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Honing Scientific Logic: Cognitive Intervention Strategies in Scientific Literacy and Numeration for Primary School Children

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Abstract: This community service activity was carried out at MIS Nyalindung, Cisarua, with the aim of improving the scientific literacy and numeracy skills of elementary school students through a literacy- and STEM-based approach. This activity involved 53 students from grades 3 to 6, who were divided into two phases based on grade level. The intervention was carried out through a combination of reading literary and information texts, as well as simple experiments on changes in the states of objects. Evaluation was carried out through pretests and posttests, which showed a significant increase in students' average scores in both phases, with normalized gains of 0.38 and 0.47, respectively. The results of the paired t-test showed a statistically significant increase. In addition to cognitive improvements, this activity also showed a positive impact on the affective aspect, where 85% of students felt more motivated to learn science, and 90% expressed satisfaction with the learning methods used. The questionnaire data showed that most students had visual (43%) and kinesthetic (39%) learning styles, which supports the effectiveness of the multimodal approach in learning. This activity also contributed 450 literacy- and STEM-themed reading books as a form of ongoing support for strengthening literacy culture in schools. The results of observations showed an increase in active participation, the ability to work together, and communication skills of students. The role of teachers as facilitators also contributed to creating a fun and productive learning environment. Overall, this activity demonstrates that the literacy- and STEM-based approach is effective when implemented at the elementary school level and has a positive impact on fostering active, contextual, and sustainable learning.

Keywords: Learning styles; Literacy; Numeracy; STEM

Introduction

Elementary education is an important foundation in shaping children's character and cognitive abilities (Nilyani et al., 2023). Within it, aspects of scientific literacy and numeracy have a very strategic position as an early indicator in the development of reasoning power, scientific logic, and systematic thinking patterns in students (Fatimah et al., 2024). When viewed in the context of learning in elementary schools, scientific literacy and numeracy not only play a role in improving academic achievement, but also in shaping critical, analytical, and problem-solving thinking skills that will be very useful in everyday life (Hutomo et al., 2022).

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However, the reality in the field shows that there are still many elementary schools in Indonesia that are not optimal in developing this literacy (Parno et al., 2020; Bybee, 2013). One of the main causes is limited resources, both in terms of teacher quality, facilities and infrastructure, and learning methods that are still conventional and not contextual. One of the schools facing this challenge is MIS Nyalindung which is located in the Cisarua area. Based on initial observations and communication with the school, it is known that the condition of educational facilities in this school is still very limited. Teachers have high enthusiasm in educating, but the lack of learning resources and modern pedagogical training is the main obstacle. Children in this school have great potential, but are not supported by an adequate learning environment, both in terms of access to information, reading books, and practical science experiences that are applicable. This condition then underlies the implementation of community service activities with the theme "Learning Assistance Based on Children's Potential".

This community service activity is designed as a form of cognitive intervention that is oriented towards strengthening literacy and developing scientific logic through a contextual, creative, and sustainable approach. The target of the activity is students in grades 3, 4, 5, and 6 who are divided into two intervention phases. The first phase is intended for students in grades 3 and 4, while the second phase is intended for students in grades 5 and 6. The difference between the phases lies in the level of difficulty of the questions and the learning assistance approach that is adjusted to the level of cognitive development of students. The main strategies used in this activity include literacy activities based on stories and information texts, as well as the application of STEM (Science, Technology, Engineering, and Mathematics) through simple practical experiments (Elvira et al., 2022). This division refers to the idea put forward by Piaget in the theory of children's cognitive development, which states that children of early elementary school age (ages 7-9 years) are still at the concrete operational stage, while children aged 10-12 years begin to transition to the formal operational stage. In this context, Rahmatullah's (2021) research provides strong support by showing that compiling questions or learning activities that are appropriate to students' cognitive stages can increase learning effectiveness and prevent cognitive overload. This means that by differentiating phases based on grade level and compiling appropriate content, this intervention is able to adjust children's learning needs more precisely.

In addition, the research results of Kurniawati et al. (2022) also support this two-phase structure, where they emphasize the importance of providing gradual and structured learning stimuli so that students can experience progressive improvement in understanding. Text discussions, experiments, and reflective activities provided in the two phases allow students not only to receive information but also to process it independently according to their respective abilities. In the first phase, students are guided a lot with exploratory methods and storytelling activities that trigger imagination, while in the second phase, students are invited to be more active in building arguments, connecting data from experiments with simple theories, and expressing their findings in writing. The phase separation is also closely related to research conducted by Puspita (2018), which revealed that a story-based approach (fairy tales) is very effective in building scientific understanding in lower grade students. Stories are able to bridge abstract concepts into concrete experiences that are easy for young children to understand. Therefore, in the first phase, many imaginative stories and narrative literacy activities are used to support the accompanying science activities. In contrast, Nugroho's research (2021) shows that upper grade students are more responsive to problem-based approaches and analytical numeracy. This is the basis for compiling learning activities in the second phase, which is designed with higher logical challenges as well as data integration and simple interpretation of experimental results.

In literacy activities, students are given stimuli in the form of literary story books such as fairy tales and informational texts such as children's news that are relevant to their world. The purpose of this activity is to accustom students to understanding and analyzing texts critically, connecting information to their own experiences, and increasing interest in reading through a fun approach. Students are also invited to discuss the contents of the text in groups, answer comprehension questions, and relate information in the text to simple scientific phenomena in everyday life. Meanwhile, in the STEM section, activities focus on changes in the form of objects or materials. Simple practicums are designed so that they can be carried out with limited equipment but still provide meaningful learning experiences. Students take a pretest first to find out their initial understanding, then continue with practicums under the guidance of a facilitator, and end with a posttest to see the development of understanding after the activity. In addition, questionnaire instruments are also distributed to measure learning styles, learning motivation, and student satisfaction with the learning methods applied.

The urgency of this activity is not only motivated by the need to improve science and numeracy literacy, but also by the importance of empowering schools in areas with limited access to education. The intervention carried out is expected to be a learning model that is applicable, easy to replicate, and relevant to the local context. Through a child-based approach and the use of

simple but educational media, this activity is able to increase the capacity of teachers and students in building an active and participatory learning environment (Slavin, 2018). Various previous studies have shown that low science and numeracy literacy among elementary school students in Indonesia is a systemic problem and requires appropriate pedagogical intervention (Yekti & Mufarrihah, 2022). The Programme for International Student Assessment (PISA) report released by the OECD (2019) shows that the achievement of science literacy of Indonesian students is still below the average of OECD member countries. These findings not only illustrate the weak mastery of science concepts, but also indicate students' limited ability to apply these concepts in real-life contexts (Sholihah & Susanti, 2023; Arbain & Sirad, 2023). This condition is exacerbated by the lack of contextual and practice-based learning approaches in many elementary schools, especially in areas with limited access to education. Responding to this, Hidayati et al. Yuliati (2020) emphasized the importance of a STEM (Science, Technology, Engineering, Mathematics)-based learning approach to improve elementary school students' critical and creative thinking skills. Through simple experiments that are relevant to everyday life, students can build knowledge through direct experience, which has proven to be more effective in forming deep conceptual understanding (Nazar et al., 2023). This study provides a theoretical basis for the importance of integrating practical activities in elementary school science learning.

In line with that, Puspita (2018) showed that the use of children's stories, especially fairy tales and imaginative stories, can stimulate logical thinking skills and understanding of science concepts among lower grade students. Stories as a literacy medium not only increase reading interest but can also be a bridge to introduce scientific concepts in a subtle and interesting way. This is important in community service that integrates reading literary and informational texts as a basis for introducing scientific principles. When reviewing different studies, Nugroho (2021) found that the application of problem-based literacy modules (problem-based learning) had a significant influence on students' abilities to analyze and interpret numerical data. The problem-based approach encourages students to think critically, identify patterns, and solve problems through logical reasoning. This finding supports the need to compile questions or learning activities that are adjusted to the level of students' cognitive development as applied in two different phases in this community service activity.

Furthermore, Kurniawati et al. (2022) emphasized that cognitive intervention through text discussions and experiments can improve students' learning retention and ability to transfer knowledge from one context to another. This is relevant to child-potential-based learning assistance activities that are carried out in stages and in a structured manner, where students are invited to discuss, experiment, and reflect on their learning. Research by Mulyani (2019) shows that schools with limited facilities and infrastructure can utilize a simple practical approach based on materials and tools available in the surrounding environment. This finding is very much in line with the conditions at MIS Nyalindung, where STEM activities in this service are designed in such a way that they can be carried out with simple tools but still provide an authentic scientific experience. In addition, Rahmatullah (2021) emphasized the importance of compiling questions or learning stimuli that are adaptive to the level of children's cognitive development. When questions are adjusted to the student's thinking stage, the learning process becomes more effective and does not create excessive pressure. In this activity, the difference in phases between grades 3-4 and 5-6 reflects the adjustment of the level of difficulty according to the age level and cognitive abilities of students.

Astuti et al. (2020) showed that the integration of science literacy and numeracy through educational games and collaborative activities can significantly increase student enthusiasm and participation. This shows that an interactive and fun approach is needed in the context of 21st-century learning, especially in elementary schools (Fauziyah & Rakhmawati, 2023; Mahmud & Pratiwi, 2019; Fitria et al., 2023; Ratnasari, 2020; Simatupang et al., 2024). In more detail, Putri et al. (2020) found that students in remote schools showed a more positive response to collaborative, contextual, and experience-based learning approaches. This positive response reflects their need for learning methods that are close to their own reality, not just mechanical repetition of material. Another study used as a reference is Yuliana's study (2023) which in her study emphasized that teacher training and mentoring in the use of story-based learning media and science experiments had a significant impact on improving the quality of learning. This shows that collaboration between educators and academics in community service activities like this has an impact that is not only felt by students, but also improves the pedagogical competence of teachers in target schools. These various studies comprehensively show that the intervention approach designed in this activity has been based on strong theoretical and empirical foundations. The integration of literary and information literacy, the STEM approach through simple practicums, and the use of instruments to measure motivation and learning styles are concrete forms of relevant, applicable, and contextual learning strategies. Referring to these findings, this community

service activity is believed to be able to provide a real impact in improving scientific logic, science literacy, and numeracy of students at MIS Nyalindung, as well as contributing to an adaptive learning model for schools with similar challenges. This activity is also important in the framework of building educational equity, namely ensuring that all children, regardless of geographic location or economic background, have access to quality education. Interventions like this are a bridge between gaps and hopes, as well as a real manifestation of the tridharma of higher education in fostering and assisting the community through transformative educational practices (National Research Council, 2012). Therefore, this service is not only locally important in MIS Nyalindung, but also has broad relevance as a model for strengthening scientific literacy and logic to be applied in similar schools in various regions in Indonesia.

Method

The implementation method of this community service activity uses an educational intervention approach based on local potential that emphasizes strengthening literacy and science skills through learning assistance methods. The location of the activity is MIS Nyalindung, Cisarua District, Bandung Regency, which is an Islamic-based elementary school with limited facilities and access to learning resources. This activity involved a total of 53 students from grades 3 to 6, who were divided into two phases based on the level and cognitive capacity of the students. The first phase involved students in grades 3 and 4, while the second phase was aimed at students in grades 5 and 6. This division is based on the principle of children's cognitive development, where materials, methods, and levels of difficulty are adjusted gradually to ensure the effectiveness of learning. The series of community service activities was divided into two main stages, namely the literacy stage and the STEM stage. The first stage was carried out on April 9, 2025, and focused on strengthening students' science and numeracy literacy through reading and exploring two types of texts, namely literary texts in the form of fairy tales and information texts in the form of news or simple scientific articles. Students are directed to understand the contents of the text, examine the message, and relate it to everyday experiences through discussions and questions and answers. As a complement, numeracy questions based on story contexts are also inserted, which are designed to encourage students to integrate reading skills with logical thinking and arithmetic. The second stage was carried out on April 14, 2025, and focused on the application of the STEM approach through simple practical activities regarding changes in the state of objects/materials. In this stage, students are invited to conduct simple experiments whose results can be observed directly, such as melting ice, evaporating water, and sublimating camphor. This activity was preceded by a pretest and closed with a posttest to measure the extent to which conceptual understanding increased after the intervention. In addition, questionnaires were also distributed regarding learning styles, learning motivation, and student satisfaction with the activities, as an effort to gain a more holistic understanding of student responses to the learning process being undertaken.

Data collection techniques were carried out using several instruments. First, pretest and posttest were used as quantitative measuring tools to assess students' cognitive improvement before and after the activity. This test was compiled based on indicators of achievement of material changes in the form of objects and was given according to the level of ability of each phase. Second, the questionnaires distributed consisted of three types, namely a learning style questionnaire referring to the VARK model, a learning motivation questionnaire reflecting students' affective aspects in the learning process, and a satisfaction questionnaire describing students' perceptions of community service activities. Third, direct observations were made by the community service team on the teaching and learning process, student interactions, and student enthusiasm in participating in activities, which were recorded systematically. Fourth, documentation in the form of photos and videos was also collected as visual evidence and supporting descriptive narratives.

The data analysis techniques were carried out quantitatively and qualitatively. Quantitative data from the pretest and posttest were analyzed using a descriptive statistical approach, namely calculating the average (mean), percentage of score increase, and distribution of student achievement results before and after learning. Quantitative data from the pretest and posttest were analyzed using a descriptive statistical approach, namely calculating the average (mean), percentage of score increase, and distribution of student achievement results before and after learning. In addition, to see a significant increase more clearly, a comparative analysis was carried out between the pretest and posttest scores using the gain score and normalized gain (g) tests. The g value was then classified into three categories, namely low ($g < 0.3$), moderate ($0.3 \leq g < 0.7$), and high ($g \geq 0.7$) according to Hake's standards (1998). Thus, the increase in student understanding can be assessed not only in absolute terms, but also in proportion to their initial abilities. If needed and the amount of data is sufficient, simple inferential analysis such as paired sample t-test can also be performed to test for statistically significant mean

differences between before and after the intervention. This analysis is used to identify the effectiveness of the intervention numerically.

The questionnaire data were analyzed through frequency and percentage tabulation for each statement using a four-point Likert scale, allowing for the identification of patterns related to learning style tendencies, students' motivation levels, and their satisfaction with the implemented method. Meanwhile, the observational data were analyzed qualitatively using a descriptive thematic analysis approach, by identifying key themes emerging from field notes, such as students' emotional responses, modes of participation, and the dynamics of group interactions. Triangulation techniques were employed to confirm the consistency of data across test results, questionnaires, and observations. This analytical approach was intended to provide a comprehensive and in-depth understanding of the program's effectiveness, not only in terms of knowledge improvement but also in relation to students' learning experiences and behavioral changes in their learning practices.

Results and Discussion

Activity Implementation Strategy

The implementation of this activity involved 53 students from grades 3 to 6 and was designed in stages across two phases. The first phase included students in grades 3 and 4, who in terms of cognitive development are at the concrete operational stage according to Piaget's development theory. The second phase involved students in grades 5 and 6 who had entered the early formal operational stage, so they were readier to receive abstract material with the help of concrete experiments. This division allows for a more effective teaching differentiation approach, where the level of difficulty of the material is adjusted to the developmental abilities of the students. Each phase of the activity combines two main components, namely literacy and STEM. In the literacy aspect, students are introduced to narrative and informative texts that are relevant to everyday life, such as science stories, explanations of scientific processes, and descriptions of natural phenomena. Reading activities are carried out interactively, followed by small group discussions to foster critical thinking skills and understanding of the contents of the text. In STEM activities, students conduct simple experiments such as melting ice cubes, observing evaporation, and changes in the state of other objects that are directly related to the science material in their curriculum. This integrative approach is in line with the principles of contextual teaching and learning, which emphasize the importance of linking learning materials to students' real experiences (Harlen, 2010; Kusuma & Retnowati, 2020). According to Johnson (2002), meaningful learning occurs when students are able to link new information to the knowledge they already have in a real and relevant context.

Data Analysis of Pretest and Posttest Results

To determine the effectiveness of this activity objectively, initial and final measurements were carried out in the form of pretests and posttests, which were compiled based on indicators of achievement of basic literacy and numeracy competencies. The results showed a significant increase in conceptual understanding and basic numerical skills in both phases. In the first phase, the average pretest score of students was 58.4 and increased to 74.2 in the posttest, with a gain score of 15.8. The normalized gain (g) calculation of 0.38 indicates an increase in the moderate category. The second phase showed an average pretest score of 62.7 which increased to 80.5 in the posttest, with a gain score of 17.8 and a g value of 0.47. Paired t-test was conducted to test the statistical significance of the improvement in learning outcomes. The calculated t-value for the first phase was 5.12 and the second phase was 6.78, both of which were greater than the t-table at $\alpha = 0.05$, which was 2.01, which means that the difference between the pretest and posttest was statistically significant. This improvement indicates that science-based literacy strategies combined with practical activities have great potential in improving overall student learning outcomes (Simarmata et al., 2022). This is in line with Vygotsky's constructivist theory, which emphasizes the importance of social activities and the use of aids in learning, including experiments as a form of scaffolding in understanding abstract concepts.

Confirmation of Findings with Previous Studies

The findings of this activity are in line with Dwijayanti's (2022) research which states that contextual literacy-based learning interventions can significantly improve elementary school students' ability to understand texts. Meanwhile, the higher results in the second phase strengthen the conclusions of Sari et al. (2020), which state that high-grade students are better able to understand abstract concepts through a simple experiment-based approach. In the realm of science, the STEM approach has been shown to have a greater impact than the conventional approach. Firman et al. (2016) noted that the STEM approach can improve learning outcomes by up to 30% higher because it integrates science, technology, engineering, and mathematics in authentic and challenging activities. This makes students not only understand the concept but also be able to apply it in real situations.

Affective Aspects and Learning Motivation

In addition to cognitive reinforcement, this activity also has a positive impact on the affective aspect. Based on the results of the learning motivation questionnaire distributed after the activity, 85% of students stated that they felt more interested and enthusiastic in taking science lessons. In fact, 90% of students expressed their satisfaction with the learning methods applied and hoped to be able to take part in similar activities in the future. These results are in line with the findings of Yulianti (2021) who stated that a scientific literacy approach combined with experiments can increase students' curiosity, emotional involvement, and intrinsic motivation. The addition of scientific narratives in this activity serves as a bridge connecting students' imaginative world with the scientific concepts to be conveyed, making learning more lively and enjoyable.

Learning Styles and the Influence of Learning Media

Questionnaire data showed that as many as 43% of students have a tendency towards visual learning styles, 39% tend to be kinesthetic, and 18% have an auditory learning style. This fact shows that most students learn more effectively through the help of pictures, colors, visual illustrations, and activities that involve physical movement and direct practice (Sari & Lestari, 2018). Therefore, the approach applied in this activity, namely a combination of reading texts, pictures, experimental demonstrations, and motor involvement, is very much in accordance with the characteristics of the majority of students. Adjusting the method to this learning style also contributes to the success of learning. This is reinforced by the findings of Gunawan et al. (2019), which states that students will absorb material more easily if the approach used is in line with their dominant learning style. In addition, the multimodal approach that combines visual, verbal, and practical elements as applied in this activity is able to bridge the variety of student needs. Zaini et al. (2022) added that the use of varied and adaptive learning media not only increases student involvement in the learning process but also helps build deeper conceptual understanding.

Social Behavior and Collaborative Skills

Classroom observations during the activity showed that students experienced an increase in active participation, willingness to ask questions, and the ability to express opinions (Tomlinson, 2014). Students also demonstrated the ability to work together in small groups to complete experimental tasks. This indicates an increase in social and collaborative skills, which are important achievements in STEM-based learning. This finding strengthens the argument of Suherman et al. (2020) that a collaborative STEM approach can develop important soft skills such as communication, teamwork, and problem solving (Sujiono et al., 2017). The application of this approach is also in line with the Project-Based Learning (PjBL) model, which according to Bell (2010) is not only effective in improving learning outcomes, but also in forming the character of students who are responsible and actively involved in the learning process.

The Role of Teachers in Activities

The role of teachers in this activity greatly determines the success of its implementation. Teachers who act as facilitators not only provide instructions, but also guide, motivate, and become mediators in learning interactions. Teachers who actively accompany each work group succeeded in creating a positive, conducive, and enjoyable learning atmosphere. This is in line with the opinion of Syamsidar et al. (2018), who emphasize that the active role of teachers is very important in STEM-based learning to create positive social attachment between teachers and students. Fitria (2021) also added that the emotional involvement of teachers in building strong learning relationships is an important factor in the success of educational intervention programs, especially in elementary schools located in marginalized areas.

Implications and Recommendations

The findings of this activity imply several strategic implications that can be applied in the scope of basic education more broadly. First, schools need to develop a flexible and contextual local curriculum, by systematically incorporating literacy and STEM-based learning into routine activities. This not only enriches the learning process but also increases the relevance of the material to students' real lives. Second, it is important for teachers to receive intensive training in designing interdisciplinary learning that combines reading skills, critical thinking, and science and mathematics skills. This training needs to focus on the use of simple media, high-level questioning techniques, and collaborative classroom management. Third, the synergy between schools, local communities, and higher education institutions needs to be strengthened so that activities like this can continue to be developed sustainably. Forms of support can include the provision of contextual teaching materials, simple experimental equipment, and regular academic mentoring.

Finally, providing adaptive and engaging learning resources is essential to reach students' diverse learning styles. By compiling teaching materials that are easy to understand, relevant, and stimulate curiosity, the learning process can be more effective and enjoyable. All of these efforts, if carried out consistently, will have a positive impact on the quality of basic education, especially in forming a generation of learners who think

critically, creatively, and have character (Yanto & Arif, 2023). As a form of ongoing support for strengthening literacy and STEM learning at MIS Nyalindung, this community service activity also contributed 450 reading and reference books as learning materials for students and schools. The books cover various basic science topics, simple experiments, children's stories with science content, and informational texts that can be used in thematic literacy activities. The provision of these reading materials is expected to expand students' access to quality learning resources and stimulate reading interest from an early age, while supporting efforts to develop a culture of literacy in the school environment.

Conclusions

Community service activities carried out at MIS Nyalindung, Cisarua, have succeeded in making a real contribution to improving science literacy and numeracy among elementary school students through a literacy and STEM-based approach. Involving 53 students from grades 3 to 6, this activity was designed in stages and adjusted to the level of students' cognitive development. The interventions carried out not only focused on improving academic abilities, but also encouraged active student involvement, strengthening group cooperation, and developing curiosity and learning motivation. The results of the pretest and posttest analysis showed a statistically significant increase in understanding, both in the first phase (grades 3–4) and the second phase (grades 5–6), with a gain score in the moderate category. In addition, questionnaire data indicated that the majority of students experienced an increase in learning motivation and felt the benefits of fun and interactive teaching methods. The multimodal approach used proved effective in meeting the needs of various student learning styles, which were dominated by visual and kinesthetic tendencies. Strengthening the literacy aspect was also reinforced through the contribution of 450 reading books and references on science literacy that were donated to schools. This step is part of a long-term commitment to supporting the development of a culture of literacy and contextual learning in elementary schools. In addition, the involvement of teachers as facilitators in the learning process plays an important role in creating a conducive, supportive, and meaningful learning atmosphere for students. Overall, this activity shows that a literacy and STEM-based approach is a relevant, applicable, and effective strategy to be implemented in elementary school environments, especially in the context of education that faces limited resources. Therefore, this approach is worthy of being integrated sustainably into school learning programs and supported by teacher training and cross-institutional collaboration to ensure its sustainability and long-term impact on improving the quality of elementary education in Indonesia.

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Author Contributions

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Conflicts of Interest

All authors declare that there is no conflict of interest.

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