruments. Finally, during the assessment stage, media and material experts provided qualitative feedback in the form of input, criticism, and suggestions via an open questionnaire to evaluate the product's suitability. A quantitative approach was used to evaluate the product's practicality and effectiveness. The product's practicality was assessed by media, evaluation, and material experts using closed

questionnaires. Its effectiveness was then measured through a pretest-posttest design of 40 digital-based questions conducted with a small and a large group of students, with the results categorized into high, medium, and low effectiveness levels. The research results produced a project-based digital authentic assessment instrument, 'MAHAGA', with a valid, practical, and effective STEM approach.

An instrument is declared valid after undergoing a validation process by a validator. The calculation for analyzing the validity and practicality of an instrument is as follows:

$$\text{Validation} = \frac{total\ validation\ score}{total\ maximum\ score}\ x\ 100\% \quad (1)$$

After the validation score calculation is obtained, it will then be interpreted in the validation score interpretation criteria listed in Table 1.

Table 1. Validation Result Percentage

Score	Validity Criteria
85.01 – 100.00%	Very Valid
70.01 – 85.00%	Quite Valid
50.01 – 70.00%	Less Valid
01.00 – 50.00%	Invalid

The first instrument trial was conducted on a small group or limited test of 5 fifth-grade students. Then, the second test was on a large group of 70 fifth-grade students in three Public Elementary Schools in Palangka Raya. The effectiveness test for the digital authentic assessment instrument 'MAHAGA' was carried out using a t-test (paired t-test) and the improvement of learning outcomes using gain score analysis or N-Gain (Normalized Gain).

Table 2. N-Gain Category

Gain	Category
<g> ≥ 0.7	High
0.3 ≤ <g> ≤ 0.7	Medium
<g> ≤ 0.3	Low

Result and Discussion

This study introduces the development and evaluation of 'MAHAGA', a digital authentic assessment instrument intended to improve scientific literacy among elementary school students. The instrument integrates a project-based Science, Technology, Engineering, and Mathematics (STEM) approach and leverages the Kahoot platform for an engaging and relevant learning experience. The results of the research on the development of the digital authentic assessment instrument 'MAHAGA' are divided into several stages.

Analysis Stage

Student needs analysis was obtained through a questionnaire regarding the needs of the product to be developed among 27 fifth-grade students. The results of the questionnaire are as follows.

Table 3. Student Needs Analysis

Aspect of Student Needs	Percentage (%)
Low interest in learning science	77.8%
Perceive science as difficult	71.4%
Feel no new discoveries in science learning	74.0%
Minimal practical activities	92.5%
Not mastering science process skills	96.3%
Unengaging questions	92.5%
Questions confined to text/book answers	92.5%
Questions lack real-world/local context	96.3%
Desire technology-integrated learning	70.3%
Enjoy game-based tests	96.3%
Desire more practical activities	92.5%

Based on the challenges mentioned above, students need better learning support, especially in terms of the use of technology in learning science, practical activities to improve science skills, and the ability to increase scientific literacy.

Interviews with classroom teachers also revealed that they were unable to implement science practices due to the teachers' limited ability to develop learning materials and assessment instruments that address the nature of science, resulting in suboptimal science process skills. Test questions were compiled using textbook questions, and there were no ideas for developing more engaging test question models. According to teachers, students were less enthusiastic when given science questions because they were considered difficult and less challenging. Teachers need test questions that meet students' needs, namely questions that are technology-based and can improve science process skills, which ultimately impact scientific literacy.

At the material analysis stage, analysis served as the basis for mapping the competencies required for elementary school science subjects. The first step was to determine the learning outcomes for elementary school science in Phase C of the Independent Curriculum for Grade 5. In the Independent Curriculum, the learning outcomes for Phase C include students learning about interconnected systems, the relationship between nature and society in the context of diversity, and various natural and social phenomena. Next, the researchers determined contextual and relevant learning topics or materials and identified the learning objectives to be achieved. The learning outcomes for each selected element included science understanding and process skills, as outlined in the material analysis based on the learning outcomes and learning objective flow.

Design Stage

Based on the results of the analysis of student and teacher needs as well as material analysis, the researcher then designed a project-based digital authentic assessment instrument 'MAHAGA' with a STEM approach that includes science process skills, a STEM approach and includes digital-based scientific literacy competencies. The preparation of the instrument begins with creating a question grid and determining appropriate learning objectives. The content of the questions compiled refers to phenomena and events that occur in the environment around students, which emphasize the importance of 'MAHAGA' in protecting the nature of Central Kalimantan. Through the 'MAHAGA' assessment instrument, students can build awareness and responsibility to maintain nature in a balanced ecosystem.

The design phase was the conceptual stage where the 'MAHAGA' assessment instrument was meticulously planned. This instrument utilizes the Kahoot application as an interactive, game-based quiz model (Maraza-Quispe et al., 2024). Kahoot has been proven effective in enhancing student learning processes, classroom participation, and even fostering positive relationships among students. The platform also provides features such as questions displayed first to encourage focus, a timer for each question, score display after each question, and a podium showing top scores, which make it engaging and suitable for live or assignment modes (Figuccio & Johnston, 2022). This platform can also serve as a tool to check students' prior knowledge and verify their understanding of new concepts through its instant feedback feature.

The questions in the 'MAHAGA' instrument were developed based on phenomena and events relevant to students' surrounding environment, with a particular emphasis on the importance of 'MAHAGA' (maintaining Central Kalimantan's nature). The project-based STEM approach, central to this design, has been shown to be highly effective in improving scientific literacy and understanding of basic scientific concepts. This effectiveness is achieved through active student engagement in solving real-world problems, fostering creativity, and developing higher-order thinking skills. The integration of local context and environmental issues, such as through a place-based education approach, further enriches the STEM learning experience by making it more relevant and meaningful for students. The following is a display of the 'MAHAGA' assessment instrument design in Figure 2.

Figure 2. Design of the 'MAHAGA' Instrument

This synergistic approach, combining the high engagement and instant feedback offered by Kahoot with the authentic, in-depth relevance of project-based STEM focused on local environmental issues, leverages both extrinsic motivation (through gamified assessment) and strong intrinsic motivation (through connection

with their environment and cultural values). This dual activation is crucial for sustained engagement. It fosters not only superficial knowledge acquisition but also deep conceptual understanding and practical application of scientific principles. When students actively engage with how science relates to maintaining Central Kalimantan's nature, abstract scientific concepts are transformed into tangible, meaningful problems.

This contextualization enhances knowledge retention, promotes the development of applicable scientific literacy, and cultivates a sense of responsibility towards their environment. This design principle serves as a powerful model for future educational innovations, demonstrating that combining engaging technology with culturally and environmentally relevant content can yield more profound and sustainable learning outcomes (Picardal & Sanchez, 2022). In this stage, the researchers also developed research instruments such as expert validation sheets, teacher and student practicality questionnaires, and pre-test/post-test instruments for effectiveness measurement.

Development Stage

The development phase was a crucial stage in the Research and Development (R&D) process, where the designed instrument began to be realized and validated. The development of the digital authentic assessment instrument design 'MAHAGA' is shown in Figure 3.

Figure 3. Development of the 'MAHAGA' instrument

This process included the validation of the instrument by expert validators from three important domains: material, media, and evaluation. Expert validation is a fundamental step to ensure the internal quality, relevance, and clarity of the developed instrument.

The validation process involved a systematic assessment of several key aspects. First, the practicality of the material content was assessed to ensure scientific accuracy, curriculum alignment, and contextual relevance. Second, the appropriateness of language use was evaluated to ensure that questions and instructions were easily understood by elementary school students. Third, the quality of the instrument's presentation, including layout, format, and visual aesthetics, was checked to ensure appeal and ease of navigation. Fourth, the effectiveness of the media used was assessed to ensure that the platform supported the learning and assessment objectives.

The assessment instrument design that has been prepared was then submitted to the validator for assessment by subject matter experts. Validation was carried out by subject material experts, evaluation experts, and media experts. The validation results are displayed in Table 4.

This multidimensional validation, encompassing content accuracy, pedagogical effectiveness of the media, and reliability of the assessment methodology,

ensures that 'MAHAGA' is not only scientifically accurate but also pedagogically robust in its presentation and interaction, and capable of reliably measuring intended learning outcomes. This comprehensive approach goes beyond a singular focus on content correctness, guaranteeing that the instrument is fit for its intended purpose across various critical dimensions. Such thorough validation significantly enhances the overall quality, credibility, and trustworthiness of 'MAHAGA' as an educational assessment tool, providing a strong foundation for practical application and subsequent effectiveness testing (Alonzo & Teng, 2023).

Table 4. Material Expert Validation Results

Validator	Result	Percentage (%)
Material	4.9	97%
Evaluation	4.7	94.5%
Media	4.6	95.5%

Implementation Stage

The implementation phase was where the 'MAHAGA' instrument began to be applied in real educational settings to test its practicality and effectiveness. This process started with a practicality test, involving direct participation from fifth-grade teachers and was followed by a small group trial on five students. The teacher practicality test was conducted by providing a link/barcode to the instrument, after which teachers filled out a practicality questionnaire. The small group trial also involved students filling out a questionnaire after using the instrument. These practicality tests were designed to assess the extent to which the instrument was easy to use, feasible to implement, and suitable for actual classroom conditions from the perspective of direct users (teachers and students). Feedback from this stage was invaluable for initial refinements of the instrument. The results of the user (teacher) trial can be seen in Table 5.

Table 5. Teacher Practicality Trial Results

Assessment Aspect	Score	Total Score	Criteria
I had no difficulty understanding the instrument/questions	4	4	Very Practical
Instructions for completing the instrument/questions are clear and easy to follow	4	4	Very practical
Questions are aligned with learning objectives	4	4	Very practical
Design (colors, images, and animations) of the instrument/questions is engaging	3	4	Practical
The instrument/questions train critical thinking	4	4	Very practical
The instrument/questions are relevant to real life	4	4	Very Practical
The language used is appropriate for elementary level	3	4	practical
Total Score	26	28	Very practical
Percentage	93%	100%	Very practical

A small group trial was conducted with five students. After using the product, students were given a questionnaire to provide feedback as users, which served as data for the practicality test. The results of the small group trial are shown in Table 6.

Table 6. Small Group Practicality Trial Results

Assessment Aspect	Score	Total Score	Percentage
Ease of Use			
I had no difficulty understanding the instrument/questions.	18	20	90%
Instructions for completing the instrument/questions are clear and easy to follow.	20	20	100%
I understand the terms in the instrument questions.	17	20	85%
Average.	18.3	20	91.6%
Engagement			
Digital model instrument questions are exciting and make me more challenged to learn.	19	20	95%
Design (colors, images, and animations) of the instrument/questions is engaging.	19	20	95%
Average.	19	20	95%
Authenticity			
The instrument/questions train critical thinking.	18	20	90%
The instrument/questions are relevant to real life.	19	20	95%
Average.	18.5	20	92.5%
Total Score.	130	140	
Overall Percentage.			93%

Despite being very practical, there was some constructive feedback from students, including that some of the scientific terms used in the questions were considered difficult to understand, and that questions requiring scientific thinking were quite challenging because students were not used to that type of question. However, students also highlighted the advantages of the digital format, stating that it made learning more challenging and interesting. Based on the results obtained from teachers and students, the 'MAHAGA' assessment instrument was declared practical.

After the instrument had been declared feasible and practical, the next step was to see its effectiveness in large-scale trials. The effectiveness test of the 'MAHAGA' instrument was conducted through a large-scale trial in three elementary schools in Palangka Raya using a pre-test and post-test design. Data analysis was performed using the Paired Sample t-test and N-Gain calculation to measure the improvement in students' scientific literacy. The trials were conducted at SDN 7 Panarung, SDN 6 Panarung, and SDN 8 Langkai.

Table 7. Large-Scale Effectiveness Trial Results

Trial Location	Pre-test Average	Post-test Average	Paired Sample t-test (p-value)	N-Gain	Category
SDN 7 Panarung	50.3	72	<0.001	0.43	Medium
SDN 6 Panarung	52.5	82	<0.001	0.62	Medium
SDN 8 Langkai	72	95.5	<0.001	0.72	High
Overall Average	58.2	83.2		0.59	Medium

The results of the Paired Sample t-test showed a very high level of significance ($p < 0.001$) across all three schools. This significance value, well below the 0.05 threshold, strongly indicates that there were statistically significant differences between students' pre-test and post-test scores after the implementation of the 'MAHAGA' instrument. This proves that the instrument is effective in facilitating improvements in student learning outcomes.

Discussion

The improvement in students' scientific literacy was also reflected in the increase in average student scores from pre-test to post-test in each school. Specifically, at SDN 7 Panarung, the average score increased from 50.3 to 72, with an N-Gain of 0.43 (medium category). At SDN 6 Panarung, the average score increased from 52.5 to 82, with an N-Gain of 0.62 (medium category). At SDN 8 Langkai, the average score increased from 72 to 95.5, with an N-Gain of 0.72 (high category). The overall average N-Gain across the three schools was 0.59, which falls into the "medium" category. This indicates that the 'MAHAGA' instrument is effective in enhancing students' scientific literacy achievement. The significant increase in post-test scores compared to pre-test scores demonstrates that the intervention successfully achieved its objectives. Overall, the findings from this effectiveness test conclusively demonstrate that the 'MAHAGA' digital authentic assessment instrument significantly enhances the scientific literacy competence of elementary school students and is effective for use in science learning in Palangka Raya City.

The findings from this research consistently support the validity, practicality, and effectiveness of the 'MAHAGA' digital authentic assessment instrument in enhancing scientific literacy among elementary school students. The superiority of this product development can be explained by several factors integrated into the 'MAHAGA' design. First, the use of Kahoot as a game-based quiz model directly addresses the issues of low student interest and the perception of science as difficult, as identified in the initial needs analysis (Licorish et al., 2018). Gamification makes the assessment process enjoyable and motivating, encouraging active student participation through features like immediate feedback, score displays, and a competitive podium (Benhadj, 2019; Hellín et al., 2023).

Second, the project-based STEM approach central to 'MAHAGA' allows students to engage in authentic and contextualized learning. By formulating questions based on phenomena and events in the local environment, particularly those related to maintaining Central Kalimantan's nature, the instrument makes science concepts more relevant and meaningful for students. Project-based learning and STEM have proven effective in enhancing conceptual understanding and the application of scientific principles because they encourage students to think critically, solve real problems, and innovate (Prajoko et al., 2023). This approach directly fulfills students' desire for more practical activities and technology-integrated learning (Lee & Lee, 2025). The integration of local context, such as through place-based education, further enriches the STEM learning experience (Bascopé & Reiss, 2021).

Third, the focus on developing science process skills through questions that demand scientific thinking, although challenging for students who are not yet accustomed to them, gradually trains them to observe, question, plan investigations, analyze data, evaluate, and communicate results, which are core to scientific literacy. The instrument successfully meets teachers'

needs for technology-based test questions that can enhance science process skills, while also addressing teachers' difficulties in developing assessment instruments aligned with the nature of science (Lederman et al., 2013; Mabruroh & Ashsiddiqi, 2021). Thus, 'MAHAGA' successfully bridges the gap between unengaging science learning realities and students' preferences for interactive and relevant learning experiences, as well as teachers' need for assessment tools that support 21st-century skill development.

Conclusion

This research successfully developed a 'MAHAGA' digital authentic assessment instrument based on a project-based STEM approach that proved to be valid, practical, and effective in enhancing scientific literacy among elementary school students. This instrument was specifically designed to address challenges such as low student interest, the perception of science as difficult, limited practical activities, unengaging questions, and teachers' difficulties in developing learning materials and assessment instruments aligned with the nature of science. The success of 'MAHAGA' demonstrates that integrating gamification technology through Kahoot, a project-based STEM approach, and contextual relevance while maintaining the character of Central Kalimantan can effectively transform the science learning experience into a more engaging, meaningful, and significantly improve students' scientific literacy competencies. This instrument offers a promising, innovative solution to advance science education at the elementary level, equip students with essential 21st-century skills, and support the development of a more adaptive, critical, and innovative generation.

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Author Contributions
Conceptualization, R.R. and B.; methodology, R.R. and A.D.S.,; software, R.R. and C.A.,; validation, C.A., R.R. and B.; formal analysis, B.; investigation, R.R. and A.D.S.; resources, R.R; data curation, B.; writing—original draft preparation, R.R.; writing—review and editing, B., A.D.s and C.A.; visualization, B.; supervision, R.R.; project administration, R.R. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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