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ENHANCING GEOPHYSICAL LITERACY AWARENESS AND STUDENT INTEREST THROUGH HANDS-ON INSTRUMENTATION TRAINING FOR HIGH SCHOOL STUDENTS IN SAMBAS REGENCY

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Abstrak: Kabupaten Sambas, Kalimantan Barat, memiliki potensi geologi dan hidrologi yang besar untuk dimanfaatkan sebagai sumber pembelajaran kontekstual dalam pendidikan geosains. Namun, literasi geosains siswa SMA di wilayah ini masih menghadapi tantangan, terutama akibat keterbatasan pembelajaran berbasis lapangan dan minimnya pengenalan instrumen ilmiah. Program pengabdian masyarakat ini dilaksanakan menggunakan pendekatan Participatory Action Research (PAR) yang mencakup tahap persiapan, pelaksanaan lapangan, dan evaluasi. Kegiatan dilakukan melalui perencanaan kolaboratif dengan sekolah mitra serta demonstrasi berbagai instrumen geofisika, antara lain metode resistivitas, flowmeter, dan Automatic Weather Station (AWS), disertai pengenalan identifikasi batuan menggunakan lup geologi dan komparator batuan. Evaluasi program dilakukan melalui kuesioner pascakegiatan yang mencakup skala Likert empat poin, pertanyaan nominal, dan respons terbuka untuk mengukur tingkat pengenalan awal, ketertarikan siswa, aktivitas yang paling berkesan, serta minat melanjutkan pembelajaran di bidang geofisika. Hasil evaluasi menunjukkan bahwa lebih dari 70% peserta menyatakan tingkat ketertarikan dan persepsi manfaat yang tinggi terhadap pembelajaran berbasis pengalaman, khususnya dalam memahami aplikasi geosains dalam kehidupan sehari-hari. Temuan ini menunjukkan bahwa demonstrasi instrumen dan pemanfaatan konteks geologi lokal dipersepsikan positif sebagai media pembelajaran geosains. Selain itu, kegiatan ini menegaskan potensi Kabupaten Sambas sebagai "laboratorium alam" yang strategis untuk mendukung penguatan pendidikan kebumian, terutama di wilayah dengan kerentanan lingkungan dan kebencanaan.

Kata Kunci: Geofisika, edukasi lapangan, Kabupaten Sambas

Abstract: Sambas Regency, West Kalimantan, possesses substantial geological and hydrological potential that can be utilized as a contextual learning resource in geoscience education. However, geoscience literacy among high school students in this region remains limited, primarily due to restricted access to field-based learning and limited exposure to scientific equipment. This community service program was implemented using a Participatory Action Research (PAR) approach, consisting of preparation, field implementation, and evaluation stages. The activities involved collaborative planning with partner schools and hands-on demonstrations of geophysical instruments, including electrical resistivity equipment, flow meters, and an Automatic Weather Station (AWS), as well as introductory rock identification using geological hand lenses and rock comparators. Program evaluation was conducted through a post-activity questionnaire comprising four-point Likert-scale items, nominal questions, and open-ended responses to assess students' initial exposure, interest, most memorable activities, and motivation to engage further with geophysics learning. The results indicated that more than 70% of the participants reported high levels of interest and perceived benefits from the experiential learning activities, particularly in understanding the real-world applications of geoscience. These findings suggest that students positively perceive instrument-based demonstrations and the use of local geological contexts as effective learning media. Furthermore, this program highlights the potential of Sambas Regency as a "natural laboratory" for strengthening earth science education, especially in regions vulnerable to environmental and disaster-related challenges.

Keywords: Geophysics, field education, Sambas Regency

Introduction

West Kalimantan, including Sambas Regency, is part of the Sunda Shelf within the Sundaland tectonic domain and is influenced by complex tectonic, sedimentary, and coastal processes that shape its geomorphology and surface geology (Hall, 2012, 2013). The region is dominated by lowland alluvial plains, extensive river systems, and coastal environments, reflecting active fluvial sedimentation, groundwater processes, and shoreline dynamics typical of tropical continental margins in Southeast Asia. West Kalimantan is also known for its significant lateritic bauxite and associated mineral deposits, which are closely linked to intense tropical weathering and regional geological structures (Winarno et al., 2023). These geological characteristics provide strong potential for field-based learning in geophysics, hydrology, and environmental geology. However, despite this natural potential, the integration of local geological phenomena into school-based science education remains limited, resulting in underutilized learning opportunities for students.

Based on initial observations from the "Geophysics Goes to School" program conducted in early 2025, high school students in the West Kalimantan region showed interest in outdoor learning activities (Adriat et al., 2025). However, this interest has not been optimally supported due to limited access to hands-on fieldwork, minimal exposure to geophysics as a scientific discipline, and the lack of geoscience instruments that support contextual and applied learning experiences in schools. Similar challenges have been reported in geoscience education, where abstract content and limited practical exposure contribute to low levels of student engagement and geoscience literacy (Mogk & Goodwin, 2012; Orion & Hofstein, 1994).

This condition highlights a gap between the region’s geological resource potential and its utilization in science education at schools. Earth science learning at the high school level generally remains focused on theoretical content in textbooks and has not yet been integrated with fieldwork or the use of simple scientific instruments. In fact, experiential learning approaches through direct observation and demonstration have been shown to enhance students’ understanding and interest in science (Andriansyah, 2020; Habibah & Yasin, 2024; Hendawati & Kurniati, 2017; Ningsih, 2019; Rina et al., 2020; Rostikawati, 2018; Sahronih, 2021; Nahdi et al., 2018; Saregar & Sunarno, 2013; Subella et al., 2023). On the other hand, science teachers have expressed interest in introducing geophysics topics to their students but face limitations in equipment, training, and resources. As a result, students' geoscience literacy remains relatively low, and their understanding of the role of earth sciences in everyday life, including disaster mitigation is still limited (Hanif et al., 2022).

In response to the need for more contextually and practically oriented earth science education, this community engagement program was designed to introduce geophysics through field-based learning activities (Jumarang et al., 2025; Muhardi et al., 2025). Previous educational and community service initiatives in Indonesia have demonstrated that using local geological and environmental potential as a learning medium can significantly enhance students’ scientific understanding and engagement in the learning process. However, similar geophysics-focused programs that emphasize direct fieldwork with geoscience instruments remain limited in West Kalimantan, particularly in Sambas Regency. Therefore, this program was implemented at the BKD Sambas facility, which offers adequate infrastructure, including a hall and a spacious yard, to support hands-on geophysical experiments, instrument demonstrations, and outdoor learning activities. Selecting this site enabled students to experience geoscience concepts in a real-world context, thereby strengthening the relevance and effectiveness of Earth science learning.

Based on the identified gap between the region's rich geological potential and its limited integration into school-based science education, this community engagement program aims to (1) introduce fundamental earth science and geophysics concepts to students through hands-on, field-based learning experiences; (2) increase students' awareness of geoscience literacy and the relevance of earth sciences to everyday life and disaster mitigation; and (3) stimulate students' interest in geophysics and earth-related technologies as potential fields for further study and career exploration. Additionally, the program seeks to support schools and teachers by demonstrating contextual, practical learning models that use simple, low-cost geoscience instruments. Rather than measuring objective learning gains, the achievement of these objectives was evaluated through participants' post-activity perceptions of understanding, interest, and perceived benefits. Through these aims, the activity is expected to contribute to more engaging earth science learning practices, promote the use of local geological contexts as educational media, and support long-term efforts to strengthen geoscience literacy among high school students in West Kalimantan, Indonesia.

Method

This Community Service Program (PKM) was implemented using a Participatory Action Research (PAR) approach, which emphasizes collaborative planning, participatory implementation, and reflective evaluation involving both the academic team and community partners. The program was conducted over six months, from May to October 2025, and consisted of four main stages: preparation, field implementation, evaluation, and dissemination (Figure 1).

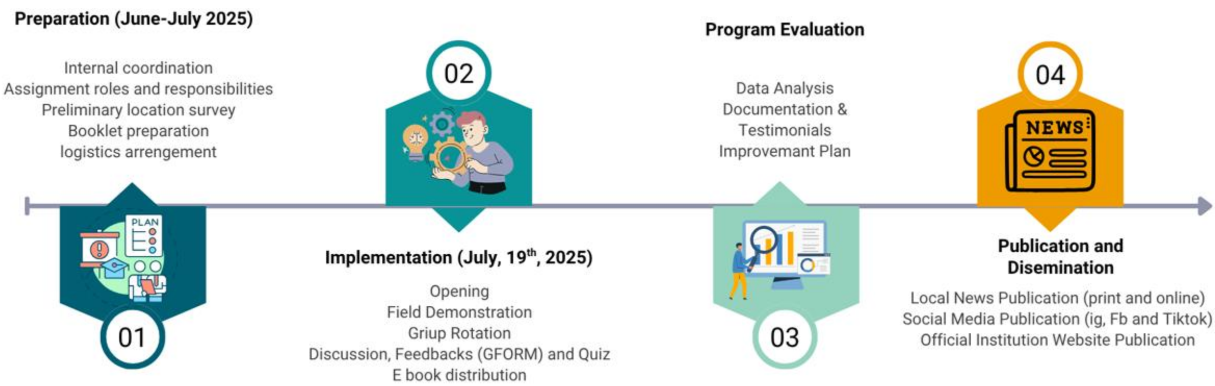

Figure 1. The Stage of Community Services Activity

SMA Negeri 1 Sambas served as the official partner and host school, facilitating coordination, venue access, and participant mobilization. The program participants were students from several senior high schools across Sambas Regency, who were centrally gathered at the activity location through coordination with the partner school. The main activity was conducted on 19 July 2025 in the outdoor area surrounding the BKD Sambas Hall, which was selected for its open, accessible space, suitable for the safe deployment and demonstration of a geophysical instrument.

The participants were divided into small groups and rotated through several learning stations, including geoelectrical measurements (Loke, 1997; Rolia & Sutjiningsih, 2018; Sanuade et al., 2022; Telford et al., 1990a), hydrological observations using flow meters (Shaw, 1994), meteorological data collection using an Automatic Weather Station (AWS) (Estévez et al., 2011; World Meteorological Organization (WMO), 2024), and introductory rock identification. At each station, the PKM team explained the basic principles, operational mechanisms, and real-world applications of the instruments, emphasizing their relevance to environmental monitoring and geoscience issues in West Kalimantan. The session concluded with guided discussions and reflective dialogues.

Program evaluation was conducted using a post-activity questionnaire-based survey designed to capture students' self-reported perceptions of their learning experience. Post-activity perception surveys are commonly used in community service and outreach programs to assess participant engagement, perceived understanding, and perceived benefits, particularly when activities are short-term and exploratory (Bringle & Hatcher, 2002; Prince, 2004). The questionnaire comprised four-point Likert-scale items, nominal questions, and open-ended responses addressing perceived understanding, interest in geoscience, and perceived benefits of field-based learning activities, which are widely used as indicators in experiential and field-based science education evaluations (Orion & Hofstein, 1994).

The collected data were analyzed using descriptive statistical methods, including frequency distributions and percentages to summarize participant responses. Descriptive analysis is commonly employed in community service and educational outreach programs to capture overall response patterns, particularly when the evaluation is based on post-activity perception surveys (Bringle & Hatcher, 2002; Creswell & Creswell, 2017). No pre-test–post-test design or inferential statistical analysis (e.g., N-Gain scores or paired t-tests) was used in this study, as the program was designed as a short-term outreach activity rather than a formal instructional intervention. Accordingly, the evaluation focuses on perceptual and experiential outcomes rather than on objective measurements of cognitive learning gains, an approach widely used in experiential and informal science education contexts (Prince, 2004). The results are presented in a single summary table to enhance clarity and readability. Supporting documentation, including activity records and partner feedback, was compiled to support program accountability and inform future community-based geoscience education initiatives.

Results and Discussion

The outcomes of the Community Service Program (PKM) were evaluated using a post-activity questionnaire, and the consolidated results are presented in Table 1. Overall, the participants reported positive perceptions across all evaluated indicators, including interest in the activity, ease of understanding the material, perceived benefits, perceived understanding of geophysics concepts, and motivation to learn more about geophysics. These findings indicate that the hands-on, instrument-based approach was generally well received by the participants.

The overall response pattern suggests that practical exposure to geophysical instruments can enhance students' engagement and perceived relevance of learning geophysics. Geophysics is often regarded as an abstract and mathematically demanding subject at the secondary education level, which may contribute to low scientific literacy and limited student interest (Telford, Geldart, & Sheriff, 1990b). By allowing students to observe and interact with real instruments directly, PKM activities helped contextualize geophysical concepts within observable environmental phenomena, thereby reducing perceived abstraction.

Table 1. Summary of Questionnaire Results on Participants' Perceptions of the PKM Activity

Indicator	Likert Scale 1 n (%)	Likert Scale 2 n (%)	Likert Scale 3 n (%)	Likert Scale 4 n (%)	Dominant Response
Interest in the activity	0	0	16,4	83,6	Very High
Ease of understanding the material	0	9	55,2	35,8	High
Perceived benefits of the activity	0	0	10,4	89,6	Very High
Perceived understanding of geophysics concepts	0	6	44,8	49,3	Very High
Motivation to learn geophysics further	0	19,4	31,3	49,3	Very High
Evaluation results on participants' knowledge gain through the PKM activity	1,5	0	17,9	80,6	Very High

Participants' self-reported interest in geophysics (Figure 2, right panel) shows that most expressed interest in the field, though some reported lower interest. This variation reflects differences in prior knowledge, academic orientation, and learning preferences. Short-term outreach programs may not fully accommodate all learner profiles; however, previous studies indicate that even brief hands-on interventions can positively influence students' attitudes toward Earth science compared to conventional classroom-based instruction (Mogk & Goodwin, 2012; Orion & Hofstein, 1994).

In terms of activity preference (Figure 2, left panel), the Automatic Weather Station (AWS) was the most favored activity. This preference can be interpreted through the lens of experiential learning theory, which emphasizes concrete experience and immediate feedback as key drivers of engagement and meaning-making (Kolb, 2014). AWS demonstrations provide real-time data visualization and clear connections to everyday weather phenomena, making them more intuitive and relatable for students than traditional methods. Similar patterns have been reported in geoscience education studies, where meteorological and environmental monitoring tools tend to attract higher student interest due to their direct relevance to daily life (LaDue et al., 2022; Monroe et al., 2019; World Meteorological Organization (WMO), 2024).

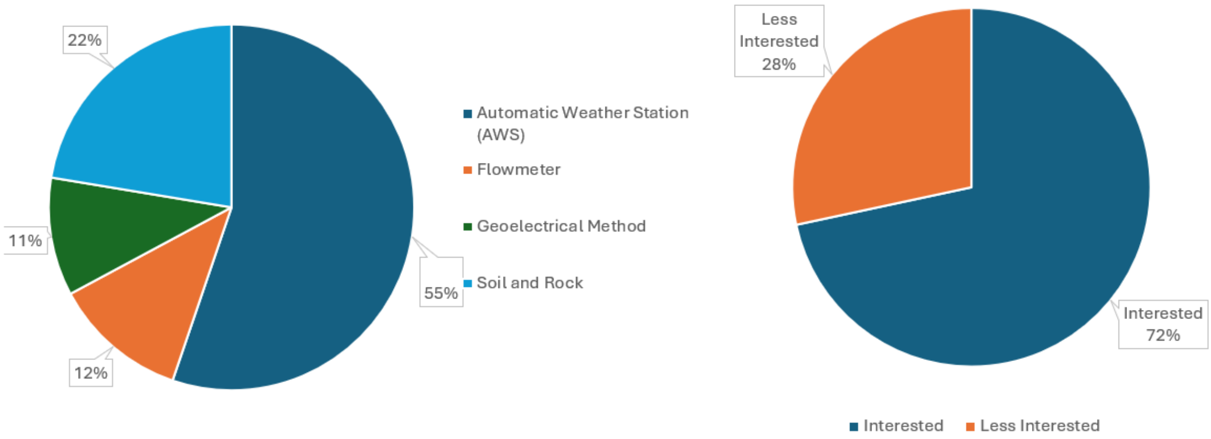

Figure 2. Participants' responses to the PKM activity, showing preferences for hands-on geophysical instrumentation activities (left) and self-reported interest in geophysics (right)

Activities perceived as more technically complex, such as geoelectrical methods, received comparatively lower preferences. This finding suggests that such methods may require additional instructional scaffolding and extended learning time to achieve comparable levels of engagement, particularly among participants with limited prior exposure to geophysics. Previous studies have emphasized that advanced geophysical techniques involve abstract concepts and multistep reasoning processes, which can pose cognitive challenges for novice learners if introduced without gradual conceptual progression (Kearey et al., 2002; Mogk & Goodwin, 2012; Orion & Hofstein, 1994).

Qualitative documentation of the PKM activities (Figure 3) supports these interpretations by illustrating the learning context in which the program was implemented. The images document small-group sessions, station-based activities involving instrument demonstrations, group discussions, and facilitator-guided explanations. Such participatory learning environments are widely recognized as effective in fostering engagement and supporting conceptual understanding in science education (Prince, 2004).

Figure 3. Documentation of Community Service Activities

Importantly, these findings address the low geophysical literacy identified in the Introduction by demonstrating that accessible, hands-on activities can serve as an effective introductory strategy for engaging high school students in geophysics. Although this study does not assess objective learning gains, the positive participant perceptions indicate improved accessibility and initial engagement, which are widely recognized as essential prerequisites for the development of scientific literacy (Bybee, 2013; Falk & Dierking, 2013; National Research Council (U.S.). Committee on a Conceptual Framework for New K-12 Science Education Standards, 2012; Osborne et al., 2003).

Because the evaluation relied solely on post-activity self-reported data, the findings reflect perceived outcomes rather than objectively measured cognitive improvement. This evaluation approach is commonly applied in community service and educational outreach programs with limited duration and logistical constraints (Bringle & Hatcher, 2002; Furco, 2014). To strengthen empirical evidence of learning outcomes, future implementations should incorporate pre–post assessments or learning gain analyses, such as N-Gain scores, which are widely recommended for evaluating instructional effectiveness in science education (Hake, 1998; Meltzer, 2002).

The post-activity evaluation indicated that the PKM activities were well received by participants, particularly in terms of perceived relevance, engagement, and motivation to learn geophysics. Rather than emphasizing the numerical outcomes already presented in the Results section, this discussion focuses on interpreting the observed response patterns and their educational implications.

The strong positive perceptions reported across the indicators suggest that hands-on, instrument-based activities can support student engagement with geophysics concepts. Direct interaction with instruments may help reduce the abstract nature often associated with geophysics learning, making the subject more approachable at the secondary school level. This finding is consistent with experiential learning theory, which emphasizes active involvement and concrete experience as key mechanisms for shaping learners' understanding and attitudes (Kolb, 2014; Prince, 2004)

Participants' interest patterns indicated that activities that provide immediate feedback and observable results are more attractive to students. Instruments such as automatic weather stations, which display real-time data and are closely related to daily weather conditions, help students better understand the learning context and see the relevance of geoscience concepts. In contrast, activities that involve more technically complex or abstract methods may require additional explanations and instructional support to achieve similar levels of student engagement (Kolb, 2014; Vygotsky & Cole, 1978).

The presence of participants who reported a lower interest in geophysics suggests that short-term interventions may not fully address diverse learning preferences or prior attitudes. Nevertheless, the overall trend indicates that practical exposure can serve as an effective entry point for introducing geophysics to a broader student audience, as experiential and informal learning experiences are known to support initial engagement in science learning (Falk & Dierking, 2013).

Qualitative documentation of PKM activities supports these interpretations by illustrating the learning context in which the program was implemented. The images reflect a participatory environment characterized by facilitator-guided demonstrations and small-group interactions, which are commonly associated with positive learner engagement in experiential learning settings (Bringle & Hatcher, 2002; Kolb, 2014). However, as the evaluation relied solely on post-activity self-reported data, future programs would benefit from incorporating pre–post assessments to more robustly examine learning gains (Hake, 1998).

Conclusion

This Community Service Program (PKM) demonstrates that hands-on, instrument-based geophysics activities can serve as a practical introductory outreach approach for high school students in the Sambas Regency. The post-activity evaluation indicated positive participant perceptions of interest, perceived benefits, the accessibility of the material, and motivation to further engage with geophysics learning. Activities involving direct interaction and real-time environmental data—particularly the Automatic Weather Station—were perceived as the most engaging. Although the program relied solely on post-activity self-reported data and did not measure objective learning gains, the findings suggest that practical exposure can help reduce the perceived complexity of geophysics and support initial student engagement in the subject. Future implementations should incorporate pre–post assessments to strengthen empirical evaluation and more robustly assess improvements in geophysical literacy, thereby enhancing the scientific rigor of community-based education initiatives.

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