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Teacher Mentoring Through Integrated Numeracy and Science Literacy Design at Madrasah Ibtidaiyah Samarinda

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Abstract

This community engagement program aimed to strengthen Madrasah Ibtidaiyah teachers' understanding and competence in designing and implementing learning that integrates science, numeracy, and environmental literacy. Conducted at MIN 1 and MIN 2 Samarinda from July to October 2025, the program involved 45 teachers of Grades I-VI. A Participatory Action Research (PAR) approach was implemented through five stages: to know, to understand, to plan, to act, and to change. Data were collected through classroom observations, interviews, and focus group discussions; analysis of learning documents; and pre- and post-reflection questionnaires using a 1-5 scale. The results showed consistent improvement in teachers' pedagogical competence. Overall program records indicated gains of approximately 23-35%; scores for integrating the three literacies increased from 2.8 to 4.2, literacy-based formative assessment from 2.6 to 4.1, and active-learning strategies from 2.9 to 4.3. Mentoring also promoted project- and inquiry-based learning, more constructive feedback, and professional reflection. These findings indicate that locally responsive participatory mentoring can serve as a teacher professional development model for strengthening integrated literacy practices in madrasahs. Sustainability requires institutionalized teacher working groups, peer mentoring, and continued support from school leaders and the local Ministry of Religious Affairs.

Keywords deep learning; environmental literacy; numeracy literacy; participatory action research

1. INTRODUCTION

Strengthening literacy is a central agenda in basic education because literacy extends beyond reading written text to include the ability to use information, quantitative data, scientific evidence, and real-life contexts to make informed decisions. This challenge remains substantial in Indonesia. PISA 2022 showed that only 18% of Indonesian students reached at least Level 2 in mathematics, 25% in reading, and 34% in science, all well below the OECD averages. In the madrasah context, the Indonesian Madrasah Competency Assessment (Mutakin & Elisyah, 2025) assesses four major domains-reading literacy, numeracy, science, and socio-cultural literacy-which underscores the need for classroom practices that consistently strengthen multiple forms of literacy (OECD, 2023); (Kementerian Agama Republik Indonesia., 2024).

National curriculum policy increasingly emphasizes meaningful and contextual learning. Regulation of the Minister of Primary and Secondary Education No. 13 of 2025 foregrounds a pedagogical deep-learning approach characterized as mindful, meaningful, and joyful learning. Within this framework, science literacy helps students explain phenomena and use evidence; numeracy literacy supports the interpretation of data and quantitative problem solving; and environmental literacy links knowledge with attitudes and action related to ecological issues (Kementerian Pendidikan Nasional., 2006); (Pertiwi et al., 2023). Indonesian primary education studies have likewise highlighted the importance of reading-numeracy integration and literacy-oriented learning in classroom practice (Anugrahana, 2024). These three literacies intersect naturally when learning is organized around authentic problems such as waste management, energy use, or monitoring conditions in the school environment.

A growing body of evidence indicates that students' literacy competence is closely connected to teachers' ability to design appropriate tasks, assessments, and learning resources. In Indonesian elementary schools, numeracy difficulties remain evident when students are required to translate situations into mathematical models, select strategies, and conclude (Sulastri et al., 2024); (Anggraini & Nazip, 2022). Project-based thematic integration has also been explored as a pathway for developing numeracy literacy (Kunahefi & Lestari, 2023), while HOTS-oriented literacy and numeracy tasks have been developed to move learning beyond routine exercises (Kusuma & Nurmawanti, 2023b). In science literacy, differentiated, project-based, and STEM-oriented approaches show potential for strengthening students' ability to understand and use scientific knowledge (Hariyanto et al., 2024); (Badaruddin et al.,

2024) and scientific-literacy elements have also been examined in Indonesian school textbooks (Mahyudi et al., 2023). Environmental literacy, meanwhile, requires learning that goes beyond knowledge to develop cognitive skills and pro-environmental action (Nugraha et al., 2022); (Yuliasih et al., 2025).

Effective teacher professional development cannot be reduced to one-off lectures. Teachers need learning experiences connected to classroom needs, opportunities to develop materials, chances to try out new practices, feedback, and collaborative reflection. A systematic review of elementary/primary teacher professional development for STEM integration emphasizes active engagement, practice, collaboration, and continuity (Boz, 2023). Research with Madrasah Ibtidaiyah teachers similarly shows that professional learning communities can support the development of teachers' scientific literacy competence (Muspiroh et al., 2024). Literacy and technology mentoring for madrasah teachers in Indonesia further illustrates the value of participatory and sustained support (Ramika, 2022);(Ridwan, 2023), while learning-by-doing training has been used to strengthen literacy-oriented thematic learning in elementary education (Radaus & Senen, 2022). The broader need to strengthen future teachers' reading-writing and digital literacy has also been documented (Deti Indah Kiranti et al., 2023).

Nevertheless, a gap remains in mentoring programs that simultaneously integrate science, numeracy, and environmental literacy into Madrasah Ibtidaiyah learning design, particularly in Samarinda. Initial observations at MIN 1 and MIN 2 Samarinda indicated that teaching remained largely teacher-centered, contextual media were used only to a limited extent, and the integration of numeracy, science, and environmental issues was not yet systematic. This gap called for more than a transfer of content; it required a change process in which teachers were involved from problem identification through reflection. Participatory Action Research (PAR) was therefore selected because it enables teachers to act as partners in identifying needs, co-designing solutions, testing practices, and evaluating change in cyclical cycles. Recent studies show that PAR can function as a vehicle for professional development by linking teachers' learning with authentic workplace problems and collaboration(Miedijensky & Sasson, 2022); (Pineda et al., 2022).

Based on these needs, the community engagement program pursued four objectives: (1) to strengthen teachers' understanding of integrated science, numeracy, and environmental literacy; (2) to improve teachers' ability to develop lesson plans/teaching modules and student worksheets based on deep learning and integrated literacy; (3) to mentor teachers in implementing active learning in the

classroom; and (4) to establish a mechanism for continuous learning through teacher collaboration. The program's principal contribution is a contextual PAR-based mentoring model that connects integrated literacy, active learning, reflective practice, and the strengthening of teachers' professional communities.

2. METHODS

2.1. Design, Setting, and Participants

The program employed a Participatory Action Research (PAR) approach, organized into five phases: to know, to understand, to plan, to act, and to change (Afandi, 2022). PAR was chosen over a one-directional community service model because the program sought not merely to transfer knowledge but to change practice through teachers' active participation as the primary agents of improvement. This principle is consistent with participatory action research traditions that position practitioners' experience, reflection, and iterative improvement as sources of professional learning(Freire, 2005); (Miedijensky & Sasson, 2022)

The program was implemented at MIN 1 Samarinda and MIN 2 Samarinda from July to October 2025. The primary participants were 45 teachers teaching Grades I-VI across the two madrasahs. They participated in needs identification, focus group discussions (FGDs), training, development of learning materials, implementation mentoring, and reflection. Because the program targeted all teachers at the two participating madrasahs, participant selection was based on total participation within the target group. The madrasah principals supported policy, scheduling, and institutional follow-up, while students were indirect beneficiaries through changes in classroom practice.

2.2. PAR Cycle

The chronological alignment between the PAR phases and field implementation is summarized in Table 1, while Figure 1 presents the participatory cycle visually.

Table 1. Alignment of PAR phases and program implementation

PAR phase	Time	Main activities
To Know	July 2025	Classroom observation, initial interviews, and mapping of readiness and barriers to literacy integration.
To Understand	July 2025	FGDs to interpret initial findings, identify teachers' needs, and prioritize problems.

PAR phase	Time	Main activities
To Plan	August-September 2025	Program design, preparation of sample lesson plans/teaching modules and student worksheets, and planning for active-learning and integrated-literacy training.
To Act	October 2025	Training on 10 October and 21-22 October 2025; development of learning materials; implementation, practice/mentoring; observation; and feedback.
To Change	Late October 2025	Joint reflection, pre-post evaluation, follow-up planning, and strengthening of teacher collaboration.

Figure 1. Participatory Action Research cycle and implementation timeline

2.3. Instruments, Data Analysis, and Credibility

Table 2. Data sources, instruments, and analytical procedures

Source/instrument	Focus	Analysis
Classroom observation	Learning flow, literacy integration, student engagement, and use of contextual media/resources.	Descriptive checklist and field notes.
Interviews/FGDs	Literacy understanding, learning barriers, material needs, strategies, and media.	Semi-structured guide; thematic analysis.
Document analysis	Lesson plans/teaching modules, student worksheets, and examples of literacy activities.	Review of alignment among objectives, activities, assessment, and the integration of the three literacies.
Pre-post reflection questionnaire	Literacy integration; active strategies; formative assessment; feedback; growth mindset/reflection.	1-5 score range; mean pre-post scores and percentage of the maximum score.
Joint reflection	Changes in practice, constraints, follow-up actions, and sustainability.	Reflective discussion and participant confirmation of findings.

Quantitative data from the reflection questionnaire were analyzed descriptively using mean pre- and post-mentoring scores. To support interpretation, mean scores on the 1-5 scale were also converted into percentages of the maximum possible score (score/5 x 100). Qualitative data from observations, FGDs, document analysis, and reflection were organized thematically around needs, changes in practice, constraints, and follow-up actions. Credibility was strengthened by comparing evidence across techniques and sources-observation, FGD, documents, and questionnaires-and by confirming the interpretation of findings during the joint reflection forum with participating teachers.

3. FINDINGS AND DISCUSSION

3.1. Initial Conditions and Teachers' Needs

First, instruction largely followed textbook sequences and was dominated by teacher explanation. Second, literacy activities most often consisted of reading and answering questions, whereas numeracy and science literacy were not yet explicitly integrated. Third, the school environment had not been optimally used as a learning resource. Fourth, the use of visual and digital media remained limited. The FGDs reinforced these findings: teachers requested examples of integrated learning materials, guidance for designing literacy-based student worksheets, a clearer understanding of pedagogical deep learning, and strategies linking science, numerical data, and environmental issues.

These initial conditions are consistent with studies showing that literacy in elementary schools requires learning designs that move beyond routine exercises and connect knowledge with context (Sulastri et al., 2024). Identified difficulties in students' processes of modeling and solving numeracy problems, while (Pertiwi et al., 2023) emphasized the importance of planning and evaluating science literacy within the Merdeka Curriculum. Research on environmental literacy likewise suggests that knowledge and attitudes do not automatically translate into cognitive skills and pro-environmental behavior (Nugraha et al., 2025); (Nugraha et al., 2022); (Yuliasih et al., 2025). Accordingly, the mentoring program focused on activities that asked students to observe phenomena, read data, calculate or compare information, and formulate actions.

3.2. Training, Development of Learning Materials, and Classroom Implementation

The action phase was carried out in October 2025. Training at MIN 1 was held on 10 October 2025 and addressed deep-learning lesson design and integrated literacy,

while activities at MIN 2 were conducted on 21-22 October 2025 with additional emphasis on the use of digital media and learning design. During mentoring, teachers developed lesson plans/teaching modules and student worksheets that incorporated higher-order learning objectives, problem- or project-based activities, contextual data sources, and formative assessment. Classroom implementation emphasized inquiry- and project-based learning, giving students opportunities to observe, ask questions, analyze, test solutions, and reflect on outcomes.

The choice of these strategies is supported by evidence indicating that well-structured project-based learning can improve learning outcomes, thinking skills, and attitudes when adequate guidance is provided (Santhosh et al., 2023); (Safitri, 2024). In the context of pre-service elementary teachers, STEM-integrated project-based learning has also been associated with stronger scientific literacy (Badaruddin et al., 2024). However, the success of active learning does not depend on methodological labels alone. Teachers still need clear objectives, guiding questions, scaffolding, formative assessment, and feedback. These elements became central to mentoring as teachers revised their materials following practice and reflective discussion.

3.3. Changes in Teacher Competence

Table 3. Comparison of teacher-competence scores before and after mentoring

Indicator	Pre	Post	Δ score	Pre achievement	Post achievement	Change
Integration of three literacies	2.8	4.2	1.4	56%	84%	+28 pp
Formative assessment	2.6	4.1	1.5	52%	82%	+30 pp
Active learning	2.9	4.3	1.4	58%	86%	+28 pp

The reflection questionnaire recap showed an overall improvement of approximately 23-35% across several program indicators. For the three indicators with complete mean-score data, the change becomes clearer when scores are converted to percentages of the maximum: the ability to integrate science, numeracy, and environmental literacy increased from 56% to 84% (+28 percentage points); the ability to design literacy-based formative assessment rose from 52% to 82% (+30 percentage points); and the ability to implement active-learning strategies increased from 58% to 86% (+28 percentage points). The pattern suggests that change extended beyond conceptual knowledge to assessment planning and the selection of classroom strategies.

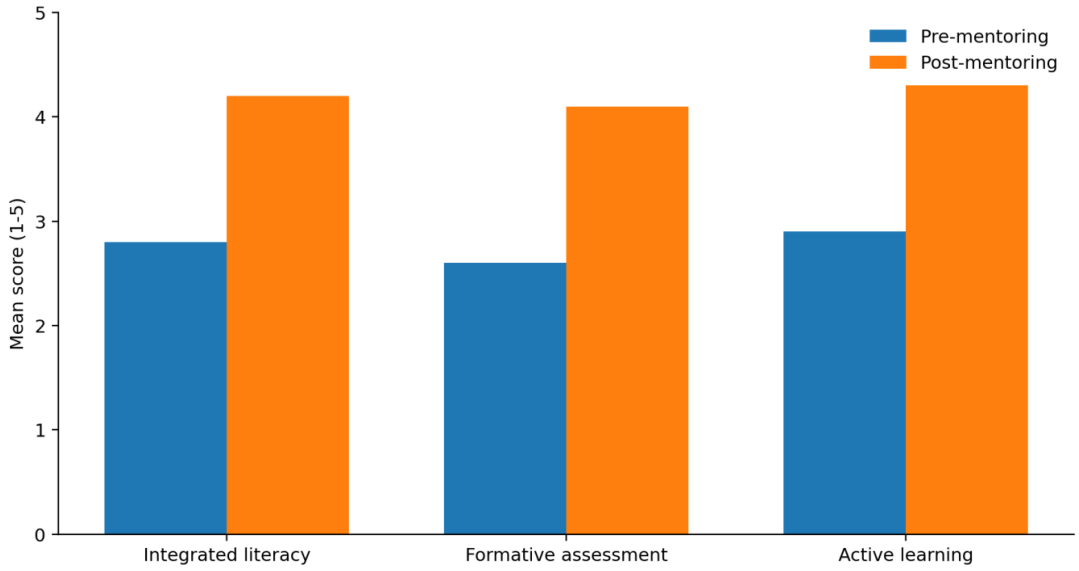

Figure 2. Mean pre-test and post-test mentoring scores on three teacher-competence indicators

3.4. Professional Development, Reflection, and Growth Mindset

Changes in teachers' learning materials and classroom practices support the view that effective professional development should be contextual, active, and collaborative. This finding is consistent with (Boz, 2023), who emphasizes opportunities for practice in professional development for STEM integration, and with (Muspiroh et al., 2024), who highlight the role of professional learning communities in strengthening scientific literacy among Madrasah Ibtidaiyah teachers. PAR reinforces these mechanisms because teachers do not merely receive content; they participate in diagnosing problems, designing solutions, testing practices, and interpreting results (Miedijensky & Sasson, 2022); (Pineda et al., 2022). Consequently, competence development is more closely connected with teachers' actual classroom routines.

Mentoring also emphasized feedback language that focused on process, strategy, improvement, and willingness to try. This dimension is relevant to a growth mindset, but it should be interpreted proportionately. Two major meta-analyses published in 2023 found that growth-mindset interventions generally have small effects and are strongly influenced by design quality, target population, and implementation fidelity(Macnamara & Burgoyne, 2023); (Burnette et al., 2023). The present program, therefore, does not interpret growth mindset as a stand-alone causal mechanism for achievement. Rather, the observed change concerns professional practice: teachers became more open to reflection, more constructive in feedback, and more willing to revise learning designs. This cautious interpretation avoids overstating causal claims.

3.5. Contribution of Integrated Literacy to HOTS and Contextual Learning

Integrating science, numeracy, and environmental literacy creates a natural space for higher-order thinking skills (HOTS). When students examine waste management, for example, they need to understand scientific processes, collect or interpret quantitative data, compare alternatives, evaluate impacts, and design actions. Literacy thus becomes a tool for analyzing problems rather than a set of isolated content areas. Research on literacy and HOTS in elementary education and meta-analytic evidence on project-based learning support the relationship between authentic activity, problem solving, and higher-order thinking (Mubarok & Anggraini, 2020); (Zhang & Ma, 2023). Indonesian work on HOTS-oriented literacy and numeracy tasks further supports the need to align assessment with these cognitive demands (Kusuma & Nurmawanti, 2023a). Environmental learning models oriented toward Education for Sustainable Development (ESD) likewise show how knowledge, attitudes, and environmental action can be integrated more systematically (Kunahefi & Lestari, 2023); (Heung et al., 2026)(UNESCO, 2020).

In practical terms, the mentoring model can be adapted for other madrasahs or elementary schools through five core components: mapping local needs, co-designing learning materials, guided practice, observation and feedback, and community reflection. The literacy content does not need to be identical across settings; schools may use issues involving water, waste, energy, health, transportation, or food, depending on local conditions. What should remain constant is the integration of scientific evidence, numerical data, environmental context, and reflective processes. This orientation is also consistent with the ESD agenda, which promotes knowledge, skills, values, and action for sustainability(UNESCO, 2021).

3.6. Program Limitations and Sustainability

The program has several limitations. First, it involved only two madrasahs in Samarinda, so its results cannot be statistically generalized to all Madrasah Ibtidaiyah. Second, the July-October 2025 implementation period was relatively short for assessing the durability of changes in teaching practice. Third, part of the outcome evidence came from teachers' self-reflection questionnaires and may therefore be influenced by self-perception. Fourth, the source data did not include standardized pre- and posttests to measure the program's direct effect on students' literacy achievement. The findings should therefore be interpreted primarily as changes in teacher competence and practice rather than as causal evidence of improved student learning outcomes.

To sustain the gains, MIN 1 and MIN 2 Samarinda are encouraged to

institutionalize the Teacher Working Group (*Kelompok Kerja Guru*, KKG) or a community of practice with regular activities such as teaching module reviews, lesson studies, peer observations, and evidence-based reflection. Madrasah principals may appoint one or two internal facilitators to coordinate peer mentoring. At the local level, the Ministry of Religious Affairs can support replication through cross-madrasah KKG activities, dissemination of tested materials, and periodic mentoring. This strategy is consistent with evidence that professional learning communities can sustain the development of Madrasah Ibtidaiyah teachers' scientific literacy competence.

4. CONCLUSION

PAR-based mentoring at MIN 1 and MIN 2 Samarinda addressed the program's four objectives. First, teachers developed a more integrated understanding of science, numeracy, and environmental literacy. Second, their ability to prepare lesson plans/teaching modules, student worksheets, and literacy-based formative assessments improved; across the three indicators with complete data, achievement increased by 28-30 percentage points. Third, teachers began to apply active project- and inquiry-based strategies supported by more constructive feedback and reflection. Fourth, the collaborative PAR process established a foundation for sustained professional learning among teachers. The model can be replicated with adaptation to local issues. Still, continuity requires teacher working groups or communities of practice, peer mentoring, support from madrasah leaders, and facilitation by the local Ministry of Religious Affairs. Future evaluation should extend the mentoring period and measure student literacy outcomes using standardized pre- and post-tests.

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