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Strengthening the Pedagogical Competence of Physics Teachers through Training in Making Recycled Learning Media Based on the Environment and Local Wisdom of Trenggalek

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ABSTRACT

This community service activity aims to improve the pedagogical competence of physics teachers in Trenggalek Regency through training in the creation of environmentally friendly, locally-based learning media based on used materials. Problems faced by teachers include limited laboratory facilities, a lack of creativity in creating teaching aids, and the lack of integration of local cultural potential, such as Reog Kendang, into physics learning. The activity methods include participatory training, hands-on practice in making teaching aids, and the preparation of Student Worksheets (LKPD) based on Problem-Based Learning (PBL). The results of the activity showed a significant increase in teachers' ability to design contextual teaching aids; 100% of participants experienced an increase in their understanding of the concept of sound, and 90% expressed satisfaction with the training results. The resulting products include PVC resonators, mini speakers made from used cans, and sound intensity measuring devices using an Android application. This activity not only fosters teacher creativity but also environmental awareness and the preservation of local culture. This training model is worthy of replication to support the implementation of the Independent Curriculum and SDGs 4 (Quality Education) and SDGs 12 (Sustainable Consumption and Production).

INTRODUCTION

21st-century science education demands a paradigm shift from teacher-centered learning to student-centered learning that is active, contextual, and oriented toward the development of higher-order thinking skills. Globally, this demand aligns with the Sustainable Development Goals (SDGs), particularly SDG 4 on quality education that promotes sustainable learning, and SDG 12, which emphasizes responsible production and consumption patterns. In physics learning, this paradigm shift requires teachers not only to master scientific concepts but also to deliver meaningful learning experiences through concrete media, scientific projects, and the integration of social and environmental values. In Indonesia, the implementation of the Independent Curriculum (Kurikulum Merdeka) reinforces this direction of educational transformation by emphasizing project-based learning and contextual learning (Kokotsaki et al., 2016). Teachers are expected to be creative and reflective facilitators in designing learning experiences tailored to student characteristics and the potential of the surrounding environment. However, in practice, many teachers still struggle to create physics learning media that are engaging, accessible, and relevant to real life (Shrestha et al., 2023). This poses a significant challenge, especially in areas with limited laboratory facilities and educational resources, such as Trenggalek Regency.

Trenggalek Regency is a region in East Java with a rich cultural and natural resources that have the potential to become contextual learning resources (Widodo & Priyanto, 2022). One of this region's distinctive cultural heritages is the Reog Kendang art form, which is steeped in the principles of vibration, resonance, and sound energy—concepts highly relevant to physics learning (Fitriyah, 2022). Unfortunately, this cultural potential

has not been optimally utilized in the learning process in schools. Initial observations and interviews with teachers from the Trenggalek Physics MGMP indicate that most teachers still use conventional methods of lectures and minimal demonstrations, without adequate support from visual aids. As a result, physics instruction in the classroom tends to be theoretical and less able to foster interest and in-depth understanding in students Hazari,et al., 2010).

The main gap faced by physics teachers in Trenggalek lies in limited pedagogical competence and innovation in designing contextual learning media. The lack of relevant training, limited laboratory resources, and the lack of integration of local wisdom into learning result in the teaching and learning process being ineffective in fostering students' scientific literacy (Suwono et al., 2022). Teachers also tend to rely on simple visual aids or online videos, which are not always appropriate for local characteristics or school facilities. This situation results in low student engagement in physics learning and limited opportunities for them to develop scientific thinking skills through hands-on experience (Fakaruddin et al., 2024). Thus, it is clear that the gap between contextual learning needs and real-world conditions remains significant and requires ongoing strategic intervention.

Several efforts have been undertaken by educational institutions and teacher communities to improve the quality of physics learning, such as training in creating media based on PhET Simulation, the use of Arduino, or interactive digital modules. However, these approaches often require relatively expensive technological devices and are difficult for schools in rural areas to access (Ahiaku et al., 2025). As an alternative, there is a need for simple, applicable training based on the use of local resources. Responding to this need, a team of lecturers from the Faculty of Mathematics and Natural Sciences, Surabaya State University, initiated a Community Service (PKM) activity entitled "Strengthening Physics Teachers' Pedagogical Competence through Training in Creating Recycled Learning Media Based on the Environment and Local Wisdom of Trenggalek." This program is designed to develop teachers' skills in making teaching aids from environmentally friendly recycled materials and integrating them with local cultural contexts such as Reog Kendang, so that physics learning becomes more contextual, creative, and sustainable.

Various studies have shown that the use of recycled-based learning media effectively improves understanding of physics concepts and fosters environmental awareness (Zahra et al, 2024; Arsyad et al., 2024). Furthermore, Project-Based Learning (PjBL) and Problem-Based Learning (PBL) approaches have been shown to strengthen students' critical thinking skills, creativity, and collaborative skills. In the context of ethnopedagogy, the integration of local wisdom, such as regional arts and crafts, into science learning can increase student relevance and emotional engagement (Fitrianto & Farisi, 2025). Therefore, training activities that combine aspects of environmental education, hands-on learning, and local wisdom are ideal models for improving teachers' pedagogical competence and strengthening the implementation of the Independent Curriculum in schools.

The urgency of implementing this PKM activity lies in the real need to strengthen teachers' capacity in designing creative, contextual, and sustainable physics learning. By equipping teachers with the skills to make teaching aids based on recycled materials and integrating Trenggalek's local wisdom, this program is expected to produce more

engaging and environmentally friendly learning innovations. The main objectives of this PKM are: (1) to improve the pedagogical and professional competence of physics teachers, (2) to foster creativity and professional reflection through the practice of learning by making, and (3) to support the realization of sustainable education through environmentally and culturally aware learning. Thus, this activity contributes to strengthening the science education ecosystem that is humanistic, adaptive, and rooted in local values.

METHOD

This community service activity is a participatory and collaborative training program (participatory training model) between a team of lecturers from the Faculty of Mathematics and Natural Sciences, Surabaya State University, and the Physics Subject Teachers' Council (MGMP) of Trenggalek Regency. This activity focuses on improving teachers' pedagogical competence through training in the creation of physics learning media based on recycled materials that are environmentally friendly and contextualized to local wisdom (Fitrianto & Farisi, 2025). The activity is designed using a learning-by-making and project-based learning (PjBL) approach, where participants not only receive theory but also engage in hands-on practice in designing and testing simple teaching aids relevant to the Independent Curriculum.

The training will be held offline in June 2025 at SMAN 2 Trenggalek as the main location. The activity is attended by high school physics teachers from across Trenggalek Regency who are members of the Physics MGMP, and facilitated by the Trenggalek Regency Education Office. The participants were 25 physics teachers from various educational institutions, including SMAN 1 Karangan, SMAN 2 Karangan, SMKN 1 Suruh, SMAN 1 Munjungan, and SMAN 1 Durenan. In addition to the implementing lecturers, the activity also involved two student mentors who played a role in documentation and practical assistance.

The activity was systematically implemented in three main stages: (1) Preparation Stage, The implementation team coordinated with MGMP partners and the Education Office to identify training needs. This was followed by the development of a training module entitled "Creating Creative and Environmentally Friendly Physics Teaching Aids to Improve Physics Teacher Competence in Trenggalek," validated by an educational physics expert, and the development of a Problem-Based Learning (PBL)-based worksheet (LKPD). (2) Implementation Phase, The training was conducted over one intensive day in four main sessions, including (a) a theoretical presentation of environment-based learning media, (b) a workshop on creating sound-concept demonstration tools using recycled materials such as PVC pipes and cans, (c) developing PBL-based student worksheets (LKPD), and (d) a presentation of project results. Participants were then given a follow-up assignment: creating a 15-minute video project on the demonstration tool explaining the design, working principles, and application of the tool in physics learning. (3) Evaluation and Follow-up Phase, Closed and open-ended questionnaires were completed to gauge participant perceptions and satisfaction, group reflections on the training process, and discussions on plans to implement the resulting media in their respective schools. The results were then published online and prepared for submission to scientific articles and Intellectual Property Rights (IPR) applications.
Data Collection and Analysis Techniques

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Activity data was collected through several instruments, namely: (1) a closed-ended evaluation questionnaire with a four-level Likert scale to measure participants' understanding and satisfaction; (2) an open-ended questionnaire to explore participants' experiences, challenges, and impressions; (3) direct observation during the activity to assess participants' activeness and skills in making teaching aids; and (4) photo and video documentation to support qualitative analysis. Data were analyzed using quantitative and qualitative descriptive approaches. Quantitative data from the questionnaire were calculated as a percentage of achievement for each indicator, while qualitative data from open-ended responses and observations were analyzed thematically to identify patterns of change in teachers' pedagogical competence and creativity after the training.

RESULT AND DISCUSSION

This community service activity was successfully implemented in Trenggalek Regency, involving physics teachers who are members of the Physics Subject Teachers' Conference (MGMP). In general, the activity focused on improving pedagogical competency through training in creating environmentally friendly teaching aids from recycled materials that are relevant to the local cultural context. This training integrated Project-Based Learning (PjBL) and Problem-Based Learning (PBL) approaches, enabling participants to learn through hands-on experience (learning by making). This approach encouraged teachers to actively think critically, creatively, and reflectively during the learning media creation process (Rahim et al., 2022).

During the preparation stage, a team of lecturers from the Faculty of Mathematics and Natural Sciences, Surabaya State University, in collaboration with the Physics MGMP partners, conducted an in-depth needs analysis. Based on interviews and initial observations, most teachers faced limited teaching aids and physics laboratory facilities. This situation resulted in learning tending to be theoretical, with students relying solely on verbal explanations without the support of experiments or direct observation activities. To address this issue, the team developed a training module "Making Creative and Environmentally Friendly Physics Teaching Aids," which includes practical guidance on making simple tools using recycled materials such as PVC pipes, used cans, and plastic bottles (Bello, 2024). The module was designed to be easy for teachers to use and adapted to the local context of Trenggalek.

The training was conducted offline at SMAN 2 Trenggalek and was attended by teachers from various high schools in the area. The intensive activity spanned four sessions: (1) a presentation of theory and the importance of contextual learning media, (2) a workshop on making teaching aids for the concept of sound, (3) developing PBL-based student worksheets (LKPD), and (4) presenting project results. Throughout the training, participants demonstrated high enthusiasm for discussion and collaboration. Many teachers shared their experiences utilizing used materials at school for simple experiments. This enthusiasm demonstrated the teachers' transformational spirit in implementing the principles of Merdeka Belajar, which emphasize project-based learning and teacher creativity as facilitators (Yudiyanton & Syukron, 2024).

The teaching aids produced by teachers in this training were very diverse and demonstrated a high level of creativity. These included PVC resonators, mini speakers made from used cans, and a sound intensity meter using the Spectroid Android app. These three tools effectively helped students understand the concepts of frequency,

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amplitude, resonance, and sound intensity in a concrete way. The innovative use of an Android app to measure sound intensity demonstrates the integration of digital technology and physics learning. This implementation aligns with the concept of 21st-century learning, which combines technology and environmental sustainability.

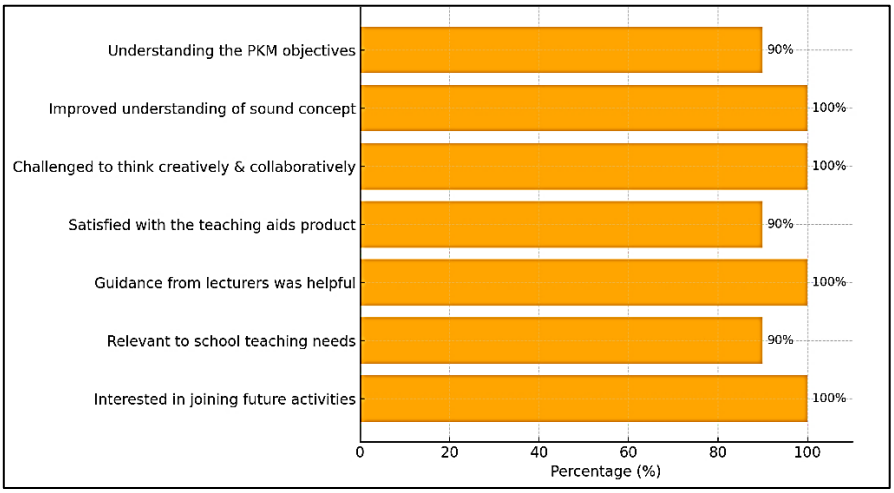

Figure 1. Participant responses to the PKM activity

Evaluation results showed in Figure 1 that this activity had a significant impact on improving teacher competency. 100% of participants experienced an increased understanding of the concept of sound waves and their use in learning. Furthermore, 90% of participants expressed satisfaction with the teaching aids they created, and all participants committed to implementing these media in their respective schools. Teachers acknowledged that this activity opened new insights into how simple media can stimulate students' curiosity and create a more active and contextual learning environment (Sasmita et al., 2021). Thus, this activity not only contributed to the mastery of technical skills but also established a new paradigm in creative and reflective physics learning.

Although the program went well, the team faced several challenges in the field. Time constraints were a major obstacle, as the activity lasted only one full day, meaning not all participants had time to complete the equipment assembly on site. Furthermore, some teachers were still unfamiliar with using the Spectroid digital application for sound intensity measurements. Rainy weather on the day of the activity also disrupted the outdoor equipment trial session. To address these challenges, the implementation team provided additional tutorial videos and opened an online Q&A forum for participants. These efforts successfully helped teachers independently complete the teaching aid project outside of face-to-face sessions (Durham et al., 2022).

In addition to technical challenges, conceptual barriers were also identified related to teachers' doubts about the scientific validity of the recycled teaching aids. Some participants questioned the accuracy of the measurement results produced by these simple tools. To address these concerns, the implementation team held a micro-validation session, which demonstrated the comparison of the results of the simple tools with standard laboratory equipment through a simple calibration procedure. This approach provided a new understanding that recycled teaching aids can function scientifically if

properly designed and tested (Carvajal et al., 2022). Thus, teachers gained scientific confidence and sufficient technical skills to apply these tools in learning.

The impact of this activity was also evident in the shift in teachers' mindsets regarding their roles as educators. Teachers, who previously served solely as users of teaching media, now transformed into designers and innovators of learning. They began to think critically in solving learning problems by designing teaching aids relevant to the local cultural context. The integration of the Reog Kendang Trenggalek culture into the Student Worksheet (LKPD) serves as an example of the application of ethnoscience, where teachers connect the sound of the drum with the concepts of resonance and longitudinal waves (Naba et al., 2024). This innovation not only enriches the learning experience but also instills the value of preserving local culture in students.

Pedagogically, this activity successfully fostered three core competencies in teachers: pedagogical, professional, and social competence. Pedagogical competence was demonstrated through teachers' ability to develop problem-based LKPD and conduct product-based assessments. Professional competence was enhanced through the application of applicable physics concepts, while social competence was evident in the collaboration and reflective communication between teachers in completing projects. Teachers stated that this activity increased their confidence in designing and implementing project-based learning that aligns with the principles of the Independent Curriculum (Miller et al., 2021).

The results of this activity have long-term implications for the development of sustainable physics education in the region. The community service team and participants plan to follow up on the activity through scientific publications in community service journals, Intellectual Property Rights (IPR) applications for teaching aid designs, and the publication of ISBN-certified training modules as a guide for other physics teachers. The Trenggalek Regency Education Office also demonstrated its commitment to replicating similar activities in the following year through best practice forums and further training. Thus, this activity not only improves individual teacher capacity but also builds an ecosystem of learning innovation based on local wisdom and environmental sustainability.

CONCLUSION

The Strengthening of Physics Teachers' Pedagogical Competence through Training in Creating Recycled Learning Media Based on the Environment and Local Wisdom in Trenggalek has had a positive impact on improving the quality of physics learning in secondary schools. This program improves teachers' skills in designing contextual teaching aids, fosters creativity and professional reflection, and encourages the implementation of the Independent Curriculum through a project-based and problem-solving approach. The implications are evident in three main aspects: pedagogical, socio-environmental, and institutional. Pedagogically, teachers become more independent and creative in developing teaching media; socio-environmentally, this activity raises awareness of the importance of utilizing recycled materials as environmentally friendly learning media; while institutionally, collaboration between universities and the Physics MGMP opens up opportunities for the formation of sustainable communities of practice. However, this activity has limitations such as the short training duration, limited number of participants, the lack of longitudinal post-training evaluation, and limited digital

measuring equipment facilities. Therefore, it is recommended that future PKM include further mentoring (coaching clinics), broadening cross-level targets, integration with classroom action research (CAR), strengthening digitalization through video sharing portals and student worksheets (LKPD), and cross-sector collaboration to develop other local culture-based media. Overall, this PKM demonstrates that empowering teachers to develop simple yet meaningful learning media can be a strategic step toward educational transformation oriented toward creativity, sustainability, and the preservation of local values in the Merdeka Belajar era.

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