

Numereadsci: Boosting Numeracy and Science Literacy through English Resources at Pondok Pesantren in Pekalongan

Rhischa Assabet Shilla ^{1,2}, Lilik Riandita ³, Abdullah Syafi'i ², Zidna Farhana ²,
Nadia Faradhillah ⁴, Nurul Husnah Mustika Sari ⁵, and Arditya Prayogi ^{3,*}

¹ Faculty of Arts and Social Sciences, Sydney University, Australia

² Elementary Madrasah Teacher Education, UIN KH Abdurrahman Wahid Pekalongan, Indonesia

³ Islamic Education, UIN KH Abdurrahman Wahid Pekalongan, Indonesia

⁴ English Language Education, UIN KH Abdurrahman Wahid Pekalongan, Indonesia

⁵ Mathematics Education, UIN KH Abdurrahman Wahid Pekalongan, Indonesia

* Email: arditya.prayogi@uingusdur.ac.id

Abstract

Numeracy and science literacy are essential competencies in navigating the increasingly complex global era. In this context, proficiency in English as an international language serves as a strategic advantage, enabling broader access to high-quality learning resources. This research-based community service aims to improve numeracy and science literacy among students at Pondok Pesantren in Pekalongan, by integrating English-based learning resources used service learning approach.. The program was introduced to improve students' readiness to face global challenges, focusing on strengthening their understanding of numeracy and science through English-based learning materials. This study evaluates the effectiveness of the program using statistically analyzed pretest and posttest data. The results showed an increase in mean score from pretest (5.44) to posttest (7.67), but statistical analysis showed that this increase was not significant. The normality test confirmed that the data distribution was normally distributed, which allowed the use of parametric statistical methods. The paired samples t-test showed no significant difference between pretest and posttest scores (p -value = 0.093). However, the effect size analysis showed a moderate effect (Cohen's d = 0.636, Hedges' g = 0.606), which suggested that the program made a meaningful impact, although not statistically significant. These results suggest that although the program has potential, it needs improvements such as longer duration, larger sample size, and more effective teaching methods to achieve significant results. The study concludes that integrating English literacy with numeracy and science education has the potential to prepare students for global challenges, and the program can be further developed with stronger implementation strategies.

Keywords: Effectiveness Evaluation, Science Literacy, English Literacy, Numeracy
SDGs: Goal 4 (Quality Education)

Manuscript History

Received: 5 December 2024

Revised: 17 January 2025

Accepted: 21 February 2025

How to cite:

Shilla, R.A., dkk. (2025). Numereadsci: Boosting Numeracy and Science Literacy through English Resources at Pondok Pesantren in Pekalongan. *International Journal of Research and Community Empowerment*, 3(1), 16-28. DOI: <https://doi.org/10.58706/ijorce.v3n1.p16-28>.

INTRODUCTION

Numeracy and science literacy are essential skills that are inseparable from human life. These abilities play a crucial role in everyday activities as they help individuals solve practical problems (Liana et al., 2024). For instance, numeracy literacy can assist in calculating the surface area of a building to estimate paint requirements, or in managing business profits to ensure sustainability (Rahmawati et al., 2023). Therefore,

these skills must be practiced and developed among students. Hanifa et al. (2024) emphasizes that numeracy teaches students how to estimate, analyze data, and think logically and critically (Aini et al., 2024).

Numeracy literacy plays a vital role in preparing a resilient generation to face the increasingly complex challenges of the world. It also supports data-driven decision-making, which is a crucial 21st-century skill (Nur Eka Putri Ardiyan, 2024). As a fundamental skill, numeracy literacy is essential to be learned in order to prepare a generation that is competent in various aspects of life. To provide a clearer framework of the competencies targeted in this program. Numeracy literacy indicators include the ability to interpret data presented in tables, graphs, or charts; perform basic arithmetic and algebraic operations; reason quantitatively; and apply mathematical concepts to solve real-world problems. Science literacy, on the other hand, involves understanding scientific concepts and processes; the ability to explain phenomena scientifically; interpreting scientific data; and evaluating and designing scientific inquiries (Gal, 2002; OECD, 2012).

Besides numeracy, science literacy also plays an important role. Science literacy is not only related to scientific knowledge, but also affects scientific communication and community involvement in social issues (Osborne & Allchin, 2024; Reddy, 2021). The Ministry of Education and Culture in the book *National Literacy Movement* (2017) explains that science literacy allows individuals to participate wisely in public discussions on scientific issues, such as health and the environment (Pendidikan & Jakarta, 2017). Harninda et al. (2019) find that people with good science literacy tend to be more open to diversity and respect other people's opinions (Agustiawan et al., 2019). The same thing is also found by Agnes (2021), who states that the population with high science literacy shows a more optimistic, creative, critical, skeptical and forward-looking social attitude in terms of readiness to behave or react in a certain way when faced with an object in scientific investigation (Harefa, 2021).

Several studies have shown that numeracy and science literacy in Islamic boarding schools remains relatively low (Aba et al., 2022; Ramli et al., 2021; Rifki, 2020). Stevi et al. (2023) identified three main factors that hinder the improvement of numeracy literacy in these institutions. These include ontogenic, didactic, and epistemological barriers, which are primarily caused by the limited availability of learning resources and English reading materials (Murniasih et al., 2022; Natalia et al., 2023; Prihandhika et al., 2020). The lack of access to appropriate learning materials makes it difficult for students to deeply understand numeracy and science concepts. The low level of science literacy among students is also attributed to the lack of English-language textbooks that could enrich their understanding of scientific concepts (Suparya et al., 2022).

A similar issue also occurs in one of the Pondok Pesantren (can be translated with Islamic Boarding School) in Pekalongan, where students' numeracy and science literacy remain low. This is due to the limited reading materials and their low English proficiency. Based on interviews with teachers, most of the students' reading materials are limited to books compiled by the teaching team, with very limited access to other reference sources. Surveys show that the library has fewer than 100 books related to numeracy and science, and the students' average TOEFL score is below 400. This indicates that their English proficiency falls into the low category. As a result, the students lag far behind those in public schools who have better access to English-language reading resources.

The decision to conduct this study in an pondok pesantren rather than a public school was deliberate and grounded in contextual needs. Pondok Pesantren often face unique challenges in terms of resource accessibility, particularly regarding English-based learning materials. Unlike public schools that may have better infrastructure and access to global educational content, many pesantren operate with limited teaching aids, outdated libraries, and less exposure to English language instruction. This creates a gap in students' readiness to engage with global scientific and numerical knowledge. Therefore, this study aims to address that gap by introducing an intervention program that integrates numeracy and science literacy using English-based resources in a pesantren setting, which has been relatively underrepresented in existing educational research. By focusing on this context, the study also contributes to educational equity and inclusivity, in line with the goals of SDGs 4.

The correlation between numeracy and science literacy and the use of English reading materials lies in the role of language as a medium for accessing knowledge. English, as the dominant language of science, technology, and global education, provides a vast array of academic texts, data interpretations, and problem-solving examples that support the development of higher-order thinking in both numeracy and science. Exposure to English textbooks enriches students' conceptual understanding, especially in interpreting graphs, analyzing quantitative data, and understanding scientific terminologies. This is based on research by Muhammed et al. (2020) that show a positive relationship between English proficiency and science literacy, including numeracy (Siddique Kadwa et al., 2020). The findings suggest that improving numeracy and science

literacy in Islamic boarding schools (pesantren) can be done by improving English language skills and providing relevant reading materials.

The program of strengthening numeracy and science through English literacy resources was designed as part of the Numereadsci Program at Pondok Pesantren. This program aims to improve the numeracy and science literacy of santri through the integration of English-language reading resources that are relevant to their learning needs. Although Pondok Pesantren does not implement a bilingual education program or English as a Medium of Instruction (EMI), the integration of English-based learning resources in this study was designed as an enrichment strategy. This approach aims to gradually introduce students to global academic content while enhancing their English literacy, particularly in science and numeracy contexts. The program serves as an initial effort to bridge the limited access to English-language learning materials commonly found in non-bilingual Islamic boarding schools.

This article is a research-based community service study. In its implementation, the activities were conducted as a form of community service using the service learning method, which emphasizes experiential and reflective learning to address real-world educational needs. Although the primary aim was community engagement, the program was designed systematically and its outcomes were documented, measured, and analyzed using scientific methods. Therefore, the results were transformed into research data, allowing for a deeper evaluation of the program's effectiveness.

While this study is not categorized as action research, it adopts an academic framework to evaluate the impact of a service learning intervention within an pondok pesantren context. The Numereadsci program uses the Service Learning (SL) method, which focuses on the application of experiential learning in the community. Through this method, academic knowledge is directly linked to the needs of the community, in this case the needs of students in boarding schools, so that it is expected to help overcome the problem of limited learning resources they face. This approach also aims to enable students to develop critical and creative thinking skills, which are essential skills for readiness to face future global challenges (Nugroho et al., 2023; Vincent-Lancrin et al., 2019; Yu, 2024)

Numereadsci stands for Numeracy and Science through Literacy, a program designed to strengthen students' competencies in numeracy and science by integrating English-based learning resources. The program is specifically tailored for students in pondok pesantren who have limited access to global academic content. It combines contextual mathematics and science learning with English reading materials, using a service learning framework that promotes active student participation, problem-solving, and critical thinking.

The program aims not only to improve academic literacy, but also to enhance students' readiness for global engagement. The Numereadsci program does not provide a formal textbook. Instead, it offers newly developed learning modules specifically designed to meet the needs of the community service program. These modules differ from conventional textbooks in that they are contextually tailored to the students' backgrounds, incorporating relevant numeracy and science content presented through English reading materials. The materials emphasize practical application, localized examples, and bilingual support to help students gradually build their academic literacy while addressing real-life problems. Thus, the modules are more flexible, interactive, and community-focused compared to standard textbooks.

METHOD

This study is a research-based community service project aimed at enhancing numeracy and science literacy among students in an Islamic boarding school through the integration of English-based learning resources using the Service Learning (SL) approach. Although not categorized as action research, the program was systematically designed and evaluated to generate empirical data. The SL approach was chosen to connect academic learning with community needs while fostering students' critical thinking and creativity. The research was conducted at Pondok Pesantren Al-Mubarak, located in Pekalongan, Central Java. This pesantren was selected due to its representative characteristics as a traditional Islamic boarding school that faces challenges in accessing English-based learning materials and global academic content. The setting provided a relevant context to implement and evaluate the Numereadsci program, particularly in improving students' numeracy and science literacy through the integration of English resources.

The study adopted a pre-experimental design with a single group pretest-posttest approach to assess the impact of the Numereadsci program. The SL method was employed to connect academic learning with community needs, fostering critical thinking and practical skills through experiential and reflective learning. Data were collected through quantitative (pretest and posttest scores) and qualitative (interviews and classroom observations) methods, with triangulation to enhance validity.

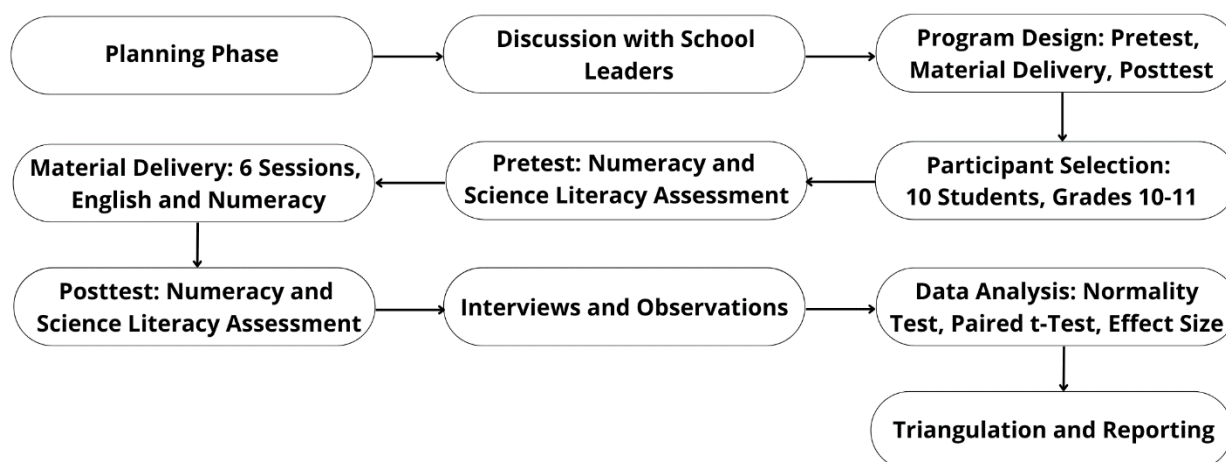


Figure 1. Research Flowchart

Figure 1 illustrates the implementation flow of the Numereadsci program, which was systematically designed to enhance the numeracy and science literacy of students in Islamic boarding schools through the integration of English-based learning resources. The process began with a planning phase and discussions with school leaders to understand the local context and specific needs. The program was then designed to include a pretest, material delivery, and posttest stages. Ten students from grades 10–11 were selected as participants. A pretest was conducted prior to the learning sessions to assess the students' initial numeracy and science literacy levels. The program was carried out over six learning sessions that combined English language, numeracy, and science content. After the intervention, a posttest was administered to measure students' progress. Additionally, interviews and classroom observations were conducted as part of qualitative data collection. All data were analyzed using a normality test, paired t-test, and effect size calculation. The findings were then validated through data triangulation before being compiled into a final report. This flow reflects a service learning approach, which integrates academic instruction with active engagement in addressing community needs.

Data were collected through three primary methods. First, the data collection technique involved the use of pretest and posttest assessments. The pretest and posttest were designed to measure students' numeracy and science literacy before and after the intervention. The tests included questions evaluating critical thinking, data interpretation, and application of numeracy and science concepts in English. The pretest established a baseline, while the posttest assessed improvement. To ensure validity, the test items were developed based on established numeracy and science literacy frameworks and aligned with the program's learning objectives. Content validity was confirmed through expert review by two instructors specializing in mathematics and science education, who verified that the questions accurately represented the targeted competencies. Construct validity was ensured by including diverse question types (e.g., data interpretation, problem-solving) that reflected the indicators of numeracy and science literacy outlined in the introduction. For reliability, a pilot test was conducted with a separate group of 10 students from a similar pesantren context. The Cronbach's alpha coefficient was calculated to assess internal consistency for the posttest. Test-retest reliability was not feasible due to time constraints, but item consistency was further validated through item analysis to ensure each question performed as expected.

Second, the data collection technique involved conducting interviews. Semi-structured interviews were conducted with two teachers to identify challenges during program implementation. The questions focused on resource availability, student engagement, and perceived effectiveness of the English-based materials. The interview questions were designed to align with the program's objectives and were reviewed by a qualitative research expert to ensure content validity. To enhance reliability, a standardized interview protocol was used, with questions asked in the same order and phrasing. Responses were recorded and transcribed verbatim to minimize bias.

Third, the data collection technique involved classroom observation. Observations were conducted during the six material delivery sessions to assess student participation, interaction with materials, and instructor delivery. A structured observation checklist with a Likert scale was used to ensure consistency. The

observation checklist was developed based on established educational observation frameworks and validated by two instructors to ensure it captured relevant aspects of student engagement and instructor effectiveness. To ensure reliability, two observers independently rated the same sessions. Observer training was conducted prior to data collection to standardize the use of the checklist.

To comprehensively evaluate the effectiveness of the program, multiple data analysis techniques were employed. First, the Shapiro-Wilk normality test was conducted to ensure that the pretest and posttest data were normally distributed, allowing for the use of parametric statistical methods. Once normality was confirmed, a paired samples t-test was performed to compare the scores before and after the intervention, determining whether the changes were statistically significant. To assess the practical impact of the program, effect size analyses using Cohen's d and Hedges' g were carried out. In addition, qualitative data from interviews and classroom observations were thematically analyzed to identify contextual factors that may have influenced learning outcomes. Finally, triangulation between quantitative and qualitative findings was conducted to strengthen the validity of the interpretations and overall conclusions of the study.

RESULTS AND DISCUSSION

Numeradsci program is neither a formal bilingual education program nor EMI but an enrichment program integrating English-based resources to enhance numeracy and science literacy in a non-bilingual pesantren setting. There are two materials provided, namely language material and numeracy material. In the language material, this session focuses on reading skills and understanding scientific data in English. The purpose of this activity is to: Improve oral communication skills in English, familiarize participants with scientific terms and data analysis techniques in English. And increase self-confidence in conveying academic information using a foreign language.

Participants are given a guidebook containing various scientific texts and graphs to help them learn to read and analyze scientific data. The activity begins with an explanation of how to read graphs, understand scientific texts, and draw conclusions from the information presented. Participants are then given the opportunity to read English texts independently, followed by an activity to introduce themselves in English.

In the numeracy material, participants are taught the application of mathematics in the context of everyday life and science. The material includes Algebra Applications: Discussing the use of algebra in solving everyday problems, such as calculating parking fees and using linear functions. Proportion: Using direct and indirect proportions to calculate ingredient requirements, such as brownie recipes. Population Models: Discussing population growth models, both exponential and logistic, which are used to understand demographic patterns and population change. Trade and Discounts: Discussing the concepts of selling price, production costs, profit, loss, and discount calculations in trade.

Participants are given practice questions to apply these concepts, such as calculating parking fees, modelling population growth, and choosing products with the most efficient discount prices. These two sessions are designed to provide participants with integrated science and numeracy literacy skills, so that they can understand, analyse, and convey information in a more structured and academic way. These activities are illustrated in Figure 2.



Figure 2. Presentation of Material

The activity was continued with a post-test aimed at evaluating students' understanding and skills after attending the entire training series. This post-test serves as a measuring tool to determine the extent to which

the material that has been delivered can be absorbed by the participants, as well as a material for evaluating the effectiveness of the program. Through this evaluation stage, it is expected to obtain a clear picture of the increase in student competence and provide input for the development of similar activities in the future.

The results of the normality test show that the significance value for the pretest is 0.949 and for the posttest is 0.200. Both values are greater than 0.05. Since the sample size ($n = 9$) is less than 50, the Shapiro-Wilk normality test is used as the reference. Therefore, it can be concluded that the pretest and posttest data are normally distributed. Based on this, further analysis can be conducted using parametric statistical methods such as the paired samples t-test. A normal data distribution ensures the validity of the statistical analysis results, making the conclusions drawn more reliable.

Table 1. Statistical Results

Component	Paired Samples Statistics		Paired Samples Correlations	Paired Samples Test		Paired Samples Effect Sizes
	Mean	Standart Deviation	Correlation	Mean	Sig.	Point Estimate
Pre-test	5,44	2,068	0,430	-2,222	0,093	Cohen's d: 0.636 Hedges' g: 0.606
Post-test	7,67	3,841				

Based on the data in Table 1, there was an increase in the average score from pretest to posttest, rising from 5.44 with a standard deviation of 2.068 to 7.67 with a standard deviation of 3.841. Although this improvement appears evident descriptively, further statistical analysis was necessary to determine its significance. The correlation test between pretest and posttest scores showed a correlation value of 0.430 with a significance value (Sig.) of 0.248, which is greater than 0.05. This indicates that there was no statistically significant relationship between the initial (pretest) and final (posttest) scores, meaning that the improvement in the posttest score was not directly related to the students' initial performance.

Table 1 also shows that the paired samples t-test revealed a mean difference of -2.222 with a two-tailed significance value of 0.093, which is also greater than 0.05. Based on this result, it can be concluded that the increase in scores from pretest to posttest is not statistically significant. Thus, although there was a rise in the average score, the program aimed at strengthening numeracy and science through English literacy resources did not have a statistically significant impact on the students' numeracy and science skills. These findings serve as a critical basis for evaluating and improving the implementation of the program to achieve better effectiveness in enhancing student competencies in the future.

The analysis of the program's effectiveness showed that Cohen's d was 0.636 and Hedges' g was 0.606. Referring to the effect size categories, a value of 0.2 indicates a small effect, 0.5 a medium effect, and 0.8 a large effect. Therefore, the obtained effect size values place the program in the medium category, indicating that the program had a fairly meaningful impact on improving students' numeracy and science skills. Although previous statistical tests did not show statistically significant results, these effect size values suggest that the program still had a practically substantial influence on the development of students' competencies.

Although the average increase is not statistically significant, the effect size indicates that the program has a meaningful impact on the numeracy and science skills of the students. The program has a fairly good impact on improving students' abilities although it is not statistically significant. This could be due to other factors such as the limited time of program implementation or the complexity of the material.

Numeracy and Science Literacy: Their Role in Everyday Life

According to Hanifa (2024) and Nur Eka (2024), numeracy literacy is very important in everyday life, especially in terms of data-based decision-making. (Aini et al., 2024; Nur Eka Putri Ardiyan, 2024). Numeracy literacy allows a person to manage information needed in various situations, such as calculating business profits or estimating needs in work (Setyaedhi, 2024). In the context of Pondok Pesantren Al-Mubarak, this program aims to improve the numeracy literacy of students who have been hampered by limited reading resources and their understanding of English.

The increase in mean scores reflects improved student performance in numeracy and science literacy, despite limited access to English resources. Students showed progress in applying mathematical concepts, such as calculating discounts or modeling population growth, and analyzing scientific texts and graphs in English. Classroom observations noted active participation, with students engaging in discussions about real-world problems, such as environmental data. However, low English proficiency, with average TOEFL scores below

400, hindered full comprehension of English-based materials, as teachers reported struggles with terms like “proportionality” or “hypothesis.” The pesantren’s library, with fewer than 100 relevant books, further limited exposure. The moderate effect size suggests that the program’s tailored modules began to bridge this gap, enhancing students’ ability to solve practical problems and engage in scientific discussions, critical for global readiness.

Numeracy literacy is not merely the ability to perform mathematical operations, but also involves the capacity to interpret, analyze, and communicate quantitative information in real-life settings (Gal, 2002). This skill becomes increasingly important in an age where data-driven decision-making governs various aspects of everyday life—from financial planning and consumption habits to evaluating information presented in the media (Lange, 2005; OECD, 2012; Umbara & Suryadi, 2019). The santri/student at Pondok Pesantren Al-Mubarak, who often have limited exposure to formal mathematical discussions, particularly through English-language sources, face challenges in accessing these critical literacies. The integration of English-based numeracy resources in this study is therefore intended to introduce students not only to mathematical concepts but also to the language and context in which they are commonly applied in global settings. Classroom observations revealed positive changes in students’ behavior during learning activities, underscoring the program’s impact despite limited English resources. Students showed high engagement (rated 4/5 on the observation checklist) when working with bilingual modules and participating in group discussions. For example, they actively collaborated on tasks like calculating trade discounts or interpreting environmental graphs, demonstrating increased curiosity and critical thinking.

The Service-Learning approach, which connected academic content to real-world problems, fostered a supportive learning environment, with students rated 4/5 for participation in group activities. However, low English proficiency occasionally led to hesitation in discussing complex concepts in English, as noted by instructors. These behavioral improvements indicate that the program’s interactive and contextual activities helped students overcome initial resource and language barriers, building confidence and readiness for global challenges. Sustained interventions with more English resources could further enhance engagement.

The results show an increase in the mean score between the pretest and posttest although it was not statistically significant. This is in accordance with the concept proposed by Martha (2024), who emphasizes that numeracy skills can improve even though the changes may not be immediately visible in a short period of time (Malo et al., 2024). Although the increase in pretest to posttest scores is not statistically significant, there is an indication of progress in numeracy mastery, reflecting that despite the limitations of reading materials and English language, there is potential to improve numeracy literacy with the right program.

The observed increase in mean test scores, though not statistically significant, still indicates a degree of conceptual growth. This result aligns with assertion that improvements in numeracy are often gradual and require repeated exposure, especially when intertwined with second-language learning (Darling-Hammond et al., 2020; Ginsburg et al., 2006). Thus, the early-stage results observed at Al-Mubarak may reflect the beginning of a longer trajectory of development. The key takeaway is that introducing numeracy through a bilingual medium demands not only structured material but also time, repetition, and appropriate scaffolding to allow students to build confidence and fluency in both the language and the concepts (Gallego et al., 2018).

Science Literacy and its Effect on Social Participation

The Ministry of Education and Culture in the National Literacy Movement book (2017) explains that science literacy is not only a matter of scientific knowledge, but also the ability to participate in scientific discussions, including issues related to health and the environment (Pendidikan & Jakarta, 2017). This study notes the low level of science literacy in Pondok Pesantren Al-Mubarak, mainly due to limited English textbooks and other resources. This is in line with the findings of Stevi et al. (2023), who mention that limited English teaching materials are a major obstacle in improving science literacy in Islamic boarding schools (Murniasih et al., 2022).

Science literacy is increasingly recognized as a foundational skill not only for academic success but also for meaningful social participation. The ability to interpret scientific data, evaluate claims based on evidence, and engage in discussions on issues such as health, environment, and technology is crucial in shaping informed citizens. In the context of pesantren, where religious texts often dominate the curriculum, the integration of science learning—particularly through English-based resources—represents a shift toward preparing students for broader societal roles. The lack of science literacy among santri at Pondok Pesantren Al-Mubarak, as revealed in this study, reflects structural barriers such as insufficient access to contextualized science texts in English and limited opportunities for inquiry-based learning.

This challenge is not unique to Al-Mubarak. A study by Murniasih et al. (2022) on science literacy in pesantren environments revealed similar constraints, emphasizing that santri often struggle to relate scientific knowledge to real-life issues due to language limitations and rote learning practices. However, the modest increase in mean science scores in this study suggests that when science materials are integrated with English literacy—especially in a learner-friendly format—students begin to build conceptual bridges between scientific ideas and everyday experiences. This aligns with contextual science education in pesantren that can foster higher engagement and critical thinking when implemented with interactive and culturally relevant content. Thus, although statistically insignificant, the positive shift in the present study supports the argument that science literacy can be nurtured in pesantren settings through the thoughtful use of language-integrated instructional strategies.

Although the statistical test results show that the program has not provided a significant increase in santri's science literacy, the average increase recorded shows that the program has succeeded in having a positive impact. This program, although it has not reached the level of statistical significance, has the potential to open access for santri to understand science concepts through English literacy, which will support their ability to participate in scientific discussions.

The Effect of English Language Proficiency on Numeracy and Science Literacy

English language proficiency plays a pivotal role in students' ability to access and engage with global knowledge, particularly in subjects like science and mathematics, which heavily rely on English terminology and discourse (Cruz Neri & Retelsdorf, 2022; Martirosyan et al., 2015). In the context of Pondok Pesantren Al-Mubarak, the low level of English proficiency among santri poses a substantial barrier to understanding key scientific and numerical concepts presented in English-based learning resources. This condition is consistent with the findings of that language barriers significantly affect cognitive processing in STEM education, particularly in multilingual contexts. When learners lack foundational English skills, it hampers their ability to follow instructions, understand abstract concepts, and engage in problem-solving activities (Bastida et al., 2022)—an observation that parallels the experiences at Al-Mubarak.

The program's tailored activities and materials significantly contributed to improvements in students' numeracy and science literacy, despite the constraint of limited English resources. In numeracy sessions, students engaged with bilingual modules that presented real-life problems, such as calculating parking fees using algebra, determining ingredient proportions for recipes, and modeling population growth. These activities, reinforced by practice questions, helped students apply mathematical concepts practically, as evidenced by the mean score increase from 5.44 to 7.67. For science literacy, students analyzed English-based scientific texts and graphs (e.g., environmental data) using a guidebook designed for their context. Activities like interpreting graphs and discussing scientific phenomena in group settings enhanced their ability to understand and communicate scientific concepts, aligning with OECD (2012) indicators of science literacy.

Limited English resources and low proficiency were the primary barriers to greater program success. Students struggled to understand English-based texts due to the lack of accessible textbooks and prior language training. Qualitative data showed increased confidence in using English for academic tasks, such as presenting data, but foundational language skills remained weak. This aligns with Muhammed et al. (2020), who found that English proficiency enhances numeracy and science literacy. The program's bilingual support helped, but the short duration (eight sessions) and small sample size ($n=9$) restricted progress. The moderate effect size indicates potential for growth if language barriers are addressed, suggesting that improving English proficiency is essential for students to fully benefit from global academic resources. Muhammed et al. (2020) shows a positive relationship between English proficiency and science and numeracy literacy (Siddique Kadwa et al., 2020). This research is in line with the findings at Pondok Pesantren Al-Mubarak, where the santri's low English language skills hinder their understanding of numeracy and science literacy.

In this case, a program to strengthen numeracy and science literacy through English-language reading sources is a relevant solution. Although the statistical results show that the improvement has not been significant, this program still shows good potential to improve the English language skills of the santri, which in turn will support their understanding of numeracy and science materials. Despite the statistically insignificant improvement in scores, the moderate effect size found in this study (Cohen's $d = 0.636$; Hedges' $g = 0.606$) suggests that the program did contribute meaningfully to students' comprehension. The program, guided by CLIL's dual focus on language and content, modestly enhanced students' English proficiency, crucial for overcoming limited English resources and low initial proficiency. Activities like reading scientific texts, interpreting graphs, and practicing oral communication (e.g., self-introductions) increased students'

confidence in using academic English. CLIL was used as a framework for integrating English with content learning, not as a formal bilingual or EMI approach. This supports the view that integrating English language development with content learning—as practiced in CLIL (Content and Language Integrated Learning) approaches—can gradually enhance both language proficiency and subject mastery (Montoya, 2022).

The santri's exposure to numeracy and science through English-based texts may not yet yield significant test score improvements, but it reflects a foundational shift in learning behavior and access to knowledge. Therefore, a sustained and scaffolded intervention is needed, one that combines language learning strategies with conceptual reinforcement, to ensure that students can thrive in content areas where English is the medium of instruction. The program positively influenced students' English proficiency, a key factor in overcoming the barrier of limited English resources and low initial proficiency. Activities such as reading scientific texts, analyzing graphs, and practicing oral communication (e.g., self-introductions in English) increased students' confidence in using academic English.

Qualitative data from interviews indicated that students became more comfortable with scientific terminology, such as “proportion” or “hypothesis,” though their foundational language skills remained weak due to the pesantren's limited access to English textbooks and prior language training. Teachers noted that the bilingual support in the modules helped students navigate English content, but the short program duration (eight sessions) constrained significant language gains. This aligns with Muhammed et al. (2020), who found that English proficiency enhances numeracy and science literacy. The moderate effect size reflects modest improvements in language skills, suggesting that extended exposure to English-based materials could further address the proficiency barrier and enhance access to global academic content.

The Service-Learning Method and its Relationship to Experiential Learning

The Service-Learning method, which is used in this program, focuses on applying experiential learning to address real needs in the community (Nugroho et al., 2023). In this case, the Numereadsci program is designed to improve numeracy and science literacy in a way that is more relevant to santri, who come from backgrounds with limited access to English reading materials. The program connects academic knowledge with the practical needs of students in boarding schools, which is very relevant to the concept of Service Learning. Service Learning is a pedagogical approach that bridges academic learning with community engagement, emphasizing reflective and experiential learning processes. In the context of the Numereadsci program at Pondok Pesantren Al-Mubarak, Service Learning is implemented to enable santri to experience science and numeracy not merely as abstract subjects, but as applicable knowledge in their daily and communal lives.

Service Learning enhances cognitive complexity, personal growth, and civic responsibility by positioning students as active participants in addressing real-world challenges (Choi et al., 2023; Choo et al., 2016). This aligns with the structure of the Numereadsci program, which integrated contextual problems, peer discussions, and reflective activities to help santri connect English-based scientific content with the practical realities of their local environments. The integration of experiential learning through this method also fosters deeper understanding, particularly for students who learn better through hands-on or problem-based activities. Experiential Learning Theory emphasizes that learning occurs through a cycle of concrete experience, reflective observation, abstract conceptualization, and active experimentation (Gordon, 2022; Rahmi, 2024).

The Numereadsci program sought to facilitate this cycle by involving students in real-life problems that required the use of numeracy and science skills conveyed in English. Although the quantitative outcomes did not show significant differences, the qualitative engagement observed during the program—such as increased questioning, collaboration, and contextual problem-solving—supports previous findings by Nugroho et al. (2023), who found that Service Learning in pesantren-based education fosters not only academic improvement but also social awareness and confidence in using a second language. Therefore, the value of this approach lies in its holistic impact, which may not be immediately measurable through test scores but is critical for long-term educational development.

Although the statistical test results do not show significant changes, the development of critical and creative thinking skills emphasized in this approach remains relevant. This program can improve the readiness of santri in facing global challenges, in accordance with the main objective described in the literature review, which is to prepare a generation that is competent in various aspects of life.

Sample Limitations and Program Duration in Influencing Results

One of the major constraints faced in this study is the small sample size ($n=9$), which may limit statistical firepower and lead to non-significant results. This is consistent with the findings of Nur et al. (2023) who reveals that limited sample size in Islamic boarding schools may affect the quality of data obtained (Fadilah Amin et al., 2023). Therefore, there is a need for further evaluation with a larger sample to get a more accurate picture of the program's effectiveness.

This research-based community service offers early evidence of how targeted literacy interventions can support the achievement of Sustainable Development Goal (SDG) 4: Quality Education. By integrating English-based numeracy and science resources into the pesantren environment, the program addresses disparities in access to relevant learning materials often faced by students in rural or religious educational institutions. Although the statistical analysis does not yield significant differences, the increase in mean scores and the moderate effect size suggest that students begin to benefit cognitively from the program. This aligns with the SDG 4 target of ensuring inclusive and equitable quality education and promoting lifelong learning opportunities, particularly through innovative and context-sensitive educational strategies that are responsive to local needs.

Furthermore, the program contributes to SDG 10: Reduced Inequalities by promoting educational inclusion for students in pesantren settings, who are often overlooked in mainstream development agendas. The introduction of global literacy tools—like English-language science content—can empower students from marginalized backgrounds to participate more meaningfully in knowledge-based economies. As pointed out by UNESCO (2021), reducing inequality in education requires not only improving access but also aligning teaching methods and materials with the evolving global context. This research demonstrates a preliminary step in that direction. With a longer implementation period and a larger, more diverse sample, the program could yield stronger evidence of its contribution to narrowing educational gaps and enhancing global competencies among youth in underserved areas.

The findings highlight the program's potential to improve numeracy and science literacy in pesantren settings, despite resource and language constraints. The moderate effect size and qualitative improvements, such as increased engagement, suggest that students began to develop skills for global challenges. However, limited English resources and low proficiency require targeted solutions. Future programs should extend duration, increase sample size, and use interactive methods, such as digital resources or peer translation, to enhance language and content mastery. Providing more English textbooks and language training could further address the resource gap, aligning with SDG 4 (Quality Education) by promoting equitable access to global knowledge for pesantren students.

The findings also demonstrate the Numereadsci program's potential to improve numeracy, science literacy, and English proficiency in pesantren settings, despite the challenges of limited English resources and low proficiency. The mean score increase, moderate effect size, and observed behavioral improvements suggest that the program's activities laid a foundation for global readiness. To address the resource and proficiency barriers, future programs should extend duration, increase sample size, and incorporate digital English resources or language-focused activities, such as vocabulary workshops. These steps, aligned with SDG 4 (Quality Education), would enhance equitable access to global knowledge for pesantren students, amplifying the program's impact.

Based on the results of the study, several steps can be taken to improve the program in the future, in line with the recommendations outlined in the literature review. First, extending the duration of the program would allow students more time to deeply understand the material and enable more significant changes in their literacy development. Second, increasing the sample size is essential to obtain more representative data and enhance the statistical power of the findings. Third, the development of more effective learning methods—such as implementing a project-based approach and incorporating more interactive learning strategies—can boost student engagement and accelerate the santri's comprehension of numeracy and science content, especially when delivered in English.

CONCLUSION

This study-based community service aims to analyze the effectiveness of the Numereadsci program through Literacy English Resources for Global Readiness of Santri at Pondok Pesantren Al-Mubarak in improving numeracy and science literacy of students. Based on the results of the correlation test between pretest and posttest scores, there is an indication of an increase in numeracy and science literacy, although the changes that occur are not statistically significant. The increase in the average score recorded in the pretest and

posttest shows the positive impact of this program on santri understanding, although the main obstacles such as limited reading materials and low English language skills are still a challenge. The results also show a positive relationship between English proficiency and numeracy and science literacy, which is in line with findings in the literature. Thus, a program that integrates English-language reading resources is proven to contribute to improving the numeracy and science literacy of santri, although the improvements achieved are not yet statistically significant. In addition, the Service-Learning method applied in this program provides a relevant and contextual approach in overcoming the problem of limited learning resources in Islamic boarding schools. This program has the potential to improve santri's critical and creative thinking skills, which are needed to face global challenges. Overall, although the results are not yet fully significant, the findings indicate that the program has a positive impact and can be further improved by extending the duration of the program, increasing the sample size, and developing more interactive learning methods to produce more significant changes.

ACKNOWLEDGEMENT

We would like to thank UIN K.H. Abdurrahman Wahid Pekalongan for the support in the research. The support is very meaningful in helping to improve the quality of education in Islamic boarding schools and preparing students to face global challenges. Hopefully, this good cooperation can continue and provide greater benefits to the community.

AUTHOR CONTRIBUTIONS

Rhischa Assabet Shilla: Conceptualization, Methodology, Funding Acquisition, and Validation; **Lilik Riandita:** Writing – Original Draft, Data Curation, Project Administration, and Supervision; **Abdullah Syafi'i:** Resources; **Zidna Farhana:** Resources; **Nadia Faradhillah:** Writing – Original Draft, Data Curation, Project Administration, and Supervision; **Nurul Husnah Mustika Sari:** Writing – Original Draft, Data Curation, Project Administration, and Supervision; and **Arditya Prayogi:** Writing – Original Draft, Data Curation, Project Administration, and Supervision.

DECLARATION OF COMPETING INTEREST

The authors declare no known financial conflicts of interest or personal relationships that could have influenced the work reported in this manuscript.

DECLARATION OF ETHICS

The authors declare that the research and writing of this manuscript adhere to ethical standards of research and publication, in accordance with scientific principles, and are free from plagiarism.

DECLARATION OF ASSISTIVE TECHNOLOGIES IN THE WRITING PROCESS

The authors declare that Generative Artificial Intelligence and other assistive technologies were not excessively utilized in the research and writing processes of this manuscript.

REFERENCES

- Aba, M.M., Anshar, S.P., & Ralmugiz, U. (2022). Students' numerical literacy in solving islamic-based problems: studies on gender perspectives. *Proceedings of the International Conference on Madrasah Reform 2021 (ICMR 2021)*, **633**, 25–30. DOI: <https://doi.org/10.2991/assehr.k.220104.005>.
- Agustiawan, H. & Puspitasari, E.D. (2019). Pembentukan karakter siswa SMP melalui literasi sains. *Symposium on Biology Education*, **2**, 273-281. Retrieved from: <https://seminar.uad.ac.id/index.php/symbion/article/view/3548>.
- Aini, H.N., Sari, C.K., Ishartono, N., & Setyaningsih, R. (2024). Kemampuan berpikir kritis dalam memecahkan masalah berorientasi numerasi pada konten aljabar. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, **8**(1), 841–853. DOI: <https://doi.org/10.31004/cendekia.v8i1.2531>.
- Amin, N.F., Garancang, S., & Abunawas, K. (2023). Konsep umum populasi dan sampel dalam penelitian. *JURNAL PILAR: Jurnal Kajian Islam Kontemporer*, **14**, 15–31. Retrieved from: <https://journal.unismuh.ac.id/index.php/pilar/article/view/10624>.
- Ardiyani, F. (2024). *Membangun Literasi Numerasi melalui Kurikulum Merdeka untuk Menjawab Tantangan Abad 21*. Retrieved from: <https://www.researchgate.net/publication/385284759>.

- Bastida, E.L., Saysi, J.G., & Batuctoc, L.V.M. (2022). Pedagogical struggles and gaps in language literacy enhancement: the case of indigenous people's education teachers in the Philippines. *International Journal of Curriculum and Instruction*, **15**(1), 142–165. Retrieved from: <https://ijci.net/index.php/IJCI/article/view/1166>.
- Choi, Y., Han, J., & Kim, H. (2023). Exploring key service-learning experiences that promote students' learning in higher education. *Asia Pacific Education Review*. DOI: <https://doi.org/10.1007/s12564-023-09833-5>.
- Choo, J., Tan, Y.K., Ong, F., Tiong, S.S., Nair, S., Ong, J., & Chan, A. (2019). What works in service-learning? *Michigan Journal of Community Service Learning*, **25**(2), 95–132. DOI: <https://doi.org/10.3998/mjcsloa.3239521.0025.208>.
- Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, **24**(2), 97–140. DOI: <https://doi.org/10.1080/10888691.2018.1537791>.
- Fananta, M.R., Widjiasih, A.E., Setiawan, R., Hanifah, N., Miftahussururi, M., Nento, M.N., Akbari, Q. S., & Ayomi, J.M. (2017). *Materi pendukung literasi sains*. Jakarta: Direktorat Jenderal Pendidikan Dasar dan Menengah. Retrieved from: <https://repositori.kemdikbud.go.id/11631/>.
- Gal, I. (2002). Adults' statistical literacy: Meanings, components, responsibilities. *International Statistical Review*, **70**(1), 1–25. DOI: <https://doi.org/10.1111/j.1751-5823.2002.tb00336.x>.
- Gallego, F., Naslund-Hadley, E., & Alfonso, M. (2018). Tailoring instruction to improve mathematics skills in preschools: A randomized evaluation. *Inter-American Development Bank (IDB) Working Paper Series*, 905. DOI: <http://dx.doi.org/10.18235/0001090>.
- Ginsburg, L., Manly, M., & Schmitt, M.J. (2006). *The components of numeracy*. Retrieved from: <http://eric.ed.gov/?id=ED495440>.
- Gordon, S. (2022). Integrating the experiential learning cycle with educational supervision. *Journal of Educational Supervision*, **5**(3), 1–34. DOI: <https://doi.org/10.31045/jes.5.3.1>.
- Harefa, A.R. (2021). Aspects Profile of Literacy Science and Scientific Attitudes Students of Biology Education Study of IKIP Gunungsitoli. *Jurnal Pendidikan Intelektium*, **2**(1), 72-79. DOI: <https://doi.org/10.37010/int.v2i1.375>.
- Kadwa, M.S. & Alshenqeeti, H. (2020). The impact of students' proficiency in english on science courses in a foundation year program. *International Journal of Linguistics, Literature and Translation (IJLLT)*, **3**(11), 55-67. DOI: <https://doi.org/10.32996/ijllt.2020.3.11.5>.
- Lange, J.D. (2006). Mathematical literacy for living from OECD-PISA perspective. *Tsukuba Journal of Educational Study in Mathematics*, **25**, 15-35. Retrieved from: https://www.criced.tsukuba.ac.jp/math/apec/apec2006/Tsukuba_Journal_25.pdf.
- Liana, M., Elvi, M., Siregar, N.A.R., & Susanti. (2024). View of pre-service teacher regarding math and science literacy. *KnE Social Sciences*, **2024**, 1043–1051. DOI: <https://doi.org/10.18502/kss.v9i13.16030>.
- Malo, M., Dhiu, K.D., & Nafsia, A. (2024). Kemampuan numerasi mengenal angka siswa usia 7-8 tahun dalam pembelajaran menggunakan media bahan bekas. *Jurnal Ilmiah Pendidikan Citra Bakti*, **11**(2), 437–451. DOI: <https://doi.org/10.38048/jipcb.v11i2.3448>.
- Martirosyan, N.M., Hwang, E., & Wanjohi, R. (2015). English proficiency and academic performance of international students. *Journal of International Students*, **21**(1), 60–71. DOI: <https://doi.org/10.2307/3586734>.
- Montoya, O.I.R. (2022). Content and language integrated learning (clil) to develop writing skills in english. *SciELO Preprints*, **05**, 1–15. DOI: <https://doi.org/10.1590/SciELOPreprints.5155>.
- Murniasih, T.R., Suwanti, V., Syaharuddin, S., Rahaju, R., & Farida, N. (2022). Prospective teachers' perceptions of didactic obstacles in the online mathematics learning. *Jurnal Elemen*, **8**(2), 619–630. DOI: <https://doi.org/10.29408/jel.v8i2.5740>.
- Natalia, S., Darhim, Kusumah, Y.S., & Ditasona, C. (2023). Learning obstacle to ontogeny of mathematics teacher candidates on number theory. *Journal of Education Research and Evaluation*, **7**(3), 517–525. DOI: <https://doi.org/10.23887/jere.v7i3.66629>.
- Neri, N.C. & Retelsdorf, J. (2022). The role of linguistic features in science and math comprehension and performance: A systematic review and desiderata for future research. *Educational Research Review*, **36**(June 2021), 1–15. DOI: <https://doi.org/10.1016/j.edurev.2022.100460>.

- Nugroho, F.A., Iqbal, M., Ramadhan, F., Swastika, A., & Hidayat, O.T. (2023). Implementasi service learning di SD Muhammadiyah Program Khusus Ampel, Boyolali. *Buletin KKN Pendidikan*, *5*(1), 65–73. DOI: <https://doi.org/10.23917/bkknndik.v5i1.22008>.
- OECD. (2012). Literacy, Numeracy and Problem Solving in Technology-Rich Environments: Framework for the OECD Survey of Adult Skills. In *Literacy, Numeracy and Problem Solving in Technology-Rich Environments*. OECD Publishing. DOI: <https://doi.org/10.1787/9789264128859-en>.
- Osborne, J. & Allchin, D. (2024). Science literacy in the twenty-first century: informed trust and the competent outsider. *International Journal of Science Education*, 1–22. DOI: <https://doi.org/10.1080/09500693.2024.2331980>.
- Prihandhika, A., Prabawanto, S., Turmudi, T., & Suryadi, D. (2020). Epistemological obstacles: an overview of thinking process on derivative concepts by APOS theory and clinical interview. *Journal of Physics: Conference Series*, *1521*(3), 032028. DOI: <https://doi.org/10.1088/1742-6596/1521/3/032028>.
- Rahmawati, A., Wahyuningsih, S.H., & Garad, A. (2023). The effect of financial literacy, training and locus of control on creative economic business performance. *Social Sciences and Humanities Open*, *8*(1), 100721. DOI: <https://doi.org/10.1016/j.ssaho.2023.100721>.
- Rahmi, W. (2024). Analytical study of experiential learning : experiential learning theory in learning activities. *EDUKASIA: Jurnal Pendidikan dan Pembelajaran*, *5*(2), 115–126. DOI: <https://doi.org/10.62775/edukasia.v5i2.1113>.
- Ramli, M., Saridewi, N., & Rifki, A. (2021). Analysing traditional islamic boarding school students' scientific literacy using pisa framework. *Jurnal Penelitian Pendidikan IPA*, *6*(1), 31-39. DOI: <https://doi.org/10.26740/jppipa.v6n1.p31-39>.
- Reddy, D. (2021). Scientific literacy, public engagement and responsibility in science. *Cultures of Science*, *4*(1), 6–16. DOI: <https://doi.org/10.1177/20966083211009646>.
- Rifki, A. (2020). *Analisis kemampuan literasi sains siswa di pondok pesantren menggunakan framework programme for international student assessment (PISA) 2015*. Undergraduate Thesis. Jakarta: FITK UIN Syarif Hidayatullah Jakarta. Retrieved from: <https://repository.uinjkt.ac.id/dspace/handle/123456789/54363>.
- Setyaedhi, H.S. (2024). Literacy and numeracy questions based on minimum competency assessments to improve the competency of private high school teachers. *Jurnal Penelitian dan Pengembangan Pendidikan*, *8*(2), 398–409. DOI: <https://doi.org/https://doi.org/10.23887/jppp.v8i2.71373>.
- Suparya, I.K., Suastra, I.W., & Arnyana, I.B.P. (2022). Rendahnya literasi sains: faktor penyebab dan alternatif solusinya. *Jurnal Ilmiah Pendidikan Citra Bakti*, *9*(1), 153–166. DOI: <https://doi.org/10.38048/jipcb.v9i1.580>.
- Umbara, U. & Suryadi, D. (2019). Re-interpretation of mathematical literacy based on the teacher's perspective. *International Journal of Instruction*, *12*(4), 789–806. DOI: <https://doi.org/10.29333/iji.2019.12450a>.
- Vincent-Lancrin, S., González-Sancho, C., Bouckaert, M., de Luca, F., Fernández-Barrerra, M., Jacotin, G., Urgel, J., & Vidal, Q. (2019). *Fostering students' creativity and critical thinking*. Paris: OECD Publishing. DOI: <https://doi.org/10.1787/62212c37-en>.
- Yu, H. (2024). Enhancing creative cognition through project-based learning: An in-depth scholarly exploration. *Heliyon*, *10*(6), e27706. DOI: <https://doi.org/10.1016/j.heliyon.2024.e27706>.