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Development of Science Literacy Competencies of Science Teachers through Participatory Andragogy Approach

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Abstract

The science literacy in Indonesia is still far below the OECD average, reflecting the challenges of the national education system. The Independent Curriculum highlights the importance of science literacy but faces limited implementation at the local level, including Purbalingga Regency. The activity method used in this community service is Participatory Action Research (PAR). This community service activity was conducted between February and May 2024 and aimed at improving the science literacy of junior high school science teachers in Purbalingga Regency. It was carried out offline and online webinars with a participatory andragogy approach. The number of participants in the offline session was 116, while 165 people attended the online session. The activities at the online meeting focused on Science learning and literacy-based assessment for junior high school science teachers in Purbalingga Regency, while the online activity focused on Differentiated and science-based science learning for science teachers. The initial analysis identified problems in science learning that were overcome with intensive training and assistance based on science literacy. This community service can significantly improve participants' understanding, with the post-test score of the seminar on February 17, 2024, reaching an average of 88.46, and the webinar on May 11, 2024, recording 86.54. The evaluation showed effective support for the Independent Curriculum with the integration of science literacy in science learning. This community service not only improves the science literacy of science teachers in Purbalingga but also supports the vision of inclusive education and the development of HOTS. Sustainable implementation is expected to help prepare a competent generation for a better future.

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INTRODUCTION

Science education shapes future generations' HOTS. This is reinforced by PISA (Program for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study), which identify science literacy as one of the main assessments used to evaluate the global education system. Science literacy is defined as a person's ability to learn and use science in everyday life (Dewantara et al., 2019; Lestari et al., 2021; Mardiani

et al., 2024; Rini et al., 2021). The person who first used the term science literacy was Paul de Hart Hurt from Stamford University; according to him, science literacy is defined as the act of understanding science and applying it to the needs of society (Pratiwi et al., 2019; Kartimi & Winarso, 2021). Science literacy is a person's ability to interpret science in everyday life; in this case, students not only understand science concepts but are able to make solutions from science concepts to problems faced daily.

Science literacy includes not only understanding scientific concepts but also the ability to apply that knowledge in the context of everyday life (Wahidah, 2022). There are four components. A person is said to have science literacy if they demonstrate the following three competencies: 1) explaining science phenomena; 2) evaluating and designing science knowledge and skills independently; and 3) interpreting science data and evidence (Kelana & Pratama, 2019; Ummah, 2019; Wasis et al., 2020). Ultimately, learners have a high attitude and sensitivity to themselves and their environment when making decisions based on scientific considerations. Science is a branch of knowledge that studies the universe. Science has four dimensions content/knowledge, competence/process, context, and attitude (Agustin et al., 2020; Patonah et al., 2020; Zuriyani, 2017). Science/knowledge content refers to the implementation of PISA contains: a) structure and properties of matter, b) atmospheric changes, c) physical and chemical changes, d) energy transformation, e) force and motion, f) form and function; g) biology and humans; h) psychological changes; i) diversity of living things; j) genetic control; k) ecosystems; l) earth and the universe; and m) geological changes. Science content refers to the elementary school science curriculum, which contains four themes: 1) living things and their development; 2) material changes; 3) energy changes; and 4) the universe, earth, and space. These concepts continue to develop along with the changing times and human behaviour. Context in science emphasizes the importance of understanding science so that it can be used in everyday life. The context of science refers to an individual's interaction with real life. Context in science literacy includes three things: personal, local, and global. The personal context is within each individual. The local context can be regional or national, while the global context is worldwide, across countries, continents, and even across cultures and civilizations.

A benchmark is needed to determine the level of science literacy skills. The benchmarks used include four levels: Special intervention, basic, proficient, and advanced. These different levels are used as a diagnostic to implement differentiated learning. Differentiated learning is a learning concept that adapts to the needs of students (teaching at the right level). In differentiated learning, three aspects can be differentiated by the teacher so that students can understand the subject matter they are learning, namely the content aspect to be taught, the process aspect or meaningful activities that students in the class will carry out, and the third aspect is the assessment in the form of making products at the end that can measure the achievement of learning objectives. Differentiated learning differs from individualized learning used to teach children with special needs. In differentiated learning the teacher does not deal with learners specifically one by one in order for them to understand what is being taught. Learners can be in large, small or independent learning groups. There are five principles of differentiated learning, namely: 1) learning environment, 2) quality curriculum, 3) continuous assessment, 4) responsive learning, and 5) leadership and classroom routines (Kristiani et al., 2021). 4 things can be controlled in differentiated learning, namely: content, product, process, and learning environment. Therefore, differentiated learning can generally be done according to these four controllables. Content differentiation refers to what the teacher will teach and what the learners will learn. Product differentiation refers to the result of the learning process. The products can be individual or group. Differentiation of learning environment includes the classroom's personal, social and physical arrangement. The learning environment should

also be adapted to the learners' readiness to learn, their interests, and their learning profile so that they have high motivation to learn. Differentiated learning is an alternative to learning to accommodate students' needs. Learners with identified literacy levels can then be grouped with appropriate treatment to optimize learning achievement.

However, Indonesian students' science literacy achievement still shows a significant deficit compared to the average of OECD countries, with a score of 396 in PISA 2018, far below the average of 489 (OECD, 2024).

The existence of Merdeka Curriculum as an educational curriculum proclaimed in 2024 (Herwanti et al., 2022; Novita et al., 2022; Nugrohadi et al., 2022) introduced as a new educational initiative, placing science literacy as a critical component in science learning (Fembriani, 2022; Saputri, 2021; Sugih et al., 2023; Wae & Kaleka, 2022). However, its implementation is still limited, and science learning is often conventional without thoroughly integrating science literacy in the teaching and learning process. The low literacy culture among students is one of the indicators of low science literacy. Meanwhile, among educators, teachers' ability to implement science literacy in learning is still minimal. Science teachers in Purbalingga district show a deep awareness of this challenge. The problems partners face include integrating literacy and implementing differentiated learning in science learning.

The community service activities proposed in this study aim to address these challenges by improving the knowledge and skills of science teachers in designing science literacy-based learning and assessment. Through a structured and HOTS development-oriented approach, this community service is expected to provide concrete solutions to improving the quality of science learning at the local level.

METHODS

In general, the approach in this activity is Participatory Action Research (PAR). This community service activity was offline and online from February to May 2024. The service team provides material exposure and mentors science teachers in Purbalingga Regency. The methods used in this activity are workshops and mentoring with a participatory andragogy approach (Handayani et al., 2023; Liufeto et al., 2022; Umam & Anshori, 2021), which allows participants to play an active role throughout the activity.

Partner Needs Analysis Phase

This stage begins with conducting interviews and observations with partners, namely the Purbalingga Regency Science Teacher Conference (MGMP), to identify problems faced in science learning. The service team worked with partners to determine the most relevant and urgent main problems. Based on this identification, the solution offered is intensive training and mentoring to improve the science literacy of science teachers.

Preparation Stage

This stage involves intensive coordination and communication with partners to plan a program of activities based on agreed-upon solutions. Preparation includes scheduling activities, selecting materials, and developing a training format that suits the participants' needs.

Table 1 Details of the community service activity materials

No.	Material Topic	Target	Duration
1.	Introduction to Science Literacy	Teacher Insight	60'
2.	HOTS-based Science Teaching Methods & Strategies	Teacher Insight	60'
3.	Science literacy-based assessment	Teacher Insight	60'

No.	Material Topic	Target	Duration
4.	Practice and Assistance in Designing Science Literacy Learning	Teacher Skills	90'
5.	Practice and Assistance Developing science literacy instruments	Teacher skills	90'

Implementation Stage

This stage is divided into two practical steps, as shown in Table 2. The implementation of this community service activity consists of two main stages aimed at improving science literacy for science teachers in Purbalingga Regency. The first stage was an offline workshop held on February 17, 2024, at Dekopinda Purbalingga Regency. The workshop was attended by science teachers from Pokja 1 of Purbalingga District, Pokja 2 of Kalimanah and Kemangkon Districts, Pokja 3 of Padamara and Kutasari Districts, Pokja 4 of Bojongsari and Mrebet Districts, Pokja 5 of Bobotsari and Karanganyar Districts, Pokja 6 of Kaligondang and Pengadegan Districts, Pokja 7 of Karangreja and Karangjambu Districts, Pokja 8 of Kertanegara and Karangmoncol Districts, Pokja 9 of Rembang District, and Pokja 10 of Bukateja and Kejobong Districts. This workshop explores the concept of science literacy and its application in science learning assessment. The second stage was an online webinar held on May 11, 2024, through the Zoom platform, attended by 154 participants from various educational institutions in 41 districts across Indonesia. The webinar focused on differentiated science learning and integrating science literacy into the curriculum. Participants were invited to practice the concepts learned in a 90-minute hands-on and mentoring session to ensure deep understanding and effective application of the concepts in the classroom context.

Table 2 Implementation of the community service activities

No.	Implementation Stage	Date	Location	Main Focus
1.	Offline Workshop "Literacy-based Learning and Assessment for Junior High School Science Teachers in Purbalingga"	February 17, 2024	Dekopinda Kab. Purbalingga	Science literacy in science learning and assessment
2.	Online Webinar "Differentiated science learning and science literacy for science teachers"	May 11, 2024	Zoom Platform	Differentiated learning and science literacy integration in the curriculum

Evaluation and Follow-up Stage

Evaluation in this community service activity is focused on measuring the improvement of participants' understanding before and after participating in the assistance. The evaluation was carried out through pretest and post-test to measure the level of understanding before and after community service activities. The questionnaire consisted of several structured questions covering various aspects of science literacy learned during seminars and webinars (Trochim, 2006; Trochim & Donnelly, 2020). The pretest was conducted before the activity began, while the post-test was conducted after the participants attended the seminar and webinar organized. The questions given were 13 items compiled by the team to reveal the participants' level of understanding before and after participating in the knowledge activity program. The questions in the pretest and post-test are shown in Table 3 and Table 4. The instruments used to conduct the pretest and post-test were the same. This evaluation method aims to assess how effective community service activities are in improving participants' understanding of science literacy and HOTS-based learning approaches in science subjects.

RESULTS AND DISCUSSION

Implementation

This community service activity aims to improve science literacy for science teachers in Purbalingga Regency through two main stages: seminars and webinars. Both stages are comprehensively designed to support the understanding and practical application of science literacy in science learning at the junior high school level.

In the first phase, the workshop was held offline at Dekopinda Purbalingga on February 17, 2024, attended by 116 junior high school science teachers from 10 different working groups in the district. The seminar aimed to explore the concept of science literacy and its application in science learning assessment. The three main presenters, Dr. Siti Patonah, S. Pd, M. Pd; Mega Novita, Ph.D; and Dr. Intan Indiati, M. Pd, discussed in depth learning strategies and evaluation techniques that focus on using science literacy to improve student understanding. The materials presented included Literacy-Based Learning and Assessment by Dr. Siti Patonah, S. Pd, M. Pd, Application of Literacy in Daily Life and its Relationship with Science Learning Outcomes (Phase D) by Mega Novita, Ph. D, and Writing Literacy and Numeracy Instruments by Dr. Intan Indiati, M. Pd. Active discussions between participants and presenters resulted in a deep understanding of the challenges and opportunities in improving the quality of science teaching in schools. Figure 1 depicts a moment from an offline workshop held at Dekopinda Kabupaten Purbalingga on February 17, 2024. It shows the interaction between participants and presenters in a seminar setting focused on improving the quality of science teaching in schools.

Figure 1 Offline workshop activity

The second mentoring was held in an online webinar through the Zoom platform on May 11, 2024, reaching 154 participants from various educational institutions in 41 districts across Indonesia. This webinar focused on differentiated science learning and integrating science literacy into the curriculum. The same presenters as the previous seminar presented practical techniques for developing science literacy-based learning in the classroom. The webinar materials include Material 1: Designing Literate Science Learning by Dr. Siti Patonah, S. Pd, M. Pd, Material 2: Science Differentiated Learning Planning (Phase D) by Mega Novita, Ph. D, and Material 3: Designing Assessment in Differentiated Learning and Science Literacy by Dr. Intan Indiati, M. Pd. Interactive discussions during the webinar allowed participants to share best practices and address challenges in implementing these new concepts.

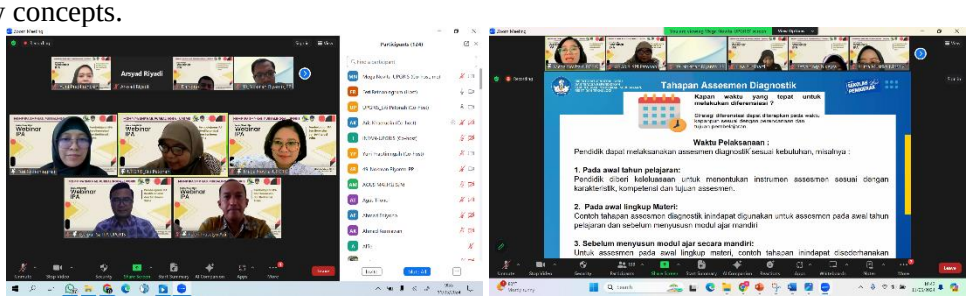

Figure 2 Online webinar activity

Figure 2 shows a moment from the webinar held online through the Zoom platform on May 11, 2024. The image reflects the atmosphere of the interactive discussion between participants from different regions, who shared their experiences and solutions to the challenges of implementing science literacy concepts in the context of science learning.

Evaluation of participants' understanding

Table 3 illustrates the evaluation results of the offline workshop "Literacy-based Learning and Assessment for Junior High School Science Teachers in Purbalingga" held on February 17, 2024. This evaluation shows an encouraging improvement in participants' understanding of science literacy concepts. Before the event started, participants took a pretest with an average score of 50.77. After attending the seminar, which covered various topics such as understanding literacy concepts, literacy-based learning approaches, assessment techniques and implementation of literacy in the curriculum, they experienced significant improvement. The post-test conducted at the end of the event showed an average score of 88.46, reflecting a deeper and more comprehensive understanding of the material presented.

Table 3 Evaluation the results of the offline workshop

No.	Parameters	Pretest Score	Post-test Score
1.	Literacy Concept Understanding	55	90
2.	A literacy-based learning approach	60	95
3.	Literacy-based assessment techniques	50	85
4.	Implementation of Literacy in the Curriculum	45	85
5.	Application of Literacy in Daily Life	60	95
6.	Relationship between Literacy and Science Learning	50	90
7.	Example of Literacy Application in Science Context	55	85
8.	Evaluating Literacy in Science Learning	45	90
9.	Definition of Literacy and Numeracy Instruments	50	90
10.	Characteristics of a Good Instrument	55	95
11.	Literacy Instrument Writing Technique	50	85
12.	Numerical Instrument Writing Technique	45	80
13.	Instrument Evaluation and Validation	40	85
	Average	50.77	88.46

The second mentoring also provided positive evaluation results in an online webinar entitled "Differentiated Science Learning and Science Literacy for Science Teachers" on May 11, 2024. Table 4 shows the evaluation results. The webinar participants, 154 people from various regions in Indonesia, took a pretest with an average score of 48.85 before starting the webinar. The webinar materials included designing literate science learning, planning science differentiation learning, and implementing and evaluating science literacy assessments. The post-test results showed an average score of 86.54, signifying a significant increase in participants' understanding of the practical application of science literacy in science learning.

This result is in line with findings from other community services that also emphasize the importance of science literacy-based learning. For example, research by Susetyarini et al. (2021) emphasizes the importance of assistance in implementing the concept of "Merdeka Belajar" in schools (Susetyarini et al., 2021). Research by Yuliati (2017) also highlights the importance of science literacy in science learning to improve the quality of education (Yuliati, 2017). In addition, research by Wibawa et al. (2022) shows that interactive workshops can directly improve teachers' understanding of the Merdeka Belajar Curriculum (Wibawa et al., 2022). Mastuti et al. (2022) added that good workshops and

mentoring can significantly improve the quality of teacher learning (Mastuti et al. 2022). Kuswahyuningsih (2023) also emphasized the positive effect of workshops and lesson planning on teacher performance (Kuswahyuningsih, 2023).

Table 4 Evaluation results of the online webinar

No.	Parameters	Pretest Score	Post-test Score
1.	Science Literacy Concept Understanding	50	90
2.	Literacy-based Learning Design Techniques	55	85
3.	A literacy-based learning approach	50	90
4.	Implementation of Literacy-Based Learning	45	85
5.	Implementation of Science Differentiated Learning	55	85
6.	Relationship between Literacy and Science Learning	50	90
7.	Differentiated Learning Planning Techniques	45	85
8.	Evaluation of Differentiated Learning	40	80
9.	Assessment Design in Differentiated Learning	45	85
10.	Definition and Purpose of Science Literacy Assessment	50	90
11.	Science Literacy Assessment Instrument Writing Technique	55	85
12.	Validation and Evaluation of Science Literacy Assessment Instruments	50	90
13.	Implementation of Assessment in Science Literacy Learning	45	85
	Average	48.85	86.54

CONCLUSION

Community service from February to May 2024 for junior high school science teachers in Purbalingga Regency, Indonesia, made an important contribution to implementing the Merdeka Curriculum. The Merdeka Curriculum emphasizes the importance of science literacy as a critical component in science education, but its implementation is still limited in many areas, including in Purbalingga Regency.

The results of this two-stage community service activity showed a significant positive impact. The first assistance, carried out as an offline seminar on February 17, 2024, improved participants' understanding of science literacy, with the average post-test score reaching 88.46, up significantly from 50.77 in the pretest. The materials presented, such as understanding literacy concepts, literacy-based learning approaches, and application in the curriculum, provide in-depth insights for participants and support the implementation of Merdeka Curriculum principles in the field.

The second mentoring, which was carried out in an on-line webinar on May 11, 2024, also showed positive evaluation results with an average post-test score of 86.54, an increase from 48.85 in the pretest. The webinar material, which focuses on designing science literacy-based learning and its implementation in science learning is important to strengthening the integration of the Merdeka Curriculum in the context of science education in Indonesia.

Thus, this community service activity is not only a concrete effort to improve the science literacy of science teachers in Purbalingga Regency but also an important step in supporting the vision of Merdeka Curriculum to create more relevant, inclusive, and HOTS development-oriented education at the local level. The continuous implementation of these concepts is expected to help prepare a generation that is more competent and ready to face future challenges with better science and technology.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, SP, MN, and II; methodology, SP and MN; data collection, SP, MN, and II; writing—preparation of the original draft, SP, MN, and II; writing-reviewing&editing, SP, MN. and II; All authors have read and approved version of the manuscript.

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