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Development and acceptability of portable DC powered soldering machine

Mark Anthony B. Pagatpatan*[1], Dr. Andres C. Pagatpatan, Jr.[2]
[1, 2] Eastern Samar State University, Guiuan Campus, Eastern Samar, Philippines
*Corresponding Author e-mail: *jemmark01@gmail.com*

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Abstract
Aim: Conventional soldering equipment is often limited by high cost, unstable power supply, and poor portability, affecting its usability in automotive and electronics workshops. This study aimed to design, develop, and evaluate a portable DC-powered soldering machine for automotive and electronics workshop applications.
Methodology: An experimental-developmental research design was employed involving the design, fabrication, functional testing, and user evaluation of the developed prototype. The system was utilized in actual soldering activities involving wires and printed circuit boards (PCBs) to provide participants with hands-on experience using the developed prototype prior to evaluation. User evaluation was conducted among 50 participants composed of students, faculty members, and automotive and electronics experts. Data were collected using a structured questionnaire and analyzed using descriptive statistics, particularly weighted mean.
Results: User evaluation results showed Excellent ratings in terms of user perception of heat stability (M = 4.78), user perception of energy consumption (M = 4.58), user perception of the quality of the soldering process (M = 4.79), and user-friendliness (M = 4.74). The overall mean rating of 4.72, interpreted as Excellent, indicates a high level of user acceptability of the developed portable DC-powered soldering machine.
Conclusion: The developed portable DC-powered soldering machine received favorable evaluations from respondents in terms of user perception of heat stability, user perception of energy consumption, user perception of the quality of the soldering process, and user-friendliness. The findings indicate a high level of user acceptability and suggest that the developed prototype may be considered for use in automotive and electronics workshop applications. Future studies may incorporate quantitative engineering measurements to complement user evaluations and provide additional technical information regarding the operation of the system.
Keywords: *DC-powered soldering machine; user perception; soldering process; user acceptability; workshop applications*

INTRODUCTION

Soldering is a fundamental process in automotive and electronics engineering, serving as an essential technique for creating electrical and mechanical connections in wiring systems, printed circuit boards (PCBs), and electronic components. With the continuous advancement of automotive and electronic technologies, the demand for practical, portable, and user-friendly soldering equipment has increased significantly. Industries, educational institutions, and technical workshops continue to seek soldering tools that support mobility, accessibility, and convenience in various working environments.

Traditionally, soldering operations rely on alternating current (AC)-powered equipment. Although widely used, these tools often present limitations in workshop and field applications, including dependence on a continuous power supply, limited portability, and operational difficulties in locations where electrical power is unstable or unavailable. These limitations may affect convenience and productivity, particularly in automotive servicing, electronics repair, and technical training activities. As an alternative, direct current (DC)-powered soldering machines have gained attention because of their portability, flexibility, and suitability for battery-powered operation.

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Recent technological developments have expanded the application of portable DC-powered devices. The use of DC–DC converters and compact power components has improved the practicality of portable soldering equipment for mobile workshop environments and on-site repair operations (Yusuf et al., 2023). These developments support current trends that emphasize portability, operational flexibility, and user convenience in tool design.

Despite these advantages, several challenges continue to limit the widespread use of DC-powered soldering machines. These include higher initial cost, limited user familiarity compared to traditional AC-powered tools, and concerns regarding battery life and long-term usability. Furthermore, while previous studies have discussed portable soldering technologies and related equipment, limited research has focused on the development and user evaluation of low-cost DC-powered soldering machines intended for instructional, automotive, and small-scale workshop applications. This indicates a need for studies that examine the acceptability and practicality of portable soldering technologies in real-world workshop settings.

To address this need, the present study focuses on the design, development, and evaluation of a portable DC-powered soldering machine intended for automotive and electronics workshop applications. The developed system aims to provide a portable and accessible soldering solution that may be considered for use in environments where mobility and ease of use are important considerations. Through an experimental-developmental approach, the study examines the acceptability of the developed prototype based on user evaluations and feedback gathered during testing.

This research is significant to engineering practice and technical education because it contributes to the development of practical and portable soldering technologies. It provides a framework for designing and evaluating engineering innovations while supporting the growing demand for accessible and user-friendly tools in automotive and electronics workshops. The findings may provide useful information for future improvements in portable soldering equipment and may contribute to enhancing user experience in workshop and instructional settings.

Review of Related Studies

Recent advancements in soldering technologies from 2021 to 2026 demonstrate a growing emphasis on automation, portability, thermal management, and energy-conscious design approaches in both automotive and electronics industries. Current trends focus on improving soldering precision, operational convenience, and adaptability through the integration of enhanced heating systems, control mechanisms, and portable power sources. Recent studies have highlighted the importance of proper heating conditions and process control in supporting satisfactory soldering outcomes and reducing defects (Havellant et al., 2024; Chnapko et al., 2025).

Automation continues to be a major area of development in soldering technology. Studies have shown that programmable logic controller (PLC)-based and computer numerical control (CNC)-assisted soldering systems can support process consistency and operational efficiency. Wahid et al. (2022) explained that automation can help reduce human error and promote more consistent soldering operations, particularly in industrial electronics applications. Supporting these findings, Ebuehi et al. (2021) highlighted the importance of electromechanical integration in developing adaptive and cost-effective equipment for modern workshop applications. Similarly, Chnapko et al. (2025) emphasized the role of appropriate soldering practices and controlled heating conditions in supporting satisfactory soldering outcomes.

Another important area of advancement involves portable and energy-conscious soldering systems. Recent studies have shown increasing interest in DC-powered and battery-operated soldering equipment because of their portability and suitability for fieldwork and workshop applications. Yusuf et al. (2023) reported that DC–DC regulated power systems can improve the practicality of portable soldering devices. Han et al. (2025) also explored heating approaches intended to support efficient operation in comparison with conventional systems. These developments contribute to improved portability, operational convenience, and broader applicability of soldering equipment in various working environments.

Recent literature also highlights the importance of process monitoring and heating control in soldering operations. Havellant et al. (2024) reported that monitoring techniques and controlled heating conditions may contribute to improved process consistency. These findings reinforce the importance of proper heating practices and operational control in supporting satisfactory soldering activities across different applications.

Overall, recent literature from 2021 to 2026 indicates that soldering technologies continue to evolve through automation, improved heating systems, portable power solutions, and enhanced process control. The reviewed studies identify soldering quality, operational convenience, portability, and user considerations as important factors in the development of modern soldering equipment. These concepts provide a foundation for the present study, which focuses on the design, development, and evaluation of a portable DC-powered soldering machine intended for automotive and electronics workshop applications.

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Synthesis and Research Gap

Recent studies show that soldering technologies have advanced through automation, improved process control, portable power systems, and user-oriented equipment designs. Existing research primarily focuses on industrial soldering applications, automation technologies, heating systems, process monitoring, and portable soldering equipment. Studies have also emphasized the importance of portability, operational convenience, and practical design considerations in supporting various soldering applications.

Despite these developments, limited studies have focused on the development and user evaluation of low-cost, portable DC-powered soldering machines intended for educational, automotive, and small-scale workshop applications. Furthermore, many existing studies concentrate on system design, industrial implementation, and technical aspects of soldering operations, while fewer investigations examine user perceptions, user experiences, portability, convenience, and overall acceptability of soldering devices in real-world instructional and workshop settings.

This gap highlights the need for the development and evaluation of accessible and user-friendly soldering equipment that can support workshop activities where mobility, convenience, and ease of use are important considerations. Understanding user perceptions and acceptability is important in determining whether a developed technology is practical and suitable for its intended users and applications.

To address this gap, the present study focuses on the design, development, and evaluation of a portable DC-powered soldering machine for automotive and electronics workshop applications. Specifically, the study determines the level of user acceptability of the developed prototype in terms of user perception of heat stability, user perception of energy consumption, user perception of the quality of the soldering process, and user-friendliness. The findings are expected to contribute to the development of practical, portable, and user-oriented soldering technologies suitable for automotive, electronics, and instructional workshop environments.

Theoretical Framework

The development of the portable DC-powered soldering machine is anchored on established engineering and technology acceptance theories, particularly the Systems Engineering Framework and the Technology Acceptance Model (TAM). These frameworks guided the design, development, integration, and evaluation of the proposed system.

1. Systems Engineering Framework

The Systems Engineering Framework served as the primary engineering foundation of the study. This framework views the soldering machine as an integrated system composed of interconnected components, including the DC power source, heating element, control components, wiring system, and user interface. Each component performs a specific function, and the overall operation of the system depends on the coordinated interaction of all subsystems.

The framework guided the systematic design, fabrication, assembly, and testing of the prototype. It also provided a structured approach for developing a portable soldering machine intended for automotive and electronics workshop applications. Through this framework, the study ensured that the various components were properly integrated to support soldering activities in workshop environments.

2. Technology Acceptance Model (TAM)

To complement the development of the system, the study adopted the Technology Acceptance Model (TAM) proposed by Davis (1989). TAM explains user acceptance of technology based on perceived usefulness and perceived ease of use. The model suggests that users are more likely to accept and utilize a technology when they perceive it as useful and easy to use.

In this study, TAM served as the basis for evaluating the acceptability of the portable DC-powered soldering machine among students, faculty members, and automotive and electronics experts. The model guided the assessment of user perceptions regarding heat stability, energy consumption, quality of the soldering process, and user-friendliness based on their experiences while using the developed prototype. By applying TAM, the study was able to determine the level of user acceptability of the developed system and gather feedback regarding its suitability for automotive and electronics workshop applications.

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Conceptual Framework

The study uses an Input–Process–Output (IPO) framework integrated with systems engineering principles to guide the design, development, testing, and evaluation of the portable DC-powered soldering machine.

Input Phase:

The inputs include the DC power supply, heating element, control components, printed circuit board (PCB), wiring materials, and other supporting components required for the fabrication of the soldering machine. Students, faculty members, and automotive and electronics experts serve as respondents and evaluators of the developed prototype.

Process Phase:

The process involves the design, fabrication, assembly, prototype testing, and user evaluation of the portable DC-powered soldering machine. The developed prototype is utilized in actual soldering activities involving wires and printed circuit boards (PCBs). User observations, experiences, and feedback are gathered through a structured questionnaire to determine the level of user acceptability of the developed system.

Output Phase:

The outputs include a developed portable DC-powered soldering machine, user perception of heat stability, user perception of energy consumption, user perception of the quality of the soldering process, user-friendliness, user satisfaction, and overall user acceptability for automotive and electronics workshop applications.

Figure 1

Conceptual Framework of the Study

INPUT

- DC Power Supply
- Heating Element
- Control Components
- Soldering Interface
- Wires and Printed Circuit Boards
- Students, Instructors, and Automotive and electronic experts

PROCESS

- System Design and Fabrication
- Circuit Integration and Assembly
- Prototype Testing
- Pilot Testing and user evaluation
- Data Collection
- Analysis of User Feedback

OUTPUT

- Developed Portable DC-Powered Soldering Machine
- User Perception of Heat Stability
- User Perception of Energy Consumption
- User Perception of the Quality of the Soldering Process
- User-Friendliness
- User Satisfaction
- Overall Acceptability for Automotive and Electronics Workshop Applications

Note. The figure illustrates the Input–Process–Output (IPO) framework used in the design, development, testing, and evaluation of the portable DC-powered soldering machine. The framework shows how the system components and respondents serve as inputs, how the prototype undergoes design, assembly, testing, and user evaluation processes, and how the study generates user perceptions regarding heat stability, energy consumption, quality of the soldering process, user-friendliness, user satisfaction, and overall user acceptability.

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Statement of the Problem

Modern automotive and electronics workshops require soldering systems that are portable, practical, and convenient to use in various working environments. However, conventional alternating current (AC)-powered soldering machines are often dependent on a continuous power supply and may be less suitable for fieldwork, mobile servicing, and workshop activities where accessibility and portability are important considerations.

Despite the emergence of direct current (DC)-powered soldering technologies, existing solutions remain constrained by issues related to cost, portability, user familiarity, and limited evaluation in instructional and small-scale workshop settings. Furthermore, there is a lack of studies focusing on the development and user evaluation of portable DC-powered soldering machines intended for automotive, electronics, and educational applications.

This situation highlights the need to design, develop, and evaluate a portable and user-centered DC-powered soldering machine that can serve as a practical alternative to conventional soldering equipment. Specifically, the study seeks to determine the level of user acceptability of the developed prototype in terms of user perception of heat stability, user perception of energy consumption, user perception of the quality of the soldering process, and user-friendliness for automotive and electronics workshop applications.

Research Objectives

General Objective

To design, develop, and evaluate a portable DC-powered soldering machine for automotive and electronics workshop applications.

Specific Objectives

1. To design and fabricate a portable DC-powered soldering machine using a DC power source, heating element, and control components suitable for workshop applications.
2. To determine the level of user acceptability of the developed portable DC-powered soldering machine in terms of:
   2.1 User Perception of Heat Stability;
   2.2 User Perception of Energy Consumption;
   2.3 User Perception of the Quality of the Soldering Process; and
   2.4 User-Friendliness.
3. To identify the strengths and areas for improvement of the developed portable DC-powered soldering machine based on user evaluations and feedback.

Research Questions

1. How can a portable DC-powered soldering machine be designed and developed for automotive and electronics workshop applications?
2. What is the level of user acceptability of the developed portable DC-powered soldering machine in terms of:
   2.1 User Perception of Heat Stability?
   2.2 User Perception of Energy Consumption?
   2.3 User Perception of the Quality of the Soldering Process?
   2.4 User-Friendliness?
3. What strengths and areas for improvement may be identified for the developed portable DC-powered soldering machine based on user evaluations and feedback?

METHODOLOGY

Research Design

This study employed an experimental-developmental and prototype-based research design to develop and evaluate a portable DC-powered soldering machine. The approach supported the design, fabrication, prototype testing, and user evaluation of the developed system for automotive and electronics workshop applications.

The methodology consisted of three phases: design and development, prototype testing, and user evaluation. In the design and development phase, the system was developed using systems engineering, power electronics, and product development principles. The design integrated a DC power source, DC–DC converter, heating element, control components, and other supporting parts necessary for soldering operations.

In the prototype testing phase, the developed system was utilized in actual soldering activities involving wires and printed circuit boards (PCBs). These activities were conducted to verify that the prototype could perform its

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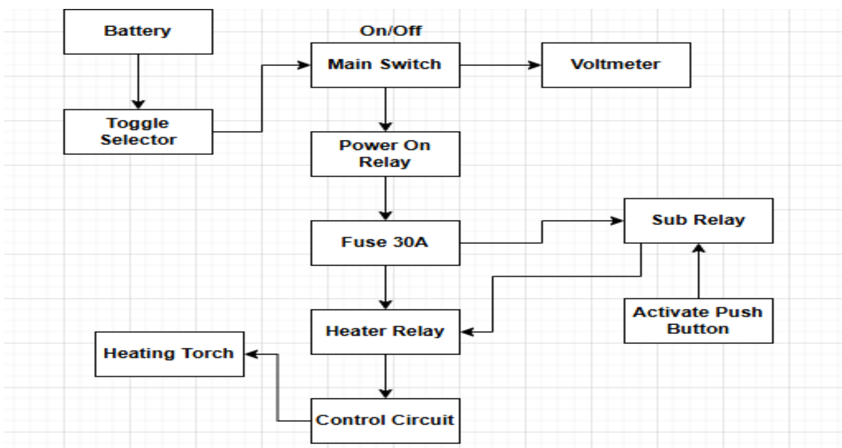
intended soldering functions and to provide participants with hands-on experience using the developed system prior to evaluation.

In the user evaluation phase, respondents composed of students, faculty members, and automotive and electronics experts tested the prototype and evaluated it in terms of user perception of heat stability, user perception of energy consumption, user perception of the quality of the soldering process, and user-friendliness using a structured 5-point Likert scale questionnaire. The evaluation focused on determining the level of user acceptability of the developed soldering machine for automotive and electronics workshop applications.

The collected data were analyzed using descriptive statistical tools such as weighted mean, frequency distribution, and percentage distribution. These statistical measures were used to determine the level of user acceptability of the developed prototype based on respondent evaluations. The results of the user evaluations served as the basis for identifying the strengths and areas for improvement of the portable DC-powered soldering machine.

Figure 2
Block diagram of portable DC powered workshop soldering machine



Note. The block diagram shows the operational flow of the portable DC-powered soldering machine. A DC battery supplies power, which passes through a selector and main switch to control system activation. Once turned on, a relay enables current flow while a fuse ensures circuit protection. Power is then directed to the heating system through a heater relay, with a sub relay and trigger switch allowing controlled activation of the heating process. A voltmeter is included in the circuit to allow users to observe the system's voltage during operation. Overall, the system is designed for safe, efficient, and user-controlled operation suitable for workshop applications.

Materials, Equipment, and Component Description

1. Battery (DC Power Source)
Serves as the primary power source of the system. It allows the soldering machine to operate without direct connection to an AC power supply, supporting portability during workshop activities.
2. Mini Relay
Serves as a switching device used to control the operation of selected circuit components.
3. Glow Plug
Functions as the heating element of the soldering machine. It produces the heat required during soldering activities.
4. Toggle Selector Switch
Used to control selected circuit functions and operating modes of the system.
5. Heater Relay
Used to control the activation of the heating element during operation.
6. Push Button Switch
Functions as a trigger switch that activates the heating process when pressed.
7. Rocker Switch
Serves as the main power switch used to turn the system on or off.
8. Fuse
Provides electrical protection by interrupting excessive current flow and helping protect circuit components.
9. Auto Wire
Used to connect the various electrical and electronic components of the system.

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10. Eye Terminal
Used to provide secure wire connections to terminals and battery connections.
11. Printed Circuit Board (PCB)
Serves as the mounting platform for electronic components and facilitates electrical connections within the system.
12. Current Controller
Used as part of the control circuit to manage the operation of the heating element and other electrical components.
13. DC–DC Converter
A DC–DC converter is an electronic device used to adjust DC voltage levels within a circuit. In this study, it was incorporated as part of the power supply system to support the operation of the soldering machine and its components.

Materials, Equipment, and System Description

The portable DC-powered soldering machine was developed using a prototype-based design that integrates electrical and electronic components necessary for soldering operations. The system was designed to provide a portable alternative to conventional AC-powered soldering equipment for automotive and electronics workshop applications.

System Components and Configuration

The device is powered by a 12V DC rechargeable battery, allowing operation without direct dependence on an AC power source. A DC–DC converter was incorporated as part of the power supply system to support the operation of the electronic components. The heating element consists of a glow plug that produces the heat required for soldering activities. Relay-controlled switching mechanisms were incorporated to control the operation of the heating element and other circuit components.

Electrical protection was provided through the use of a fuse, relay components, and insulated wiring to promote safe operation during soldering activities. The system was assembled using automotive-grade electrical components and printed circuit board (PCB) connections to facilitate the integration of the various system components.

The major components used in the development of the prototype included a battery (DC power source), mini relay, glow plug, toggle selector switch, heater relay, push button switch, rocker switch, fuse, auto wire, eye terminal, printed circuit board (PCB), current controller, and DC–DC converter. These components were assembled and integrated to support the operation of the portable DC-powered soldering machine during soldering activities and user evaluation.

System Architecture Integration

The portable DC-powered soldering machine consists of three major subsystems that work together during soldering activities:

1. **Power Supply Subsystem** – Consists of the battery, fuse, switches, wiring, and DC–DC converter that supply electrical power to the system.
2. **Heating Subsystem** – Consists of the glow plug heating element and relay components that produce the heat required for soldering activities.
3. **User Operation Subsystem** – Consists of the switches, soldering tip assembly, and PCB connections that allow users to operate and control the soldering machine.

These subsystems were integrated to support the operation and use of the portable DC-powered soldering machine during soldering activities and user evaluation.

Circuit Design Description

The circuit design of the portable DC-powered soldering machine incorporated electrical and electronic components necessary for soldering operations. The system utilized a 12V DC power source and included a DC–DC converter, switching components, protective devices, and a glow plug heating element. These components were connected and integrated to support the operation of the developed prototype during soldering activities.

The circuit layout was organized to facilitate electrical connections among the various system components and to support the assembly and operation of the portable DC-powered soldering machine. The design also incorporated protective components, such as a fuse and relay devices, to support safe operation during use.

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Instrument

The primary research instrument used in the study was a structured questionnaire adapted from the Technology Acceptance Model (TAM) developed by Davis (1989). The questionnaire was adapted from the concepts of perceived usefulness and perceived ease of use and was modified to suit the objectives of the study. The instrument was designed to gather user evaluations and determine the level of user acceptability of the developed portable DC-powered soldering machine for automotive and electronics workshop applications.

The evaluation areas included user perception of heat stability, user perception of energy consumption, user perception of the quality of the soldering process, and user-friendliness. The instrument utilized a 5-point Likert scale ranging from 5 (Excellent) to 1 (Poor). Open-ended questions were also included to gather respondents' comments, observations, and suggestions for improvement.

The questionnaire, which was adapted from the Technology Acceptance Model (TAM), served as the primary instrument for gathering respondents' perceptions and evaluations of the developed prototype. The responses obtained from the questionnaire served as the primary source of data for determining the level of user acceptability of the portable DC-powered soldering machine for automotive and electronics workshop applications.

Research Instruments and Functional Testing Procedures

The study utilized prototype testing activities and a structured evaluation questionnaire to gather user evaluations and determine the level of user acceptability of the portable DC-powered soldering machine. Prototype testing was conducted through actual soldering activities under workshop conditions to allow respondents to use the developed system and gain experience with its operation.

Actual soldering activities involving wires, printed circuit boards (PCBs), and electrical conductors were carried out to allow respondents to utilize the developed prototype in performing soldering tasks. These activities provided participants with the opportunity to observe and experience the operation of the soldering machine prior to completing the evaluation questionnaire.

A structured questionnaire adapted from the Technology Acceptance Model (TAM) developed by Davis (1989) served as the primary research instrument for gathering user evaluations of the developed system. The questionnaire consisted of criteria related to user perception of heat stability, user perception of energy consumption, user perception of the quality of the soldering process, and user-friendliness. A 5-point Likert scale was utilized to determine the level of user acceptability of the developed prototype.

During the testing phase, multiple soldering activities were conducted under normal workshop conditions. Printed circuit boards (PCBs), solder wires, and electrical conductors were used as test materials during the soldering activities. These activities allowed respondents to evaluate the developed prototype based on their actual experience using the system.

User feedback, observations, and questionnaire responses gathered throughout the testing process were used to determine the level of user acceptability of the developed portable DC-powered soldering machine and to identify its strengths and areas for improvement for automotive and electronics workshop applications.

Data Collection

Prior to the conduct of the study, formal permission was obtained from the university authorities and, where applicable, the institutional ethics committee to ensure compliance with institutional and research standards. Coordination with selected automotive and electronics workshops in Borongan City was conducted to schedule prototype testing and user evaluation activities without disrupting normal workshop operations.

Participants were oriented regarding the objectives of the study, the purpose and components of the developed portable DC-powered soldering machine, operational procedures, safety precautions, and evaluation procedures. They were provided with an opportunity to use the developed prototype through actual soldering activities involving wires and printed circuit boards (PCBs).

After using the developed soldering machine, participants completed a structured evaluation questionnaire to provide their perceptions, experiences, and feedback regarding the prototype. Participation was voluntary, and respondents were informed that they could withdraw from the study at any stage without penalty.

The completed questionnaires and participant feedback served as the primary sources of data for determining the level of user acceptability of the developed portable DC-powered soldering machine in terms of user perception of heat stability, user perception of energy consumption, user perception of the quality of the soldering process, and user-friendliness.

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Functional Testing Environment

The developed portable DC-powered soldering machine was utilized in a workshop setting using materials and components commonly employed in soldering activities. Printed circuit boards (PCBs), solder wires, and electrical conductors were used during the testing process. The testing environment was arranged to allow participants to use and evaluate the developed prototype under normal workshop conditions.

Functional Testing Procedures

To maintain consistency during testing, the same soldering materials, operating procedures, and testing activities were utilized throughout the evaluation process. Multiple soldering activities were conducted to provide participants with opportunities to use the developed prototype and gain experience with its operation prior to completing the evaluation questionnaire.

Prototype Evaluation

The developed soldering machine was evaluated based on user perceptions and user acceptability among students, faculty members, and automotive and electronics experts. The evaluation criteria included user perception of heat stability, user perception of energy consumption, user perception of the quality of the soldering process, and user-friendliness. These criteria were assessed through actual soldering activities and respondent evaluations using a structured questionnaire.

The results served as the basis for determining the level of user acceptability of the developed portable DC-powered soldering machine for automotive and electronics workshop applications and for identifying its strengths and areas for improvement.

Data Analysis

The collected data were analyzed using descriptive statistical methods to determine the level of user acceptability of the portable DC-powered soldering machine. The analysis focused on respondents' evaluations of the prototype in terms of user perception of heat stability, user perception of energy consumption, user perception of the quality of the soldering process, and user-friendliness based on their experiences while using the developed prototype.

Descriptive statistical tools such as weighted mean, frequency distribution, and percentage distribution were used to analyze participant responses regarding the evaluation criteria and overall user acceptability of the developed prototype. The weighted mean was utilized to determine the level of user acceptability of the soldering machine for each evaluation criterion.

Qualitative feedback gathered from open-ended responses and participant comments was also reviewed to identify common observations, strengths, and recommendations for improving the developed prototype.

The results of the user evaluations were summarized and interpreted using the established rating scale and descriptive interpretations. These analyses provided a basis for determining the level of user acceptability and overall user evaluation of the portable DC-powered soldering machine for automotive and electronics workshop applications, as well as identifying its strengths and areas for improvement.

Functional Testing Procedures

The developed portable DC-powered soldering machine was utilized in actual soldering activities involving wires, printed circuit boards (PCBs), and electrical conductors. These activities were conducted under normal workshop conditions to provide participants with hands-on experience using the developed prototype. Multiple soldering activities were carried out to allow respondents to use, observe, and experience the operation of the soldering machine prior to completing the evaluation questionnaire.

Quality Assurance Procedures

To enhance the credibility of the findings, standardized testing procedures and uniform evaluation criteria were applied throughout the study. The evaluation instrument was adapted from the Technology Acceptance Model (TAM) developed by Davis (1989). All respondents completed the same evaluation procedures under similar workshop conditions to promote consistency in data collection.

Integrated Evaluation

The evaluation of the developed portable DC-powered soldering machine combined actual soldering activities and user assessment. User feedback, observations, and questionnaire responses gathered during the

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testing process were used to determine the level of user acceptability of the developed prototype in terms of user perception of heat stability, user perception of energy consumption, user perception of the quality of the soldering process, and user-friendliness.

The results of the evaluation served as the basis for determining the overall user acceptability of the developed portable DC-powered soldering machine and for identifying its strengths and areas for improvement for automotive and electronics workshop applications.

Ethical Considerations

This study strictly adhered to ethical principles in conducting research involving human participants. Prior to data collection, formal approval was obtained from the relevant university authorities and, where applicable, the institutional ethics committee. Permission was also secured from the management of selected automotive and electronics workshops in Borongan City to facilitate the conduct of prototype testing and user evaluation activities without disrupting regular operations.

Participation in the evaluation of the portable DC-powered soldering machine was entirely voluntary. Respondents were fully informed about the objectives of the study, the purpose of the developed prototype, the materials and components used in its fabrication, and the procedures involved in the testing and evaluation activities. Participants were also informed of potential risks, safety precautions, and their right to withdraw from the study at any time without penalty. Informed consent was obtained from all participants prior to their involvement in the study.

To ensure participant safety, appropriate electrical safety measures and workshop safety procedures were observed throughout the testing activities. Participants were provided with the necessary instructions and were supervised while using the developed prototype. Confidentiality and responsible data management were maintained throughout the study. All responses were anonymized, securely stored, and used solely for academic and research purposes.

The researchers ensured that participation did not expose respondents to unnecessary risk and that all information gathered from participants was treated with confidentiality and respect. The findings were reported honestly and accurately, and no personal identifying information was disclosed in any part of the study.

RESULTS AND DISCUSSION

Performance and Acceptability of the Portable Soldering Machine.

Initial Testing

The Initial Testing phase was conducted with ten (10) student participants to obtain preliminary feedback regarding the developed portable DC-powered soldering machine. The purpose of this phase was to identify possible operational issues, gather user observations, and determine areas for improvement prior to the conduct of pilot testing.

During the initial testing activities, participants utilized the developed prototype in actual soldering tasks involving wires and printed circuit boards (PCBs). Feedback and observations obtained from the participants were used to assess the usability and operation of the prototype. Based on the results of the initial testing, minor refinements and adjustments were made to improve the developed system before it was subjected to pilot testing.

The Initial Testing phase served as a preliminary evaluation stage; therefore, the quantitative findings are not presented separately. The final quantitative evaluation of the developed portable DC-powered soldering machine is presented in the Pilot Testing section, which involved fifty (50) respondents composed of ten (10) students, ten (10) faculty members, and thirty (30) automotive and electronics experts.

Pilot Test Result

The pilot testing phase served as the final evaluation of the developed portable DC-powered soldering machine and involved fifty (50) respondents composed of ten (10) students, ten (10) faculty members, and thirty (30) automotive and electronics experts. The developed prototype obtained an overall mean rating of 4.72, interpreted as Excellent, indicating a high level of user acceptability.

The findings suggest that respondents provided favorable evaluations regarding their experience in using the developed prototype. Positive evaluations were obtained in terms of user perception of heat stability, user perception of energy consumption, user perception of the quality of the soldering process, and user-friendliness. The results

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indicate that the developed portable DC-powered soldering machine was well accepted for automotive, electronics, and instructional workshop applications.

Table 1.
Results of the Pilot Test on the User Acceptability of the Developed Portable DC-Powered Soldering Machine

Criteria	Mean Rating	Interpretation
User Perception of Heat Stability		
A. I perceived that the soldering machine maintained satisfactory heating conditions during use.	4.80	Excellent
B. I perceived minimal heat fluctuation during continuous operation.	4.75	Excellent
C. I found the warm-up period before use acceptable.	4.70	Excellent
D. I was satisfied with the heating characteristics of the soldering machine during continuous use.	4.85	Excellent
E. I am satisfied with my overall experience regarding the heating performance of the machine.	4.80	Excellent
Mean Rating	**4.78**	**Excellent**

The results indicate that respondents provided favorable evaluations regarding their perception of heat stability while using the developed portable DC-powered soldering machine. The high ratings suggest that users experienced satisfactory heating conditions during soldering activities, which may have contributed to a more convenient and effective soldering experience. Since consistent heating is important in soldering operations, positive user evaluations may indicate that the developed prototype was able to support the completion of soldering tasks under workshop conditions.

The findings may also be attributed to the incorporation of a DC power source, heating element, and control components that enabled the prototype to operate continuously during testing activities. Respondents' favorable perceptions suggest that the developed system was capable of supporting their soldering activities without causing significant difficulty during use.

These findings are consistent with the observations of Havellant et al. (2024), who emphasized the importance of proper heating conditions and process control in supporting satisfactory soldering outcomes. Similarly, Han et al. (2025) noted that improvements in heating technologies can enhance user experience and operational convenience in soldering applications. The favorable evaluations obtained in this study suggest that the developed portable DC-powered soldering machine may be suitable for workshop environments where portability and ease of use are important considerations.

Table 2.
User Perception of Energy Consumption

Criteria	Mean Rating	Interpretation
A. I perceived the machine's energy consumption during operation to be acceptable.	4.65	Excellent
B. I was satisfied with the machine's energy consumption while it was not actively being used.	4.50	Very Satisfactory
C. The machine's energy consumption met my expectations for similar equipment.	4.60	Excellent
D. I believe the machine can contribute to reduced energy use during soldering activities.	4.55	Excellent
E. I am satisfied with my overall experience regarding the machine's energy consumption.	4.60	Excellent

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Mean Rating	**4.58**	Excellent

The favorable ratings obtained for user perception of energy consumption indicate that respondents were generally satisfied with their experience regarding the machine's energy consumption during operation. Since the study focused on user evaluations rather than actual measurements of energy consumption, the findings suggest that respondents perceived the developed portable DC-powered soldering machine as practical and suitable for workshop activities.

The positive evaluations may be associated with the portable DC-powered design of the system, which allows operation without direct dependence on conventional AC-powered equipment. Respondents may have viewed the developed prototype as a convenient alternative for applications where mobility, accessibility, and ease of use are important considerations. These factors may have contributed to the favorable evaluations obtained during testing.

The findings support the observations of Yusuf et al. (2023), who reported that DC–DC regulated power systems contribute to the practicality of portable soldering devices. The results also align with recent developments in portable soldering technologies that emphasize portability, operational convenience, and accessibility for workshop and field applications. The favorable evaluations obtained in this study suggest that respondents considered the developed portable DC-powered soldering machine suitable for automotive, electronics, and instructional workshop environments.

Table 3.
User Perception of the Quality of the Soldering Process

Criteria	Mean Rating	Interpretation
A. I am satisfied with the appearance of the solder joints produced during testing.	4.85	Excellent
B. I was satisfied with the solder flow observed during soldering activities.	4.75	Excellent
C. I am satisfied with the quality of the soldered connections produced by the machine.	4.80	Excellent
D. I found that the soldering results met my expectations during testing.	4.70	Excellent
E. I am satisfied with the overall quality of the soldering process.	4.85	Excellent
Mean Rating	**4.79**	**Excellent**

The highest mean rating was obtained for user perception of the quality of the soldering process, indicating a high level of satisfaction among respondents regarding the soldering outcomes achieved during testing. Positive evaluations of solder joint appearance, solder flow, and overall soldering results suggest that users considered the developed prototype capable of supporting satisfactory soldering activities.

These findings may be attributed to the integration of appropriate heating and control components that enabled users to perform soldering tasks effectively. Favorable user evaluations indicate that the developed prototype was able to support the needs of automotive and electronics workshop activities where soldering quality is an important consideration.

The findings are consistent with Wahid et al. (2022), who emphasized the importance of maintaining consistent soldering operations to support satisfactory soldering outcomes. Similarly, Chnapko et al. (2025) highlighted the role of proper soldering practices and controlled heating conditions in supporting soldering quality. The positive evaluations obtained in this study suggest that the developed prototype may serve as a practical soldering tool for workshop applications.

Table 4.
User-Friendliness

Criteria	Mean Rating	Interpretation
A. I found the machine easy to set up and start using.	4.85	Excellent
B. I found the controls and interface intuitive and user-friendly.	4.80	Excellent

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C. I found adjusting the temperature, tip, or other settings simple and convenient.	4.75	Excellent
D. I found the instructions and labels clear and easy to understand.	4.70	Excellent
E. I found the maintenance and cleaning procedures straightforward.	4.60	Excellent
Mean Rating	**4.74**	**Excellent**

The results indicate that respondents provided favorable evaluations regarding the user-friendliness of the developed portable DC-powered soldering machine. The excellent mean rating suggests that users found the prototype easy to set up, operate, and maintain during soldering activities. Positive evaluations regarding the controls, interface, and operating procedures indicate that the developed system was generally accessible and convenient for users with varying levels of experience in soldering activities.

The high ratings may be attributed to the simplicity of the system design and the incorporation of user-oriented control components that facilitated operation during testing. Respondents' favorable evaluations regarding the clarity of instructions and ease of adjusting settings suggest that the developed prototype was able to support a positive user experience. These findings indicate that ease of use and operational convenience were important factors contributing to the acceptability of the developed soldering machine.

The findings are consistent with the Technology Acceptance Model (TAM) proposed by Davis (1989), which suggests that users are more likely to accept a technology when they perceive it as easy to use. The favorable evaluations obtained in this study indicate that respondents considered the developed prototype user-friendly and convenient for workshop applications. Furthermore, the results support the observations of Yusuf et al. (2023), who emphasized the practicality of portable systems for workshop applications, and Wahid et al. (2022), who highlighted the importance of user-oriented design in supporting efficient operation. The positive evaluations suggest that the developed portable DC-powered soldering machine may be suitable for automotive, electronics, and instructional workshop environments where ease of use and accessibility are important considerations.

Table 5.
Overall Summary of Pilot Testing Results

Criteria	Mean Rating	Interpretation
User Perception of Heat Stability	4.78	Excellent
User Perception of Energy Consumption	4.58	Excellent
User Perception of the Quality of the Soldering Process	4.79	Excellent
User-Friendliness	4.74	Excellent
Overall Mean Rating	**4.72**	**Excellent**

Overall Discussion of Pilot Testing Results

The pilot testing results indicate a high level of user acceptability of the developed portable DC-powered soldering machine among students, faculty members, and automotive and electronics experts. The Excellent ratings obtained across all evaluation criteria suggest that respondents generally had positive experiences while using the developed prototype during soldering activities.

The favorable evaluations regarding user perception of heat stability suggest that respondents were satisfied with the heating characteristics of the soldering machine during use. Positive evaluations regarding user perception of energy consumption indicate that users considered the developed prototype practical and suitable for workshop applications. Similarly, the high ratings obtained for user perception of the quality of the soldering process suggest that respondents were satisfied with the soldering outcomes achieved during testing activities. The favorable evaluations regarding user-friendliness further indicate that respondents found the developed prototype easy to operate, accessible, and convenient to use.

These findings suggest that the portability, usability, and operational convenience of the developed soldering machine contributed to its high level of user acceptability. The positive evaluations are consistent with the observations of Yusuf et al. (2023), who emphasized the practicality of portable DC-powered systems for workshop applications. Likewise, the findings support the work of Wahid et al. (2022), which highlighted the importance of user-oriented design in promoting positive user experiences with technical equipment. Furthermore, the favorable

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evaluations align with the observations of Havellant et al. (2024) and Han et al. (2025), who emphasized the importance of proper heating characteristics and operational convenience in supporting satisfactory soldering activities.

Overall, the findings indicate that the developed portable DC-powered soldering machine was positively evaluated by respondents and demonstrated a high level of user acceptability for automotive, electronics, and instructional workshop applications. The results suggest that the developed prototype may serve as a practical and portable soldering tool for users who require mobility, accessibility, and convenience during soldering activities.

Conclusion

The study successfully designed, developed, and evaluated a portable DC-powered soldering machine for automotive and electronics workshop applications. Based on user evaluations, the developed prototype obtained Excellent ratings in terms of user perception of heat stability, user perception of energy consumption, user perception of the quality of the soldering process, and user-friendliness. The findings indicate a high level of user acceptability of the developed prototype among students, faculty members, and automotive and electronics experts who participated in the evaluation.

The favorable evaluations obtained from respondents suggest that users were satisfied with their experience in using the portable DC-powered soldering machine during soldering activities. The developed prototype was positively evaluated in terms of usability, portability, and overall user experience. These findings suggest that the developed prototype may be considered for use in automotive servicing, electronics repair, technical training, and small-scale workshop applications where portability and user convenience are important considerations.

Recommendations

Based on the findings of the study, future improvements to the developed portable DC-powered soldering machine may focus on enhancing its usability, portability, and overall user experience. Additional features such as improved temperature adjustment mechanisms, digital temperature displays, and enhanced power management components may be incorporated to provide greater user convenience and operational control. Increasing battery capacity may also help extend operating time and improve the practicality of the device for workshop and field applications.

Future studies may incorporate quantitative engineering measurements such as temperature profiling, voltage monitoring, current analysis, and power consumption assessment to complement user evaluations and provide additional technical information regarding the operation and performance of the system.

Additional testing involving a larger number of users and different workshop environments is also recommended to obtain broader feedback regarding user perceptions, usability, user satisfaction, and overall acceptability of the developed prototype.

Furthermore, future researchers may explore the integration of advanced monitoring and control features, including sensor-based feedback systems and automated temperature regulation mechanisms, to enhance the usability, adaptability, and user experience of portable soldering technologies for automotive, electronics, educational, and industrial applications.

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