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From Research to Community Impact: Training for the Operation and Maintenance of Patented Electric Pedicabs (E-Becak)

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ABSTRACT

Background: The transition toward sustainable transportation requires solutions that balance technological innovation with cultural preservation and community empowerment. In Indonesia, the becak (pedicab) remains both a cultural icon and a livelihood for many low-income families. However, conventional and motorized becaks pose challenges related to driver fatigue, environmental pollution, and operational inefficiencies. To address these issues, researchers developed the electric becak (e-becak), a patented innovation (Patent No. IDS000011210).

Contribution: The program contributes to the community by equipping drivers with practical skills. It also empowers participants by fostering ownership of sustainable technology.

Method: The program attended by 25 participants was implemented in four stages: (1) socialization to introduce drivers to the concept and benefits of e-becak; (2) training on operational use, including driving, battery charging, and safety practices; (3) training on preventive and corrective maintenance; and (4) evaluation and monitoring through pre- and post-tests, observations, and feedback sessions.

Results: Findings showed significant improvements in drivers' knowledge and skills, with post-training assessments indicating a 70–80% increase in competency levels.

Conclusion: The training program effectively bridged innovation and community practice by ensuring that drivers were capable of sustaining e-becak adoption. This initiative demonstrates how research-based innovations can be integrated into community livelihoods, contributing to sustainable transportation and community empowerment.

1. Introduction

The urgency of transitioning toward sustainable modes of transportation has intensified globally in response to escalating environmental challenges [1]–[3]. Issues such as greenhouse gas emissions, urban congestion, and fossil fuel dependency continue to exert pressure on governments, industries, and communities to rethink their mobility systems [4]–[8]. In many countries, transportation remains a significant contributor to air pollution and carbon emissions. For example, in China, transportation is the third-largest source of greenhouse gases and a major driver of urban air pollution, contributing up to 35% of NOx and significant shares of other pollutants [9]–[12].

This situation reflects a broader global challenge, where the environmental impact of transportation necessitates context-specific strategies rather than uniform solutions. Effective mitigation efforts require approaches that are sensitive to the socio-economic realities and cultural dynamics of each nation. In Indonesia, for example, addressing transportation-related emissions calls not only for the adoption of advanced technological solutions but also for innovations that are socially inclusive, culturally attuned, and economically feasible. This becomes especially relevant in communities where traditional modes of transport, such as the becak (pedicab), remain integral to everyday mobility and livelihoods. Designing interventions that respect and adapt to these local characteristics is therefore crucial to ensuring both environmental sustainability and social acceptance [13]–[15].

The becak holds a unique position in Indonesian society as both a cultural icon and an essential livelihood for many low-income families. Traditionally pedal-driven, and later modified into motorized versions, becaks have long served as an affordable and accessible means of transportation. However, reliance on manual labor has subjected drivers to physical strain, while the introduction of small combustion engines has increased operating costs and environmental burdens. Thus, while becaks continue to support local economies, they simultaneously highlight the tension between cultural preservation and the necessity for modernization. Without immediate and thoughtful intervention, there is a risk that becak drivers already among the most economically vulnerable, will be left behind in the transition to sustainable mobility.

One such intervention is the development of the electric becak (e-becak). Designed to maintain the cultural heritage of the becak while reducing its environmental footprint, the e-becak introduces a more energy-efficient and driver-friendly alternative. By incorporating electric propulsion, this vehicle significantly reduces greenhouse gas emissions, minimizes noise pollution, and alleviates the physical exhaustion associated with manual pedaling [16]–[18]. Beyond these environmental and ergonomic benefits, the e-becak also offers economic advantages, including lower maintenance costs and reduced dependence on increasingly volatile fuel prices.

The e-becak is the outcome of extensive research and development efforts, formally recognized through a registered patent (IDS000011210) [19], signaling both its novelty and potential scalability. The contribution of this innovation lies not only in its technological features but also in its potential to serve as a model for integrating cultural preservation with sustainable design an area where practical examples remain scarce in the literature on green transportation transitions.

Community engagement is therefore indispensable to bridging the gap between technological innovation and real-world application. For the e-becak to thrive, its drivers must be equipped with the knowledge and skills to operate, troubleshoot, and maintain the vehicles effectively. Training programs in this regard go beyond imparting technical knowledge they foster self-reliance, strengthen local capacities, and encourage community ownership of the innovation. By enhancing driver competencies, training reduces the likelihood of operational breakdowns, prolongs the lifecycle of the vehicles, and builds confidence among users. The urgency of such training cannot be overstated, as the success of sustainable technologies often falters when end-users are excluded from the learning process. This initiative contributes by directly addressing the often-overlooked human dimension of technology adoption, ensuring that innovation is matched with capability development.

This community service initiative was specifically designed to train e-becak drivers in operational and maintenance practices, with the broader aim of ensuring the sustainability and acceptance of this innovation. Through structured training modules, practical demonstrations, and interactive discussions, participants were guided to understand the technical, safety, and environmental aspects of e-becak use. The program also emphasized the broader benefits of adopting electric vehicles, such as contributions to environmental sustainability, reductions in urban air pollution, and alignment with national development priorities. The contribution of this initiative lies in its dual impact: while it provides immediate, tangible skills to participants, it also creates a foundation for long-term socio-technical change, where local communities become active agents in the sustainable mobility transition rather than passive recipients of technology.

The significance of this initiative extends beyond local community empowerment. At a broader level, it contributes to Indonesia’s commitments to sustainable development, particularly the Sustainable Development Goals (SDGs). Specifically, the program aligns with Goal 7 (Affordable and Clean Energy), Goal 11 (Sustainable Cities and Communities), and Goal 13 (Climate Action). Furthermore, it offers a replicable model for integrating research outcomes into practical community service that strengthens livelihoods while addressing environmental concerns. By situating the becak an enduring cultural symbol within the discourse of sustainable mobility, this initiative demonstrates how tradition and innovation can coexist to produce meaningful societal impact.

In this paper, we describe the design, implementation, and outcomes of the e-becak training program. The discussion highlights not only the technical competencies gained by participants but also the social and environmental benefits realized through the initiative. In doing so, the paper underscores the urgency of equipping communities with the skills to adapt to sustainable technologies and the contribution of this program in demonstrating a community-centered model for technological adoption. Ultimately, the findings suggest that

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empowering communities through education and training is a crucial pathway for ensuring the longevity and impact of innovations such as the e-becak, particularly in societies where cultural heritage and sustainability must advance hand in hand.

2. Method

This community service program was designed and implemented at the Ahmad Dahlan Becak Association (Pabelan), Yogyakarta Special Region, Indonesia, to facilitate the adoption of electric becaks (e-becaks) by strengthening the technical capacity of users, primarily becak drivers. The program ran from April to September 2025, with a total duration of 2-3 days per week. The program involved 25 participants who were active members of the Ahmad Dahlan Becak Association. Participants were male becak drivers, aged 48-62, with an average of 20 years of experience operating conventional and motorized becaks. These participants were selected based on their active community status and interest in transitioning to sustainable, electric-powered transportation. The methodology used followed a series of structured activities, beginning with community engagement and continuing with training, practice, and evaluation. The program's approach emphasized participatory learning, cultural sensitivity, and practical demonstrations, ensuring that the training process was accessible, relevant, and sustainable for the target community [20], [21]. The key implementation steps are outlined below.

1. Community Socialization

The first stage involved a structured socialization process aimed at introducing the concept and benefits of the e-becak to local becak drivers. This event conducted by 2 days. This phase was critical for building trust, dispelling misconceptions, and creating a sense of ownership among participants. Socialization activities included interactive discussions, visual presentations, and informal dialogues, which were conducted in familiar community settings to ensure accessibility. The sessions highlighted the environmental, economic, and ergonomic advantages of e-becak adoption, while also addressing drivers' concerns related to safety, affordability, and cultural identity. Feedback from participants was actively collected to inform the design of subsequent training modules, ensuring that the program was responsive to the community's needs.

2. Training on E-Becak Operation

The second stage focused on training participants in the practical operation of the e-becak. Training sessions were conducted using a hands-on approach, allowing drivers to familiarize themselves directly with the vehicle. Key components of this training included understanding the vehicle's basic features, battery charging procedures, safe driving practices, and troubleshooting common operational issues. Trainers emphasized experiential learning by allowing participants to practice driving under supervision, ensuring that they developed confidence and competence in using the e-becak. To ensure inclusivity, the sessions were tailored to different learning paces, with opportunities for peer-to-peer mentoring among drivers.

3. Training on E-Becak Maintenance

The third stage addressed the technical knowledge required for routine maintenance of the e-becak. Proper maintenance is vital for ensuring the reliability and longevity of the vehicle, reducing operational costs, and fostering user independence. Training covered both preventive and corrective maintenance practices, such as regular inspection of electrical components, tire and brake checks, lubrication of moving parts, and battery care. Practical demonstrations were integrated into each session, with participants performing the tasks themselves under supervision. This stage also provided illustrated manuals and simple checklists in the local language to serve as reference tools for drivers. By equipping participants with maintenance skills, the program sought to minimize reliance on external technicians and strengthen local self-sufficiency.

4. Evaluation and Monitoring

The final stage involved systematic evaluation and ongoing monitoring of both the training process and participants' competencies. Evaluation was conducted through pre- and post-training assessments, observation of practical exercises, and participant feedback sessions. These assessments measured improvements in knowledge, operational skills, and confidence levels. In addition, monitoring activities extended beyond the training period, involving periodic follow-ups to track how drivers applied the skills in their daily work. Monitoring also provided valuable insights into challenges encountered in real-world usage, such as battery performance or road conditions, which were documented for continuous improvement of the program. This stage ensured accountability and enabled the refinement of training materials to better suit community needs in future implementations.

Throughout the program, ethical principles were carefully observed. Participation was voluntary, with informed consent obtained from all participants. The training was conducted in an inclusive and respectful manner, ensuring equal opportunity regardless of age, literacy level, or previous experience with motorized vehicles. Data collected during evaluation and monitoring were used solely for program improvement and academic reporting, with confidentiality maintained at all times.

3. Results and Discussion

The implementation of the training program produced valuable insights into the readiness of becak drivers to adopt the e-becak, as well as the effectiveness of participatory approaches in promoting sustainable transportation. To objectively measure the increase in technical competency, participants underwent a pre-test prior to the training and a post-test upon completion. The assessment covered essential operational skills, maintenance knowledge, and safety protocols. As shown in Table 1, the program resulted in a substantial improvement in participant understanding.

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Table 1. Comparison of Participants' Competency Scores (Pre-test vs. Post-test)

Assessment Category	Average Pre-test Score	Average Post-test Score	Improvement (%)
Operational Knowledge	55	82	49.0%
Maintenance Procedures	45	79	75.9%
Safety & Troubleshooting	42	80	90.5%
Overall Average	47.3	80.3	69.83%

Note: Scores are based on a 0–100 scale.

The data indicates a significant shift in technical readiness, with an overall average increase of approximately 69.83%. This result confirms that structured training is a critical intervention for the successful adoption of new technologies in non-formal sectors. Results are presented in line with the four stages of the methodology, socialization, operational training, maintenance training, and evaluation with monitoring, followed by a broader discussion of implications for community empowerment and sustainable mobility transitions.

1. **Outcomes of Community Socialization**

Figure 1 presents the socialization stage that successfully built awareness and interest among drivers, who initially expressed skepticism regarding the practicality and affordability of the e-becak. Through open dialogue and participatory discussions, drivers were able to voice their concerns, which centered on battery durability, cost implications, and potential income changes. These conversations not only clarified misconceptions but also fostered trust between researchers and the community. As a result, participation rates in subsequent training sessions exceeded initial expectations, with many drivers motivated by the promise of reduced fuel expenses and improved working conditions.

Figure 1. Community Socialization

The effectiveness of this stage underscores the importance of early community engagement in technology adoption. Socialization allowed participants to contextualize the innovation within their own livelihoods, aligning with findings in community-based participatory research that stress dialogue as a foundation for acceptance. Without this stage, resistance and mistrust could have undermined later training efforts, highlighting those successful technological transitions depend as much on relational processes as on technical design [22]–[24].

2. Outcomes of E-Becak Operation Training

During the operational training sessions, participants demonstrated significant improvement in their ability to operate the e-becak safely and efficiently, as shown in Figure 2. Drivers learned to manage acceleration, braking, and maneuvering, while also familiarizing themselves with battery charging protocols and dashboard indicators. By the end of the sessions, over 90% of participants were able to independently operate the e-becak with minimal supervision, indicating a rapid uptake of new skills. Practical demonstrations were particularly effective, as drivers appreciated the experiential approach over theoretical explanations.

Figure 2. E-Becak Operation Training

These results highlight the value of hands-on learning in vocational contexts. For participants with limited formal education, practical demonstrations proved to be the most accessible method of knowledge transfer. This reinforces the argument that training methodologies must be adapted to participants' backgrounds, ensuring inclusivity. The rapid skill acquisition also signals strong potential for scaling up e-becak adoption, as operational challenges were quickly overcome once participants were given structured opportunities to learn and practice.

3. Outcomes of E-Becak Maintenance Training

Maintenance training, as presented in Figure 3, revealed that while participants initially lacked familiarity with basic electrical systems. They were able to acquire essential maintenance skills with guided practice. Drivers successfully performed tasks such as checking brake systems, inspecting tire pressure, and monitoring battery connections. Maintenance checklists distributed during training were consistently used by participants, serving as practical references. Furthermore, several drivers expressed interest in developing peer-support networks to collectively address technical issues, indicating a sense of ownership and community initiative.

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Figure 3. E-Becak Maintenance Training

This stage illustrates how skill-building in maintenance not only improves technical reliability but also strengthens community resilience. By equipping drivers with preventive maintenance skills, the program reduced dependency on external mechanics and minimized operational downtime. The emergence of peer-support initiatives demonstrates that capacity building can trigger collective problem-solving mechanisms, a feature often overlooked in sustainability programs. This outcome aligns with literature on socio-technical systems, which emphasizes that sustainable innovations succeed when local users actively co-create maintenance and troubleshooting practices.

4. Outcomes of Evaluation and Monitoring

Evaluation through pre- and post-training assessments revealed a marked improvement in participants' knowledge and confidence. Post-training scores indicated a 70–80% increase in understanding operational and maintenance procedures. Monitoring over subsequent weeks confirmed that drivers applied the skills consistently, with fewer reported breakdowns and more efficient use of battery charging practices. Feedback sessions also revealed that drivers felt a greater sense of pride and dignity in their work, as operating the e-becak distinguished them as pioneers of environmentally friendly transport in their communities. The monitoring phase highlights the long-term significance of combining training with follow-up support. While short-term skill acquisition is important, ongoing observation ensured that knowledge translated into sustained behavior change. The findings also suggest that training programs contribute not only to technical competence but also to intangible outcomes such as self-esteem and social recognition. These elements are crucial for long-term adoption, as they strengthen the psychological and social drivers of technology acceptance [25], [26].

The outcomes of this program contribute to broader discussions on sustainable mobility, community service, and technology adoption in developing contexts. First, the training demonstrates that innovations such as the e-becak cannot succeed without parallel investments in human capacity. Technology alone is insufficient; it is the people who operate and maintain it that determine its sustainability. Second, the participatory design of the program created a sense of co-ownership, showing that cultural icons like the becak can be revitalized rather than displaced in the sustainability transition. Finally, the initiative provides a replicable model for other communities facing similar challenges, offering a practical blueprint for integrating research outputs with community service in pursuit of the Sustainable Development Goals (SDGs).

4. Conclusion

This study demonstrates that the integration of sustainable transportation technologies into traditional sectors fundamentally depends on aligning technical innovation with human capacity building in urban areas. As noted in the introduction, the e-rickshaw initiative successfully bridged the gap between patented innovation and real-world adoption by actively engaging rickshaw drivers in a structured, participatory training program. The results confirm that addressing the socio-technical dimension, particularly through practical operational and maintenance training, can significantly improve driver competency, as evidenced by a 70–80% increase in post-training assessments and a sustained reduction in operational barriers.

Beyond the immediate technical outcomes, this initiative provides a replicable framework for integrating research-based solutions into urban livelihoods at tourism hubs, effectively aligning local transportation needs with national and global sustainability goals (SDGs). Future research and application efforts should prioritize the formalization of peer support networks to ensure ongoing knowledge transfer and problem-solving. By institutionalizing this training model, stakeholders can ensure that innovations like e-rickshaws remain economically viable and culturally integrated, thus providing a strong pathway for the transition to greener and more inclusive urban mobility.

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