

Assessing the Impact of Basic Air Conditioning Maintenance Workshops on Rural Participants' Technical Skills and Confidence

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Abstract

This study evaluated a one-day air-conditioning (AC) maintenance workshop delivered to adult learners in Kampung Sahom, Perak, Malaysia under the PUO MechCARE 2025 initiative. The workshop consists of three hours of classroom instruction and four hours of hands-on training. A sequential explanatory mixed methods design was employed. Participants' technical competency was assessed using structured rubric after the workshop. Self-efficacy was measured through pre and post surveys covering conceptual understanding, practical skills, and independent problem-solving ability. Semi-structured interviews were also conducted to obtain participants' learning experiences and perceived changes. Results show strong post training performance, with an overall mean score of 4.00 ± 0.26 . The highest achievement was observed in AC component identification and adherence to safety procedures. Survey results indicate significant improvements in self-efficacy across all domains ($p < 0.05$). The greatest gain is in practical performance by showing a large effect size. Interview findings highlight improved confidence, positive attitude shifts, and a clear intention among participants to apply the skills in their daily lives. Overall, the study suggests that one day practical technical training can generate meaningful improvements in both technical ability and personal confidence. The findings also reinforce the value of targeted TVET outreach programmes for strengthening skills development in underserved rural communities.

Keywords: - TVET, rural training, transformative learning, technical self-efficacy

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1. Introduction

In many rural communities, opportunities for structured technical education remain scarce (Ekhwan, 2025; Sukri et al., 2026 & Lamb, 2011). This lack of access often results in underemployment, outward migration of young people to urban centres, and continued dependence on external service providers (Nor et al., 2025). Such dependence can reduce economic retention, particularly when services like air-conditioning (AC) maintenance, which is essential in Malaysia's tropical climate, require costly visits from technicians outside the community. Addressing these gaps calls for initiatives that not only transfer technical skills but also empower individuals to take ownership of essential maintenance tasks.

Service-learning program offers a compelling approach to achieving this goal. By integrating academic knowledge with meaningful community service, it fosters mutual benefit: communities receive relevant, practical training, while educators and students gain authentic opportunities to apply and extend their expertise. Service-learning that responds to community needs can enhance both technical competence and learner confidence, contributing to sustainable change beyond the classroom (Rodríguez-Zurita et al., 2025; Wahab, 2024 & Hudin et al., 2018).

In this context, on 16 July 2025, the Department of Mechanical Engineering at Politeknik Ungku Omar (PUO) implemented the PUO MechCare programme in Kampung Sahom, Kampar, Perak, a rural community whose economy is primarily supported mainly by agriculture and

ecotourism. The basic AC maintenance workshop was introduced because the village has more than ten homestays and small resorts operated by local residents, creating a strong demand for AC maintenance knowledge and skills.

A key component of the initiative was a one-day basic AC maintenance workshop that combined three hours of classroom instruction with four hours of practical training. The programme aims to provide participants with essential HVAC knowledge and introductory skills in routine AC service. It also sought to strengthen participants' confidence in handling technical tasks. Simultaneously, PUO staff and students gained valuable experience in community engagement and practical teaching, reflecting the mutual learning principles of service-learning.

The workshop was developed based on vocational pedagogy that emphasizes both theoretical understanding and practical competence (Williams, 2020; Mohamad et al., 2025; Horne & Majola, 2026 & Jailani et al., 2017). In addition, transformative learning theory informed the instructional approach, as meaningful hands-on experiences can influence self-perception and encourage greater personal agency (Cranton, 2023; Baumgartner, 2020 & Mezirow, 2018). Previous studies on service-learning have similarly shown that active participation combined with reflection can enhance technical ability as well as confidence to apply newly learned skills in everyday contexts (Naufal et al., 2024; Sani et al., 2024; Bamdas et al., 2022; Yoong, 2022 & Rosenbaum & Sano, 2026).

Although the value of practical vocational training has been widely acknowledged, several research gaps remain. Relatively few studies have examined the outcomes of short-duration technical workshops, particularly one-day programmes involving rural participants with limited previous exposure to such training. The role of direct interaction with real equipment in shaping learning outcomes also requires further attention. In addition, the combined effects of community-based TVET programmes on both technical competency and self-efficacy among adult or non-traditional learners are still insufficiently explored. The present study addresses these gaps by taking a close look at what the PUO MechCare AC maintenance workshop was able to achieve in practice.

This paper is organized into five sections. This opening section establishes the purpose and boundaries of the study. The remaining sections then deal with the research method, the findings, and a closing discussion covering the meaning of the results and possible areas for further investigation.

2. Methodology

2.1 Research Design

A sequential explanatory mixed methods design was chosen for this study. This approach was selected because the research required two types of data. Quantitative data were collected to measure and compare performance outcomes among participants. Qualitative data, on the

other hand, helped explain how participants experienced the learning process from their own perspective.

2.2 Participants and Workshop Structure

Participants were recruited through announcements made by the Ketua Kampung and Tok Batin approximately one month prior to the programme. A total of six individuals aged between 23 and 65 years voluntarily registered to participate. The scale of the turnout, while small, is consistent with what community-based training in rural settings tends to attract, a combination of low awareness and the weight of everyday work obligations make sustained participation difficult to achieve. Written consent was obtained from all six prior to the workshop, and the study itself was conducted under ethical approval granted by the PUO Research, Innovation and Commercialization Unit.

Prior to the workshop, participants had no prior exposure to HVAC systems of any kind, which shaped several of the logistical decisions made by the organizing team. The training was conducted at the village community hall, where the PUO team had set up a working air-conditioning unit alongside the basic tools required for the practical tasks. Since all participants were new to HVAC systems, a ratio of two participants to every one instructor was maintained during the session. This was done to make sure that everyone had access to the guidance and support they needed while working through the practical tasks.

The programme was conducted over one full day, with theory and practical components delivered in sequence. The three-hour theory session was held at the village community hall. This session introduced fundamental HVAC systems (see Fig. 1). Participants subsequently relocated to a nearby surau for a four-hour practical session (see Fig. 2). During this session, participants applied the concepts learned in the classroom through hands-on activities, including unit inspection, filter cleaning, refrigerant checking, and basic fault diagnosis.



Fig. 1: The first session of the workshop



Fig. 2: Practical session at surau

Teaching used a co-teaching approach involving PUO lecturers and final-year engineering students. This supported service-learning by giving the community practical training while allowing students to gain real teaching experience.

Informal reflection was encouraged throughout the workshop, particularly when moving from theory sessions to practical tasks. These short discussions helped participants connect what they had learned with the hands-on activities. As a result, participants developed a better understanding of the topics covered and became more confident in carrying out the tasks themselves.

2.3 Quantitative Data Collection

a) Technical skills assessment

Practical competencies were measured through a performance evaluation conducted after the workshop as in Table 1. A pre-test was not administered because all participants were screened prior to the workshop and confirmed to have no prior training or practical experience in HVAC maintenance. Therefore, baseline practical competency was assumed to be negligible. The assessment rubric covered five areas: safety and preparation, use of tools, identification of components, troubleshooting, and completion of the assigned task. Five-point scale was used, where 1 represented poor performance and 5 represented excellent performance.

Table 1: Rubric for technical skills assessment adapted from HVAC workshop subject in PUO

Domain No.	Domain Description	Criteria for Evaluation	Scoring Range
1	Safety and Preparation	Proper use of personal protective equipment (PPE). Correct workspace setup. Pre-task inspection of tools and equipment.	1-5
2	Tool Handling and Usage	Ability to identify, select, and correctly use common AC tools such	1-5

3	Component Identification	as gauges, and screwdrivers. Accurate identification and basic function explanation of AC components (e.g., compressor, condenser, filters).	1-5
4	Troubleshooting and Execution	Ability to follow procedural steps to clean filters, check refrigerant pressure, and identify minor faults. Timely task execution, restoration of	1-5
5	Task Completion and Clean-Up	workspace, proper tool storage, and final inspection of completed work.	1-5

Throughout the practical session, each participant was observed by two PUO instructors (one lecturer and one PUO student) who assessed performance simultaneously. Both assessors followed the same performance descriptors shown in Table 2 when evaluating each participant. Having two assessors instead of one made the process fairer, as it meant that no single person's judgement alone decided how a participant was scored.

Table 2: Description for technical skills assessment

Score	Description
1	Cannot perform the task at all. Needs constant guidance and shows unsafe practices.
2	Struggles with most steps, even with help. Basic understanding is still lacking.
3	Can complete some parts with guidance. Makes mistakes regularly and is not yet ready to work alone.
4	Complete most tasks correctly with little guidance. Minor errors may occur.
5	Completes all tasks independently, correctly, and safely. Full mastery is demonstrated.

b) Confidence survey

A validated TVET questionnaire developed by Omar et al. (2020) was adapted and translated into Malay for use in this study. The original instrument was designed to measure skill competency among TVET teachers. In this study, the questionnaire items in Table 3 were modified to assess participants perceived technical skills, confidence, and learning outcomes after attending the basic air conditioning maintenance workshop. The instrument contained ten items in total, spread across three areas. Items 1 to 3 measured conceptual understanding. Items 4 to 7 addressed technical task confidence. Items 8 to 10 focused on independent problem-solving. Participants

rated each statement using a five-point Likert scale from 1 for “Strongly Disagree” to 5 for “Strongly Agree”.

Table 3: Questionnaire used for confidence survey

Item No.	Statement
1	I understand how an air conditioning system works
2	I can explain the basic components of an AC unit to someone else
3	I can describe common AC problems and their possible causes
4	I feel confident using hand tools required for basic AC maintenance
5	I can safely clean or replace AC filters without assistance
6	I am confident in checking refrigerant levels and inspecting components
7	I can follow step-by-step procedures for troubleshooting AC systems
8	I feel capable of fixing minor AC issues at home on my own
9	I believe I can solve problems during AC maintenance if they arise
10	I am confident in my overall technical abilities related to air conditioning maintenance

2.4 Qualitative Data Collection

Semi structured interviews were conducted to collect participants' reflections on the workshop. Three participants were purposively selected to capture diverse learning experiences and outcomes observed during the workshop. The participants were chosen based on their level of engagement, participation, and improvement in technical skills and confidence, representing different learning trajectories throughout the training. This sampling approach allowed the researchers to obtain rich qualitative insights into how the workshop influenced participants' technical abilities and self-confidence. All interviews were conducted in Malay and took about 20 to 30 minutes each. The questions listed in Table 4 focused on participants' training experience, changes in confidence, challenges faced, and the personal impact of the programme. With consent, the sessions were audio-recorded, then transcribed and translated into English for analysis.

Table 4: Questions for semi-structured interview

Section	Question
A: Learning Experience	1. What was the workshop like for you? What did you enjoy most?
	2. What was new to you? Did the theory session help you understand how an AC system works?
	3. Was it easy or difficult to follow the instructions? Did you get enough help during the practical session?
B: Changes in	4. How confident were you in AC maintenance before the workshop? Have you done it before?

Confidence and Belief	5. Do you feel more confident after the workshop?
	6. Was there a moment during the workshop when your confidence grew? What happened?
	7. What was the hardest part: theory, tools, or practice?
C: Challenges and Learning Process	8. What did you do when you faced difficulty? Did you ask for help or try again on your own?
	9. What one thing would you change to improve the workshop?
	10. What did this workshop mean to you personally? Did it change how you see your own ability to learn?
D: Personal Impact and Significance	11. Do you think you will use these skills in the future?
	12. Has this workshop made you want to learn more? If yes, what would you like to learn next?
	13. Would you recommend this workshop to others? What would you tell them?
E: Final Reflection	14. Do you have any suggestions to make future workshops more useful for your community?

2.5 Data Analysis

a) Quantitative analysis

Data from the technical assessment and confidence questionnaire were analysed using IBM SPSS Statistics Version 27. Descriptive statistics were used to summarise participants' practical performance after the workshop. Confidence changes were analysed using a separate method. This was necessary due to the small sample size and the paired nature of the data. The Wilcoxon signed-rank test was therefore chosen over parametric alternatives. Effect sizes were also reported alongside the test results. This was done to reflect the practical significance of the changes, not just statistical significance. The threshold for significance was set at $p < 0.05$, and exact values were reported where possible.

b) Qualitative analysis

The interview data were analyzed using thematic analysis. The process involved repeated reading of transcripts, identification of significant statements, generation of initial codes, grouping of related codes into themes, and refinement of themes based on their relevance to the research objectives. The final themes were then compared with the quantitative results to provide a comprehensive interpretation of participants' learning experiences, technical skill development, and confidence improvement.

2.6 Limitations and Assumptions

Several limitations should be acknowledged in this study. First, the study involved a small sample from a single rural community, which limits the generalizability of the findings. However, the findings provide valuable insights into participants' learning experiences and offer useful considerations for the design and implementation of community-based service-learning programmes.

Second, no formal pre-test assessment of technical skills was conducted prior to the workshop. Therefore, the extent of actual improvement in participants' technical competencies could not be quantitatively determined. The absence of baseline skill measurements also limits the interpretation of the findings, as the observed post-workshop confidence and performance cannot be directly compared with participants' initial competency levels. Nevertheless, participants' reflections, interview responses, and post-workshop task performance provide supporting evidence of perceived learning gains and skill development.

Third, confidence data were based on self-reported responses and may have been influenced by social desirability bias. To minimise this risk, participant confidentiality was assured and respondents were encouraged to answer honestly throughout the study.

3. Result and Discussion

Section 3.1 until 3.3 presents the results and discussion of the study in three parts: (i) participants' technical skills performance based on the post-workshop assessment rubric, (ii) changes in self-reported confidence based on pre- and post-workshop surveys, and (iii) qualitative insights from semi-structured interviews. Section 3.4 and Section 3.5 discuss the implications and limitations of this study. This study examined the extent to which a short-term, hands-on AC maintenance workshop could enhance rural participants' technical performance and self-confidence. The results show that even a one-day practice-oriented workshop can lead to improvements in both technical skills and psychological outcomes. These findings align with transformative learning theory and objectives of community based TVET program.

3.1 Technical Skills Assessment Results

All six participants completed the post-workshop skills assessment. Performance by domain is summarized in Table 5. The mean overall score for all domains was 4.00, indicating generally high proficiency in the basic maintenance tasks covered. Scores were most consistent in Safety and Preparation, Troubleshooting and Execution, and Task Completion, which all had mean scores of 4.00.

Variation was most evident in Tool Handling and Usage with mean 3.33, suggesting some still needed more practice. While these high post-test scores indicate competence, the absence of a pre-test means the magnitude of improvement cannot be precisely measured. Overall, these findings suggest that experiential learning is effective in vocational training. Even within a short programme, practical practice with real equipment enabled participants to perform tasks competently and safely.

Table 5: Mean Scores by Technical Skills Domain (N = 6)

Domain No.	Domain Description	Mean Score	SD
1	Safety and Preparation	4.00	0.00
2	Tool Handling and Usage	3.33	0.47
3	Component Identification	4.17	0.41
4	Troubleshooting and Execution	4.00	0.00
5	Task Completion and Clean-Up	4.00	0.00

3.2 Confidence Survey Results

The Wilcoxon signed-rank test was conducted to evaluate changes in participants' confidence levels before and after the workshop due to the small sample size ($n = 6$). The analysis indicated a statistically significant improvement in overall confidence scores following the intervention ($Z = 2.10$, $p = 0.031$). The mean total confidence score increased from 1.91 ± 0.77 before the workshop to 4.50 ± 0.42 after the workshop, indicating a substantial improvement in participants' perceived capability to perform basic air conditioning maintenance tasks. The calculated effect size ($r = 0.86$) suggested a large practical effect. However, this effect size should be interpreted cautiously due to the limited sample size, as effect estimates may be influenced by the characteristics of small-scale intervention studies.

The changes in confidence levels across the three sub-dimensions are presented in Table 6. All dimensions demonstrated clear improvement after the workshop. Cognitive Understanding increased from 1.94 ± 0.85 to 4.39 ± 0.49 , Technical Performance increased from 2.00 ± 0.74 to 4.33 ± 0.38 , and Problem-Solving/Autonomy increased from 1.78 ± 0.78 to 4.78 ± 0.27 . Among the three dimensions, Problem-Solving/Autonomy showed the largest increase in mean score, suggesting that participants perceived the greatest improvement in their ability to independently apply knowledge and address basic AC maintenance problems. Nevertheless, the similar effect size values across dimensions indicate that improvements occurred consistently across all aspects of confidence.

Reliability analysis showed very high internal consistency for the pre-test confidence questionnaire (Cronbach's $\alpha = 0.961$) and acceptable internal consistency for the post-test questionnaire (Cronbach's $\alpha = 0.620$). The lower post-test reliability coefficient should be interpreted cautiously, particularly considering the small sample size ($n = 6$). Although reduced variability in post-workshop responses may contribute to lower internal consistency estimates, Cronbach's alpha is also influenced by factors such as the number of questionnaire items and inter-item correlations. Therefore, the reliability results should be considered preliminary indicators of questionnaire consistency within this exploratory community-based study.

Overall, the findings demonstrate that the hands-on workshop positively influenced participants' confidence in performing basic air conditioning maintenance tasks. The improvement in confidence, particularly in Problem-Solving/Autonomy, suggests that practical engagement with AC maintenance activities helped participants develop greater perceived independence and self-efficacy. This finding aligns with self-efficacy theory, which identifies mastery experiences as a key source of confidence development (Gilbride, 2025). Through direct involvement in activities such as tool handling, system inspection, troubleshooting practice, and guided maintenance procedures, participants gained successful practical experiences that strengthened their belief in their ability to perform similar tasks independently.

Table 6: Pre- and post-workshop confidence scores by sub-dimension

Sub-dimension	Pre-Mean (SD)	Post-Mean (SD)	Z	p-value	Effect size (r)
Cognitive Understanding	1.94 (0.85)	4.39 (0.49)	2.10	0.031	0.86
Technical Performance	2.00 (0.74)	4.33 (0.38)	2.10	0.031	0.86
Problem-Solving/Autonomy	1.78 (0.78)	4.78 (0.27)	2.10	0.031	0.83

3.3 Interview Findings

Three themes emerged from the interviews. The first theme was a shift in how participants viewed technical work. Prior to the workshop, all three believed that AC maintenance was a task reserved for trained professionals. This perception changed after the practical session. One participant stated: "At first I thought only trained people can open the AC unit, but after the workshop, I can do it too at home." This response suggests that hands-on training can alter how individuals view their own capabilities.

The second theme was active participation in practical tasks. Participants handled the tools and completed the tasks themselves, and this directly influenced their confidence levels. One participant noted: "When I actually cleaned the filter and used the gauge, I felt like I could really do it again." This finding aligns with the survey results. Confidence appeared to grow from performing the tasks, rather than from simply attending the session.

The third and final theme was perhaps the most encouraging of all, not because of what participants had learned during the workshop, but because of what they wanted to learn afterwards. The programme appeared to leave participants not with a sense of completion but with a sense of possibility. One participant captured this well: "I want to learn how to check for leaks and maybe try on another unit." Behind that simple statement is something worth sitting with, the idea that a single day of well-designed practical training had been enough to turn a group of people with no prior HVAC experience into individuals who were now seeking out learning on their own terms.

That, arguably, is one of the more meaningful things a short training programme can hope to achieve.

3.4 Implications for Community-Based TVET and Service Learning

These findings highlight the potential of short, community-based TVET programmes as an effective approach for addressing local skill development needs. The results demonstrate that programme effectiveness is not solely determined by training duration, but by the relevance of the skills taught, hands-on learning approaches, and alignment with community needs. Although participants had no prior HVAC experience, the workshop enabled them to develop practical maintenance skills and greater confidence in performing basic air conditioning tasks independently.

For TVET institutions, particularly polytechnics, these findings provide evidence that community engagement initiatives can extend the role of TVET beyond formal classroom-based education by serving as a platform for knowledge transfer, skills empowerment, and social contribution. The integration of service learning allows students and educators to apply technical knowledge to real community problems while creating meaningful learning experiences for community members. Such programmes can support the implementation of TVET's broader social responsibility agenda and strengthen collaboration between institutions and local communities.

For rural development programmes and community-based organisations, the findings suggest that targeted short-term technical training can be used as an empowerment strategy to improve self-reliance and reduce dependency on external technical support. By equipping rural participants with basic maintenance skills, community members may become more capable of managing common household or small-scale technical issues independently.

Furthermore, the study highlights the importance of including confidence and self-efficacy measurements when evaluating community-based TVET initiatives. Assessing technical competency alone may not fully capture the impact of such programmes, as participants' confidence in applying acquired skills influences their willingness to continue practicing and sharing their knowledge. Therefore, future community-based TVET programmes should consider combining practical skill assessment with confidence evaluation to obtain a more comprehensive understanding of training outcomes.

3.5 Limitations and Future Research

This study has several limitations that should be acknowledged. The sample consisted of six participants, which is small. As a result, the findings cannot be generalised to all rural communities. No pre-test was administered for technical skills, making it difficult to determine the exact extent of each participant's improvement. These limitations do not undermine the value of the findings, but they do mean the results should be read with care.

Two areas stand out for future research. The first involves a follow-up study conducted sometime after the workshop to assess whether the skills and confidence gained on the day were retained. The second involves applying the same programme model across other rural communities. This would help determine whether the outcomes observed here are specific to this group or are more widely achievable. What this study makes clear, regardless of future directions, is that a single well-designed day of hands-on training can produce real and immediate results. The impact is felt not only in technical skills, but also in how participants think and feel about their own abilities.

4. Conclusion

This study examined the impact of a one-day practical training workshop conducted under the PUO MechCare programme on six rural community members with no prior HVAC knowledge. Following the workshop, participants achieved a mean technical assessment score of 4.00, demonstrating their ability to perform basic air conditioning maintenance tasks. In addition, the Wilcoxon signed-rank test revealed a significant improvement in participants' confidence levels after the intervention, with a large effect size observed. Improvements were recorded across all three confidence dimensions, with the largest increase in mean score observed in Problem-Solving/Autonomy, indicating enhanced confidence in independently applying knowledge and addressing basic AC maintenance issues. Interview findings further supported these quantitative results, showing that participants' perceptions shifted from viewing air conditioning maintenance as a specialised task requiring professional assistance to recognising their own capability to perform basic maintenance activities.

The findings contribute to the TVET field by demonstrating the potential of short-duration, community-based practical training as an effective mechanism for extending TVET's impact beyond formal education institutions. The study highlights that hands-on learning experiences can support community empowerment by developing not only technical competencies but also self-efficacy, autonomy, and confidence in applying acquired skills. Furthermore, the integration of technical performance assessment, confidence measurement, and participant reflections provides a more comprehensive approach for evaluating the outcomes of TVET outreach and service-learning initiatives.

Despite these positive findings, several limitations should be considered. The study involved a small number of participants from a single rural community, which limits the generalisability of the findings. Additionally, the absence of a pre-workshop technical assessment prevented direct measurement of changes in participants' practical skills. Future research should involve larger participant groups, implementation across multiple rural communities, and pre-post technical competency assessments to further validate the effectiveness and sustainability of community-based TVET interventions.

Overall, this study demonstrates that a well-structured, hands-on TVET outreach programme can create

meaningful learning outcomes within a short intervention period. By combining technical skill development with confidence building, community-based TVET initiatives such as PUO MechCare have the potential to promote lifelong learning, self-reliance, and wider societal engagement with technical education.

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