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Bridging Academic Learning and Community Needs: A Project-Based Learning-Based Drainage Planning Initiative for Sustainable Development Goal 6

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ABSTRACT: This paper examined the implementation of a community service program based on a Project-Based Learning (PBL) framework to support rural infrastructure planning while highlighting its pedagogical and practical contributions. The study adopted a qualitative, practice-based approach to document and reflect on activities conducted in Rejosari Village, Bojong, Pekalongan Regency. The program was initiated in response to a request from the village government to address recurring waterlogging problems through the development of a drainage system plan. The program was implemented through several stages, including initial discussions with village officials, joint site surveys, on-site problem identification, collaborative analysis, design development, cost estimation, and the formal handover of technical drawings and budget plans. The process emphasized participatory engagement, field-based learning, and iterative design, involving both lecturers and students in direct interaction with the community. The results indicated that the program generated tangible benefits for both students and the community. Students gained experiential learning opportunities by applying theoretical knowledge to real-world challenges while developing critical-thinking, teamwork, and problem-solving skills. For the community, the program provided a practical and context-sensitive drainage design that could serve as a reference for future infrastructure development. The findings demonstrated that community-based PBL could be effectively implemented in rural contexts and could bridge academic learning with practical application. The study also provided a replicable framework for integrating education, community engagement, and infrastructure planning to support sustainable rural development.

KEYWORDS: Project-Based Learning; community service learning; rural infrastructure planning; participatory approach; drainage system design

1. Introduction

Academicians play an important role in rural infrastructure planning by contributing research, conceptual frameworks, and methodological approaches that address emerging challenges and improve planning processes. Beyond generating theoretical knowledge, academic involvement can bridge knowledge production and practical implementation in rural contexts. For example, the “Working with People” (WWP) model emphasizes social learning and participatory

approaches as essential components of sustainable rural development [1]. Interdisciplinary approaches integrating ethnographic methods with conventional planning tools have also been developed to better capture local dynamics and strengthen local and regional planning [2]. Community-based management approaches further emphasize the importance of involving local stakeholders throughout planning, organization, and implementation, thereby aligning development initiatives with local needs and strengthening their long-term sustainability [3, 4]. Similarly, participatory action research (PAR) demonstrates how collaborative knowledge production can be integrated with service-learning to mobilize local capacities and support inclusive and context-sensitive rural development [5].

Rural infrastructure planning provides a valuable context for involving academicians, including lecturers and students, and can be effectively incorporated into a PBL framework. Integrating community service with PBL, commonly associated with service-learning, connects academic objectives with real-world community engagement. This approach creates reciprocal relationships between universities and communities by linking classroom knowledge with practical applications. Previous studies have demonstrated that service-learning can enhance learning outcomes and strengthen students' civic responsibility [6–9]. Through direct participation in community-based projects, students can apply academic knowledge to practical problems while developing a deeper understanding of contextual challenges.

Service-learning can also promote interdisciplinary collaboration and strengthen teamwork, communication, and problem-solving skills [10, 11]. These competencies are particularly important in rural infrastructure planning, where complex challenges require integrated and context-sensitive solutions. Participation in community-based projects can further strengthen technical knowledge, leadership, critical thinking, collaboration, and cultural sensitivity [12]. Engagement with real-world problems may also increase students' motivation and commitment [6] while developing self-efficacy, professional ethics, and social responsibility [13].

Despite the documented pedagogical benefits of service-learning and participatory rural development, an important research gap remains regarding their application in vocational education. Previous studies have generally emphasized the social dimensions of community engagement or broad soft-skill development, with less attention given to the direct integration of quantitative engineering outputs, such as drainage-capacity calculations addressing Sustainable Development Goal (SDG) 6. Furthermore, limited empirical research has examined how community-based PBL can be systematically implemented among vocational architecture and civil engineering students in developing rural contexts. This study addressed these gaps through an approach that integrated technical infrastructure planning with the development of students' applied competencies. The study therefore provided a replicable model linking engineering deliverables, community engagement, and experiential learning.

This study examined a community service initiative conducted by Universitas Diponegoro in Rejosari Village, Bojong, Pekalongan Regency. The initiative originated from a request by the Head of Rejosari Village for assistance in planning essential infrastructure, particularly a drainage channel to address recurring waterlogging. Lecturers and students engaged directly with village stakeholders to identify local problems, conduct field assessments, and develop a drainage plan appropriate to the environmental and spatial

conditions. Accordingly, this study examined the implementation of community-based PBL in rural infrastructure planning and evaluated its practical and pedagogical contributions.

2. Methods

This study employed a qualitative, practice-based approach to document and reflect on a community service program conducted in Rejosari Village, Bojong, Pekalongan Regency. The program was implemented within a PBL framework, enabling lecturers and students to respond directly to community needs while applying academic knowledge in practice [14, 15]. The overall process emphasized collaboration, field-based learning, participatory engagement, and context-sensitive planning. The program was implemented through several stages. The first stage involved discussions with village officials to identify the primary problem, namely recurring waterlogging caused by inadequate drainage. The scope and expected outputs of the program were also established during this stage (Figure 1).

Figure 1. Students Discussed with Village Officials.

The second stage involved a joint site survey conducted by lecturers, students, and village officials. The team examined the existing drainage system and physical site conditions, including land contours, drainage paths, and locations where water accumulated. Village officials provided contextual information based on their experience with local conditions (Figure 2). The third stage involved on-site problem analysis. Lecturers, students, and village stakeholders jointly evaluated the observed conditions and discussed potential solutions. The fourth stage involved drainage-system design. Under lecturer supervision, students developed the drainage plan based on field observations and technical requirements, including water flow, channel dimensions, and existing settlement conditions. The design was developed iteratively and reviewed to ensure its technical appropriateness and feasibility.

Figure 2. Site Survey.

The fifth stage involved preparation of the budget plan. Cost estimates were developed alongside the technical drawings to assess the feasibility of future implementation. Finally, the technical drawings and detailed budget plan were formally handed over to the Head of Rejosari Village. This process demonstrated how discussion, field investigation, collaborative analysis, and iterative design could generate practical community outputs while providing meaningful experiential learning for students.

The final stage was the handover of the planning documents to the Head of Rejosari Village. The documents included technical drawings and a detailed budget plan. This handover marked the completion of the program and provided the village with a ready-to-use reference for future implementation. Overall, this method shows how a structured yet flexible process, combining discussion, fieldwork, and collaborative design, can produce practical outcomes for the community while also supporting meaningful learning experiences for students.

3. Results and Discussion

The community service program was implemented according to the stages established in the methodology. Close collaboration between the academic team and village stakeholders enabled the planned activities to progress from problem identification to the delivery of technical outputs.

3.1. Problem Identification and Data Collection.

The program began with direct engagement among lecturers, students, and village officials. Within the PBL framework, students actively participated in identifying the recurring waterlogging problem associated with inadequate drainage. This approach positioned students as active participants addressing authentic community problems rather than simulated classroom cases. During the joint site survey, students examined land conditions, existing drainage paths, and water-accumulation points (Figure 3). The field investigation enabled students to develop practical site-analysis skills while incorporating local knowledge provided by village stakeholders. This process reflected the fundamental PBL principle of learning through direct engagement with authentic problems.

Figure 3. Site Survey Process, Measure the Existing Drainage Path.

3.2. Problem Analysis and Development of Outputs.

On-site discussions enabled students to analyze the identified problems collaboratively with lecturers and community representatives. Students proposed potential solutions based on technical knowledge and actual field conditions, strengthening their critical-thinking and problem-solving abilities. Under lecturer supervision, students subsequently developed the proposed drainage route and detailed technical drawings (Figures 4). The design process involved iterative evaluation, technical considerations, and adaptation to local conditions. Students also prepared a cost estimate to assess the feasibility of future implementation. These activities reflected the output-oriented nature of PBL, in which learning outcomes were demonstrated through tangible and practically applicable deliverables.

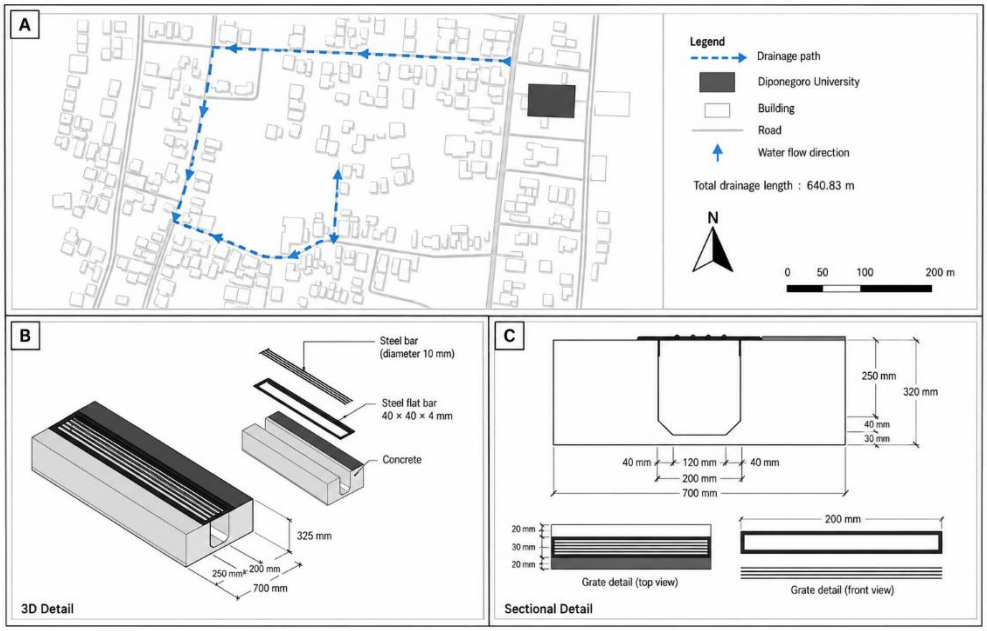

Figure 4. Proposed Drainage System: (A) Drainage Alignment and Flow Direction; (B) Isometric View of the Drainage Structure; and (C) Detailed Cross-Sectional Design.

3.3. Delivery of Outputs to Village Officials.

The final outputs, consisting of drainage design drawings and a detailed budget plan, were formally handed over to Rejosari Village officials (Figure 5). This stage demonstrated the practical relevance and accountability of the project because the students' work became a technical reference that could support future infrastructure development in the village.

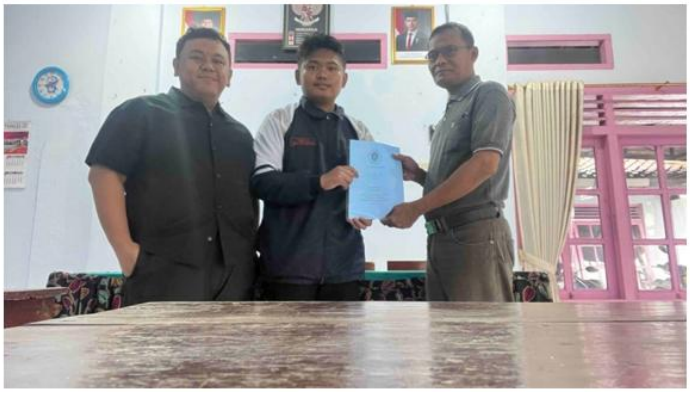

Figure 5. Hand Over the Drawings and Budget Plan to Village Official.

3.4. Effectiveness and Contributions of Community-Based PBL.

The findings demonstrated that PBL could be effectively integrated into community service when learning activities were based on authentic community needs. Students translated theoretical knowledge into practical solutions through their involvement in problem identification, field investigation, analysis, design, budgeting, and delivery of project outputs. This process promoted experiential learning while strengthening critical thinking, creativity, communication, teamwork, and problem-solving skills, consistent with previous studies. The involvement of village officials as real stakeholders further strengthened students' engagement and professional responsibility. Students were required to develop outputs that were not only academically appropriate but also technically relevant and responsive to community needs. This interaction strengthened the connection between theory and practice and demonstrated the value of PBL for addressing authentic and complex problems [16, 17]. The program also generated tangible benefits for the community. The drainage design and budget plan provided practical references for future infrastructure development. Thus, community-based PBL functioned not only as a pedagogical strategy but also as a mechanism for delivering context-sensitive solutions to community problems [18]. The reciprocal relationship between learning and community impact reinforced the role of higher education institutions in supporting sustainable and community-oriented rural development

4. Conclusions

This study demonstrated that a community service program implemented through a PBL framework could simultaneously support rural infrastructure planning and enhance student learning. The program in Rejosari Village integrated problem identification, field surveys, collaborative analysis, drainage design, budgeting, and the formal delivery of planning documents. Collaboration among lecturers, students, and village officials resulted in a context-sensitive drainage design and cost estimate intended to address recurring waterlogging. For students, the program provided opportunities to apply theoretical knowledge to an authentic

infrastructure problem while developing technical competencies, critical thinking, teamwork, communication, and problem-solving skills. For the community, the project generated technical drawings and a budget plan that could serve as references for future infrastructure development. Future programs should consider longer engagement periods, broader participation by local residents, greater interdisciplinary collaboration, and post-implementation monitoring and evaluation. Such improvements would enable the technical effectiveness and long-term community impacts of proposed infrastructure solutions to be assessed. Overall, integrating PBL with community service provided a practical framework for bridging academic learning and societal needs while supporting sustainable and context-responsive rural development.

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Author Contributions

Muhammad Ismail Hasan contributed to the conceptualization, methodology, data analysis, manuscript preparation, and supervision of the study. Muhammad Naufal Nararya contributed to data collection and data analysis. The community service program was supported by funding from Universitas Diponegoro. Both authors reviewed and approved the final manuscript.

Competing Interests

The authors declare that they have no competing financial or non-financial interests related to this community service program or the preparation of this manuscript.

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