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Designing Impactful STEAM Project-Based Learning for Brebes Science Teachers through Local Context Integration

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ABSTRACT

In the 21st century, creativity, critical thinking, and problem-solving have become essential, especially in the education sector. However, the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach is effective in improving these skills. Many science teachers struggle to translate conceptual understanding into authentic classroom practice. The objective of this community service is to assess the competence of 30 science teachers from Brebes Regency in planning impactful STEAM-based learning. The methods used were SMART objectives with the DACUM technique. The implementation stages were carried out through five community service programs, namely socialization, training, technology transfer, mentoring, and program sustainability. The results of the study showed a very high level of understanding (93.60%) of the STEAM concept and their ability to design lesson plans. In addition, more than 50% of the participants successfully designed draft lesson plans for STEAM projects relevant to the local context of Brebes and presented them at a results seminar. This community service evaluation focused on short-term pedagogical outcomes rather than long-term impact. Therefore, this community service program aims to provide a foundation for advanced STEAM professional development, focusing on design thinking, authentic integration of local problems, and sustainable classroom implementation.

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INTRODUCTION

Creativity, critical thinking, and problem-solving skills are essential for twenty-first-century education. In response, the integrative STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach, particularly through Project-Based Learning (PjBL), has gained global recognition for its efficacy in fostering these skills (Meiliasari et al., 2024). Due to its diversity, Indonesia has significant strengths in producing more contextually and meaningfully oriented learning (Haryanto & Arty, 2019; Anggraheni et al., 2025). The 2035 Demographic Bonus Momentum and Indonesia Gold 2045 Vision present challenges and opportunities for the Indonesian education system (Cholifihani & Septiavin, 2025). However, there remains a significant implementation gap in the Indonesian context (Choi et al., 2016; Hayati et al., 2020). The Ministry of Research, Technology, and Higher Education focuses on PN 4, one of the 2025–2029 Asta Cita National Priorities (PN). PN 4 focuses on improving education, human resources, science, and technology. Higher education is

oriented towards a New Paradigm of Higher Education Transformation Towards a Knowledge Society for Sustainable Development (Giesenbauer & Müller-Christ, 2020). This will increase the relevance and accessibility of equitable, high-quality education, develop STEAM, increase productivity, enhance graduate competitiveness, increase graduate employment opportunities, and improve the competitiveness of higher education institutions (Brojonegoro et al., 2025). Research shows that very few scientific instructors regularly use STEAM, frequently encountering obstacles, including conceptual misconceptions and difficulty creating contextual projects (Boice et al., 2021; Boice et al., 2024). Therefore, this community service program aims to provide a foundation for advanced STEAM professional development, focusing on design thinking, authentic integration of local problems, and sustainable classroom implementation.

The STEAM (Science, Technology, Engineering, Arts, Mathematics) approach transforms learning into a holistic experience grounded in real-world problem-solving. The integration of arts is not merely aesthetic, but a catalyst for divergent thinking, empathy, and design innovation (Perignat & Katz-Buonincontro, 2019; Leavy et al., 2023). A meta-analysis (Taşdemir, 2022) shows that STEAM increases the effect size for students' cognitive achievement by 0.78 and their learning motivation by 1.02 (Quigley et al., 2020). The Merdeka curriculum policy aligns with the 2020-2035 National Education Roadmap, which emphasizes contextual education to build global competitiveness (Saptadi et al., 2024). However, a systematic study (Nurbaya et al., 2024) revealed critical implementation gaps; only 12% of science teachers in Central Java consistently implement STEAM.

Brebes Regency has many unique local contexts that can serve as a basis for STEAM projects. Examples include the salt-making process in coastal areas (integrating chemistry, technology, and economics), the mangrove ecosystem (integrating biology, ecology, and environmental science), and the processing of agricultural products such as shallots (integrating biology, chemistry, and entrepreneurship). However, science education usually focuses on scientific material presented in books while ignoring local culture (Kasi et al., 2024). In the current educational context, science learning that integrates culture and local context is an important approach that needs to be developed (Meyer & Crawford, 2011). Along with the increasing demand for skilled and competitive human resources, learning needs to be adapted to prepare students for the 21st century. In addition, teachers can improve students' abilities, especially their scientific attitudes, by integrating local context into science-based learning. (Wilujeng et al., 2019). Not only will this make learning more meaningful, but it will also instill a sense of respect and love for local culture in students by incorporating this local context (Garzón-Díaz, 2021; Sakti et al., 2024). A special approach that integrates multidisciplinary sciences, such as STEAM, tailored to the local context, is needed. However, it is necessary to analyse the upstream and downstream factors that underpin the need to adopt a STEAM approach grounded in the local context (Hayati et al., 2022; Nugroho et al., 2019). Theoretically, STEAM, when grounded in a local context, has many advantages for improving students' understanding. However, many teachers face difficulties integrating this method into their curriculum (Spyropoulou & Mathiopoulos, 2025).

MGMP is the target of PKM for the category of productive economic or social partners (Taufiq et al., 2023). The facts on the ground, especially in Brebes Regency, reveal a discrepancy between this idealism and teachers' actions. As a result of initial interviews with the Brebes Science Teacher Working Group, most teachers face three main challenges: 1) a misconception of STEAM, often seeing it as merely a combination of five subjects rather than an integrated philosophy; 2) difficulty designing project scenarios that are relevant and applicable to students' daily lives; and 3) insufficient utilization of the local context as a vast learning resource's PjBL, and only 8% authentically integrate local contexts (Wahyudin & Permatasari, 2020). However, there are still a few science lessons that use a multidisciplinary approach to address school learning issues. This has become the basis for

community service activities to describe the STEAM competency profile of MGMP IPA Brebes Regency teachers. This community service activity was meant to address these problems by helping IPA MGMP teachers in Brebes improve their ability to create effective lessons using the Local Context-Based STEAM Project method. The Brebes Regency MGMP IPA has conducted numerous training activities and workshops in collaboration with PPII. This has enabled the Brebes Regency MGMP IPA to become a model productive MGMP IPA in Central Java. The novelty of this community research lies in empowering junior high school teachers to integrate local context into their STEAM Projects. This effort is meant to be a real step forward in making science education better at the local level. This article reveals the in-depth interaction, in the form of community service activities funded by the Indonesian Science Educators Association (PPII), with MGMP IPA teachers in Brebes Regency on STEAM, grounded in the local context. These activities were carried out through workshops and seminars, resulting in impactful learning plans.

METHOD

The method used to assess the skills of science teachers in Brebes Regency in creating effective learning using a context-based STEAM project approach is the SMART goals method. SMART stands for Specific, Measurable, Achievable, Relevant, and Timebound (Macleod, 2013). This method comprises three stages: preparation, implementation, and evaluation. We used the DACUM (Developing A Curriculum) job analysis technique to make sure the training curriculum was exactly in line with the teachers' professional needs, developed by Willett & Hermann in 1989 (Cho & Choi, 2018), to design a curriculum that matches the needs of the participants, who are the science teachers.

DACUM stands for Develop A Curriculum and is a job analysis method that produces process and function analysis (DeOnna, 2002). To break down the competency of "designing a local-context STEAM project" into precise, observable activities and knowledge needs, this technique enabled a collaborative workshop with master teachers and facilitators. The ensuing DACUM chart directly influenced the learning modules and workshop activities. The result was a detailed job description and an analysis of external tasks (Dzulkifli et al., 2022). To assess the success of the SMART goals method, the planning and implementation stages are linked. The Goal-Oriented Evaluation Model (GOEM), developed by Tyler, is one of the evaluation models used to assess the achievements of programs designed and implemented. This community service activity targeted N = 30 junior high school science teachers who were involved in the Brebes MGMP. The MGMP chair used invitation letters to attract participants. The evaluation focused on short-term pedagogical outcomes rather than long-term classroom impact. Five phases made up the program, which ran from July to September 2025: 1) socialization; 2) training (two sessions: offline and online); 3) technology transfer (digital portfolio); 4) mentoring and evaluation; and 5) sustainability planning.

Before and after training, a 20-item STEAM comprehension test and a workshop satisfaction survey were given. Qualitative data sources included submitted instructional films, lesson plan drafts, and observational notes. Every session was recorded with pictures, attendance records, and digital artifacts. Participation was voluntary; informed consent was obtained. The instruments' validity and reliability will be considered in future research. Qualitative data (lesson plans, videos, observation notes) were analysed thematically to identify levels of contextualization and transdisciplinary integration. Program success thresholds: comprehension ≥75% considered adequate; at least 10 complete STEAM learning packages and ≥1 good practice video per school as program output indicators. The project used a participatory workshop and mentoring approach, which included several stages. At this stage, coordination was carried out among the community service lecturer team, the Head of the Brebes Regency Junior High School Science Teacher Working Group (MGMP IPA), and the Central Java PPII, particularly to agree on the activity schedule. After that, invitation letters were

sent to partner teachers by the Head of the Brebes Regency Junior High School Science Teacher Working Group (MGMP IPA) and by the Central Java PPII, a partner member. At this stage, mentoring is carried out through workshop and seminar activities to deepen STEAM material, collect test data, and document activities. In this activity, the output is an impactful learning tool using the STEAM approach, based on the local context of Brebes, and a video on good learning practices.

The evaluation stage involved distributing satisfaction questionnaires for the workshop activity to participants. The evaluation process is explained in detail below: (a)To enhance the success of STEAM achievement, the competency test success indicator must be more than 75%; (b) The results of the mentoring must show that at least ten packages (lesson plans, student worksheets, and assessments) are STEAM-themed and based on the local potential of Brebes; and (c) There is at least one good practice video for STEAM activities carried out in each school. The program was structured according to SMART principles across three phases: a two-week preparation (Specific), a four-week implementation involving hybrid workshops (Measurable, Achievable), and a two-week evaluation using the Goal-Oriented Evaluation Model (Relevant, Timebound)."The method summary is shown in Table 1.

Table 1. The summary stages of the method activity

Methods	Planning	Implementation	Evaluation
Specific	The planning stage is carried out using the DACUM technique.	The implementation stages are carried out with workshops and seminars on the results.	The evaluation stages were carried out using the GOEM (Goal-Oriented Evaluation Model)
Measurable	Program, Objectives, and Outcomes	Targeted workshop implementation and active participant involvement	Program achievement in accordance with the design and implementation
Achievable	STEAM learning design based on local potential is available	At least 10 STEAM learning kits based on local potential are available.	Device analysis feedback available on publication
Relevant	Planning guidance documents are used to implement and evaluate programs.	Sustainability impact documents and MOUs (to public/private universities under PPII)	Activity reports and program evaluation documents are used for program follow-up and reporting.
Timebound	2 weeks	4 weeks	2 weeks

In summary, this community service program has five implementation stages. First, there is socialization through direct and indirect channels. Direct socialization was delivered by the Head of the Brebes Regency MGMP IPA through a letter of community service sourced from the PPII Central Java Region, for the implementation of joint activities with the Brebes Regency MGMP IPA. The implementation team also carried out indirect socialization through flyers distributed on social media. Second, the training was conducted twice, in a hybrid format. The first training was conducted offline at one of the public junior high schools in Brebes Regency, while the second training was conducted online. The activities were carried out in August 2025, with 30 active MGMP IPA teachers serving as mentors participating in the community service program. It was followed by technology transfer, documented in a digital portfolio accessible at https://steamipa.moodlecloud.com/. This website is free and can only be accessed for one month. It contains workshop materials and participants' assignment results (Fatkhomi & Widiyanto, 2025); Mentoring and evaluation were conducted online during the Results Seminar. Evaluation was measured through questionnaires and observations during the activity. The last is a program. This program's sustainability can be implemented and further developed in line with the MoU and the partners' future needs.

RESULTS AND DISCUSSION

The results of the needs analysis between the partners and the implementers are a community service plan in the form of TORR (Time of Reference) activities. The activities will be carried out during August -September, with August dedicated to the implementation of the Workshop and Results Seminar, and September to the implementation of tasks assigned to participants. The first event took place in a hybrid format. Key attendees included the Deputy Principal of SMP N 2 Brebes, the Chair of the Brebes district MGMP, and a representative from the Brebes Education Office. The Chair of PPII Jateng opened the event, Prof. Dr. Purwo Susongko. It included a competence test to assess participants' STEAM knowledge profile. The event was conducted in a blended format. Speakers from LPTK UPS Tegal included Muriani Nur Hayati, M. Pd, Bayu Widiyanto, M.Si, and from LPTK UNNES were Prof. Dr. Purwo Susongko, M. Pd, and Muhamad Taufiq, M. Pd. The event discussed STEAM projects grounded in local contexts, explaining that STEAM is an approach without specific steps like PBL. The speaker also discussed holistic assessment in STEAM projects, focusing on both process and outcomes (Susongko et al., 2024). Not only that, the discussion covered the Engineering Design Process within STEM, highlighting specific stages. The last discussed environmental issues in STEAM education, indicating their potential integration into deeper learning (Widiyanto et al., 2023).

To further the program, sign an Implementation Agreement to signify ongoing initiatives. The attendees were enthusiastic, engaging in discussions and providing feedback. Participants who asked questions included Ahmad Akbar, S. Pd. Bio, Cukaesih, S. Pd., and Cucu Ratnasih, S. Pd. Teacher feedback revealed ongoing systemic and motivational challenges in STEAM education. Main issues included integrating project-based learning with standardized exam preparation, transitioning from fragmented workshops to coherent, policy-supported practices, and creating projects that effectively engage student curiosity. While teachers have developed planning skills, successful STEAM implementation requires alignment with the curriculum, institutional support, and effective pedagogical design.

Assessment reform is needed to reconcile STEAM learning in projects with preparation for standardized national exams (Khattri & Sweet, 2013). There is a structural relationship between learners' perceptions of a test, learning practices, and learning outcomes (Dong, 2020). It is important to move from fragmented workshops to professional learning communities (Harris & Jones, 2010) and to implement educational policy to improve educational skills (Young & Lewis, 2015). Designing projects that are effective in stimulating student curiosity and effort (Wijnia et al., 2024). The second event was a seminar presenting the workshop's results. The event was held via Zoom. The speakers are Dr. Novi Ratna Dewi, M.Pd., from UNNES; Lufiana Krismiyanti,M.Pd., from MGMP Brebes Regency; and Fahmi Fatkhomi, M.Pd., from UPS Tegal. The event shared about strengthening productive MGMP models in Central Java, emphasizing the need for support from various parties. The speakers also shared information on the benefits of being a PPII member. The last speaker spoke about technology transfer using a digital portfolio website (Moodle). The core of the seminar presented the results of implementing videos in science teaching using the STEAM approach. The events aimed to assess the STEAM competency profiles of MGMP IPA teachers in Brebes, using understanding tests. The results of the comprehension test are presented in Table 2.

Table 2. Results of the STEAM competency understanding test

Test grid	Number of Statements	Average Score (%)	Explanation
The STEAM concept in science education	1,3,4	98,67	Very Good
Integration of STEAM into the local context of Brebes	2, 8,16,19	90	Very Good

Test grid	Number of Statements	Average Score (%)	Explanation
The Concept of Engineering Design Process in STEAM	5, 6, 7,9, 10	91,1	Very Good
The Concept of Assessment in STEAM	11, 12, 13,14,20	93,6	Very Good
Local Environmental Issues in STEAM	15,17,18	94,6	Very Good
Average Score		93,60	Very Good

Although mastery of STEAM concepts is indicated by the post-test average score of 93.60%, this theoretical comprehension did not translate smoothly into transdisciplinary design activity. The highest scores were observed in understanding basic STEAM concepts and assessment design, while lower scores were observed in engineering design processes and contextual problem formulation. They find joy in learning STEAM (Spyropoulou & Mathiopoulos, 2025). Teachers can also be guided in STEAM learning because they have a really good understanding of the concepts. However, teachers struggle to implement transdisciplinary integration models such as Connected, Shared, or Weaved (Perignat & Katz-Buonincontro, 2019; Tang et al., 2025). This discrepancy draws attention to a prevalent issue in teacher professional development: the difference between "knowing what" and "knowing how"(White & Delaney, 2021), especially when working with intricate pedagogies like STEAM. This mirrors findings from Perignat and Katz-Buonincontro (2019), indicating that effective integration requires advanced curriculum design skills that are often lacking in typical teacher training. These results imply that while short-term training can effectively improve conceptual comprehension, longer-term practice is necessary for greater transdisciplinary skills.

Only a few teachers were able to design projects that integrated Science, Technology, Engineering, Arts, and Mathematics (only 5 videos of good practice). The lesson plans showed improved coherence across project activities, learning objectives, and evaluation techniques. In addition, there were limitations in creative pedagogy (Gloria et al., 2023), as teachers were not trained in design thinking or creative problem-solving, which are essential in STEAM (Yeomans et al., 2025). Although only five good practice videos were made in the seminar, the results showed that more than 50% of participants successfully created lesson plans (Mullick et al., 2025). This shows the difference between planning theory and implementation practice. This will be a problem in the future. Is it due to time constraints or the complexity of the video-making process? Or is it because the designed project is still difficult to implement?

Despite positive outcomes, several challenges were identified, including limited time for collaborative planning, difficulties in integrating arts and engineering components, and limited access to local data and stakeholders. These challenges are consistent with previous studies highlighting the complexity of STEAM implementation in school settings. For example, learning is disconnected from the local context. There is an ethnopedagogical gap, namely the inability to transform local potential (e.g., the salt crisis on the coast of Brebes, the onion pest outbreak) into a driving question for a project (Aljallal & Alshamrani, 2019). Only a few teachers use Brebes BPS data as a basis for their projects. The lack of curriculum contextualization strategies is a problem, as are most projects, which are pseudo-contextual (without involving real data or collaboration with local actors). Another problem that arises is the quality of learning, which still lacks impact. Most learning has not been designed to achieve deep conceptual understanding. Teachers often rely on written tests to assess projects, even though STEAM requires triangulation of assessments (portfolios, observations, products) (Alcaraz-Dominguez & Molas-Castells, 2024). The dynamic nature of the curriculum sometimes confuses teachers when implementing it in the field. This can certainly be overcome if there is synergy among the policies adopted, for example, through agreements within a school. This aligns with Nuragnia et

al. (2021), who note that implementation sometimes faces obstacles in administration, budgeting, and content access. The Brebes MGMP forum has not yet functioned optimally as a community of practice (CoP) for STEAM. As a result, measuring the impact of learning has become difficult. Therefore, advanced training should include specific courses on assessing the needs of the surrounding environment and on turning local potential (such as the salt crisis) into interesting questions. Before closing, there was a discussion and feedback session, with an instrument linked for access. Feedback from participants suggested that, while they recognized the importance of STEAM, time constraints and limited resources were significant hurdles (Park et al., 2016). Many expressed the need for further training that included broader participation and preferably in-person formats to enhance focus. Nearly 100 percent of participants stated that STEAM training is important and interesting to implement in learning to make it more meaningful (Diana & Turmudi, 2021). In general, based on the questionnaire results, participants reported an increase in pedagogical content knowledge (PCK) (Dewi et al., 2021). This is because teachers must integrate multidisciplinary sciences into their delivery and address contextual issues (Herro et al., 2019). However, most participants also stated that time was the main reason for implementing STEAM, along with limited resources. Participants needed more time to explore creative ideas, especially when related to local issues and the integration of multidisciplinary knowledge (Costa et al., 2022).

The findings underscore the importance of structured, context-based professional development programs that combine conceptual training with hands-on practice and mentoring. Integrating local wisdom not only enhances learning relevance but also strengthens teachers' connection to their communities. Suggestions also included using design thinking techniques to support authentic project development and improve learning outcomes. Furthermore, the training involved a broader participant pool and was conducted offline, allowing participants to focus more on the training (Suebsing & Nuangchalerm, 2021). This is certainly in line with Shernoff et al. (2017), who found that the number of STEAM training sessions also supports the success of STEAM learning. Additionally, training using the design thinking technique (empathize-define-ideate-prototype-test) is needed for the development of authentic projects (Plattner et al., 2015). Overall, the events were positively evaluated, and the need for continued training and development in STEAM education was highlighted. By creating consistently accessible online modules and providing periodic mentoring plans for a broader scope, this service is expected to have a significant impact on MGMP teachers. This study has limitations, including the lack of a control group, which affects claims about the causal efficacy of the SMART-DACUM framework. Data on long-term implementation in classrooms were not collected, thus limiting the analysis to the planning phase. Additionally, reliance on self-reported satisfaction and facilitator-graded rubrics may introduce bias.

CONCLUSION

This community service activity indicates the Brebes Regency MGMP Science teachers' knowledge of STEAM is very good, with a very high average of 93.60%. This indicates that teachers are actually capable of implementing STEAM concepts in the field. This study provides recommendations based on the questionnaire results. There is a need for further training that is not theory-based, but rather focuses on skills in designing projects using local issues as context. There is a need for training that uses the concept of design thinking to facilitate teachers in designing multidisciplinary learning. The scope of training should be broader than just the Brebes Regency MGMP. This community service project highlights the effectiveness of a SMART DACUM framework in enhancing science teachers' understanding of the local STEAM context. However, it identifies a

significant gap between conceptual knowledge and practical project design skills, marking this as a critical area for future professional development in STEAM education.

DECLARATION OF GENERATIVE AI

The authors declare that no generative AI or AI-assisted technologies were used in the writing process of this manuscript.

CONFLICTING INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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