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Automated Automotive Wire Dispenser and Cutting Device

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Abstract

This study aimed to develop and evaluate an Automated Automotive Wire Dispenser and Cutting Device intended to improve wire cutting accuracy, reduce material wastage, and enhance efficiency in automotive electrical laboratory activities. Anchored on Feenberg's Critical Theory of Technology, the Technology Acceptance Model (TAM), the Theory of Reasoned Action (TRA), and Garvin's Eight Dimensions of Quality, the study employed developmental and descriptive research designs. The device was designed, fabricated, tested, and evaluated using an input–process–output framework. Data were collected through a standardized functionality and acceptability questionnaire administered to seventy-five (75) purposively selected respondents composed of automotive, electrical, and electronics technology students and faculty members from the University of Southern Mindanao–Kidapawan City Campus. Weighted mean was used as the primary statistical tool for data analysis. Results showed high levels of functionality and acceptability, with overall weighted means indicating strong agreement in terms of performance, features, reliability, durability, and serviceability, as well as high perceived usefulness, ease of use, and intention to use. Minor challenges were identified, including dependence on grid power, a slightly time-consuming cutting mechanism, minimal motor vibrations, and lower ratings related to complete automation without human intervention. Despite these concerns, the study concluded that the developed device effectively meets its intended purpose and serves as a reliable, user-friendly, and innovative instructional tool for automotive technology education. The study recommends targeted refinements to improve cutting efficiency and operational consistency, as well as further testing and extended evaluation to strengthen reliability and educational impact. The study aligns with Sustainable Development Goal (SDG) 4 on Quality Education by enhancing practical learning through instructional technology, SDG 8 on Decent Work and Economic Growth by improving productivity through automation, and SDG 12 on Responsible Consumption and Production by reducing wire wastage. Overall, the sustainability impact of the study lies in supporting educational, technological, and institutional sustainability through efficient resource use, improved instructional practices, and skill development in automotive technology education.

Keywords: Automated wire dispenser; Automotive technology education; Functionality and acceptability; Sustainable development goals; Technology acceptance; Wire cutting device

1. Introduction

The increasing complexity of automotive electrical systems has intensified the demand for precise, efficient, and reliable wire handling solutions. Manual wire measuring and cutting methods remain widely practiced in educational and small-scale automotive settings; however, these approaches are labor-intensive, time-consuming, and susceptible to human error. As automation becomes integral to modern automotive practices, there is a growing need for cost-effective and accessible technologies that enhance productivity, accuracy, and resource efficiency. This study focuses on the development and evaluation of an Automated Automotive Wire Dispenser and Cutting Device, designed to improve wire cutting precision, reduce material wastage, and assess its functionality and acceptability among automotive faculty and students.

1.1 Background on Automated Wire Dispensing and Cutting in Automotive Education

Wires function as the core transmission system of modern vehicles, delivering power and signals to critical components. The growing sophistication of automotive systems has increased reliance on accurate wire cutting and dispensing technologies. The wire-cutting machine market encompasses the development and use of equipment designed to cut various types of wires with high precision, serving industries such as automotive, electronics, manufacturing, and construction (Verified Market Reports, 2024). Despite technological progress, many automotive workshops and educational institutions continue to rely on manual wire cutting, which leads to inconsistent wire lengths, slow production rates, and increased material waste. Automated solutions, particularly those using programmable controllers, have demonstrated potential in addressing these inefficiencies. An automated automotive wire dispenser and cutting device controlled through Arduino programming enables accurate wire measurement, dispensing, and cutting without continuous human intervention, thereby improving productivity and operational consistency (Abawan, 2023).

1.2 Technological Efficiency, Precision, and Automation in Wire-Cutting Systems

Automation in wire cutting offers significant advantages over manual methods, including enhanced speed, accuracy, and consistency. Developers have attempted to address manual wire measurement challenges; however, many existing devices remain costly, heavy, and complex, limiting their practicality and accessibility (Saraswat, 2022). Automatic wire cutters allow for rapid measurement, stripping, and cutting of wires, outperforming handheld tools that process one wire at a time (Jackie Dove, 2015). Automatic wire-cutting machines also minimize human error and improve safety while ensuring reliable and repeatable results. These systems reduce dependency on manual labor, lower operational costs, and decrease the need for repeated testing and maintenance. As a result, automated wire-cutting technologies contribute to improved quality, dependability, and efficiency in electrical systems.

1.3 Automotive Industry Demand and Educational Context

The automotive industry continues to drive demand for automated wire-cutting devices, particularly with the growth of electric vehicles and increasingly complex wiring architectures. Automated machines are widely used to cut and shape wires for harnesses, connectors, and sensors. According to market analyses, the outlook for multi-strand wire-cutting machines remains strong due to expanding industrial applications and technological advancements (Archives Analytics, 2023). Within the educational context, particularly in automotive technology programs, the need for efficient and accurate wire cutting is equally critical. Institutions such as the University of Southern Mindanao – Kidapawan City Campus require affordable and functional technologies to support practical training activities. The proposed automated device addresses both industry trends and institutional needs by offering a compact and cost-effective solution suitable for instructional use.

1.4 Theoretical and Conceptual Basis of the Automated Automotive Wire Dispenser and Cutting Device

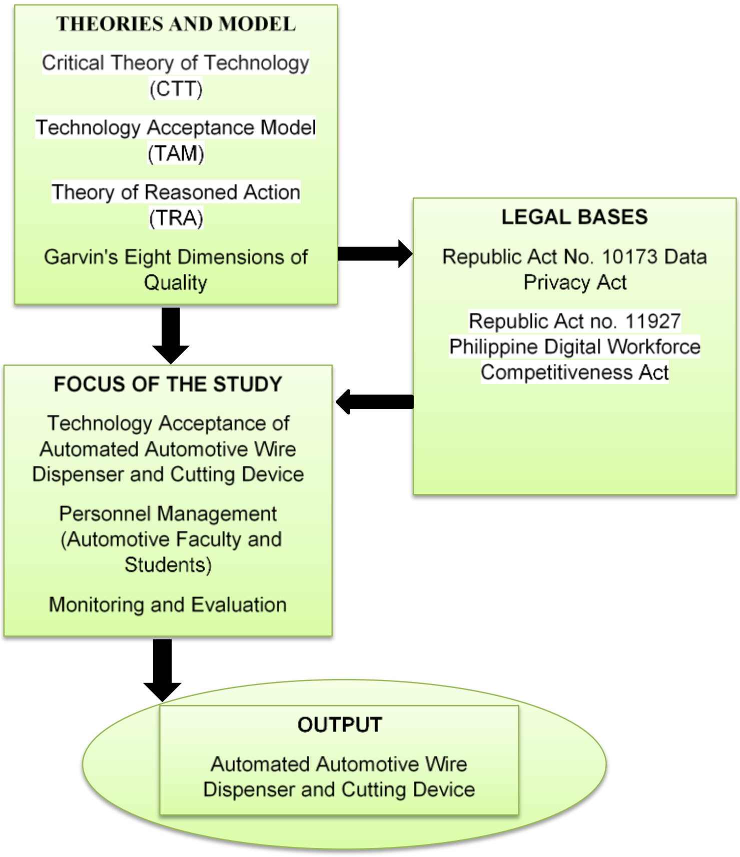


Figure 1
Theoretical and Conceptual Framework of the Study

This study is grounded in established theories and quality models that guide both technological development and user evaluation. Figure 1 illustrates the Theoretical and Conceptual Framework of the Study, showing the relationship between automation, quality dimensions, and technology acceptance in assessing the device's functionality and usability. The study adopts Feenberg's Critical Theory of Technology (CTT), which views technology as a socially embedded system rather than a neutral tool. From this perspective, the automated wire dispenser and cutting device promotes responsible resource use, efficiency, and equitable access to technological innovation within the automotive education setting. The Technology

Acceptance Model (TAM) provides a framework for assessing user acceptability through perceived usefulness and perceived ease of use, which directly influence intention to use. These constructs are essential in evaluating how automotive faculty and students respond to the device. Additionally, the Theory of Reasoned Action (TRA) supports the assessment of behavioral intention toward adopting the technology. The study also utilizes Garvin's Eight Dimensions of Quality, focusing on performance, features, reliability, durability, and serviceability, to evaluate the device's functional effectiveness.

1.5 Research Gaps and Rationale for the Study

Although automated wire-cutting technologies are widely available, there is a lack of affordable, portable, and user-friendly devices specifically designed for automotive education and small-scale applications. Many existing systems prioritize industrial-scale production and overlook the needs of instructional environments. This study addresses this gap by developing an automated automotive wire dispenser and cutting device that reduces human effort, minimizes wire wastage, and evaluates both functionality and acceptability among intended users.

1.6 Alignment with Relevant Sustainable Development Goals (SDGs)

The study aligns with SDG 4 – Quality Education by enhancing practical learning through efficient instructional technology. It supports SDG 8 – Decent Work and Economic Growth by promoting automation that improves productivity and reduces labor-intensive processes. Furthermore, the reduction of wire wastage aligns with SDG 12 – Responsible Consumption and Production, emphasizing efficient resource utilization in both educational and technical contexts.

1.7 Importance of the Study to Multidisciplinary Sustainability

This research contributes to educational sustainability by improving instructional efficiency and skill development in automotive technology programs. It supports technological sustainability through the development of accessible and adaptable automation solutions. By minimizing material waste and operational costs, the study advances socio-economic and institutional sustainability, benefiting students, faculty, and the university while providing a foundation for future innovations in automotive and electrical technology education.

2. Materials and methods

2.1 Research Design

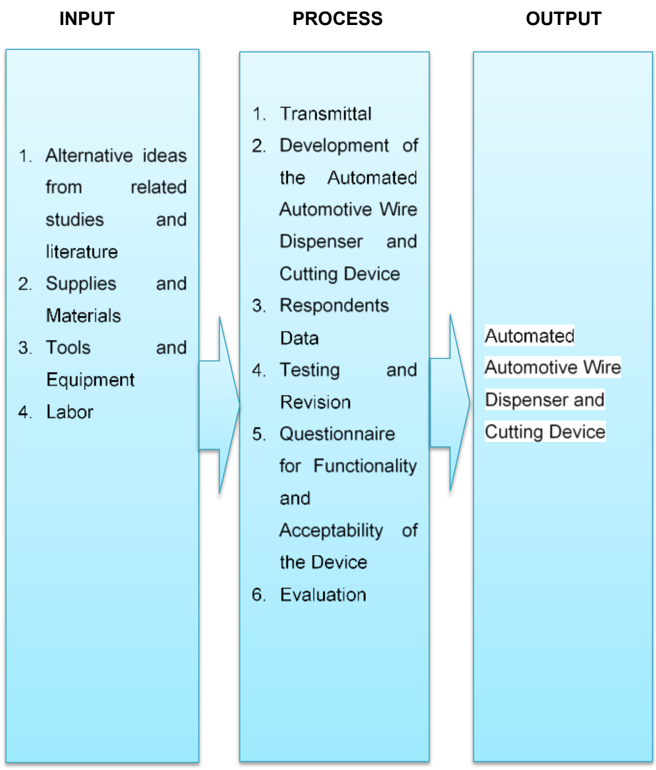


Figure 2
Flow of the Study

The study employed both developmental and descriptive research designs to evaluate the functionality and acceptability of the Automated Automotive Wire Dispenser and Cutting Device. The developmental research method was used specifically for the design, construction, and evaluation of the device. This approach aligns with the first type of developmental research which focuses on product development and evaluation to determine its potential for actual application once functionality and acceptability criteria are met. The descriptive research method was utilized to assess the extent of functionality and acceptability of the developed device based on respondent evaluations. The overall research process followed an input–process–output framework, as illustrated in Figure 2. The input phase consisted of related literature, materials, tools, equipment, and labor necessary for conceptualizing and designing the device. The process phase involved device fabrication, testing, revision, and evaluation using respondent feedback. The output phase resulted in the finalized Automated Automotive Wire Dispenser and Cutting Device.

2.2 Locale of the Study

Figure 3
Location Map of the Environment

The study was conducted in Kidapawan City, located in Region XII of Cotabato Province, at the foot of Mount Apo. Kidapawan City, known as the “City of Highland Springs,” has a total land area of 358.47 square kilometers and consists of 40 barangays. It serves as a central hub for economic and industrial activities due to its proximity to nearby cities such as Davao, General Santos, and Cotabato City. Specifically, the research was carried out at Barangay Sudapin, where the University of Southern Mindanao–Kidapawan City Campus (USM-KCC) is located. USM-KCC offers programs in technology, engineering, and education and is composed of the College of Technology, College of Engineering, and College of Education, Arts, and Sciences. The geographical location of the study site is presented in Figure 3.

2.3 Respondents of the Study

The respondents of the study consisted of faculty members and students from the Automotive, Electrical, and Electronics programs of USM-KCC. These respondents were selected because of their technical expertise and direct relevance to the evaluation of the developed device’s functionality and acceptability. A total of seventy-five (75) respondents participated in the study, comprising automotive students and instructors, electrical students and instructors, and electronics technology students and instructors.

2.4 Sample and Sampling Procedure

Respondents	Population Size (N)	Percentage (%)
Automotive Students	20	26.67%
Automotive Faculty	7	9.33%
Electronics Students	20	26.67%
Electronics Faculty		
Electrical Students	4	5.33%
Electrical Faculty	20	26.67%
TOTAL	**75**	**100%**

Table 1
Distribution of the Respondents

Purposive sampling was used to select respondents who possessed adequate technical knowledge and experience relevant to the evaluation of the Automated Automotive Wire Dispenser and Cutting Device. The sample included twenty (20) automotive students, seven (7) automotive instructors, twenty (20) electrical students, four (4) electrical instructors, twenty (20) electronics technology students, and four (4) electronics instructors. Table 1 presents the distribution of the respondents according to program affiliation. As shown in the table, the total population size was seventy-five (75) respondents, representing 100 percent of the sample.

2.5 Research Instrument

The primary research instrument used in the study was a standardized functionality and acceptability questionnaire. The questionnaire was divided into two parts. The first part measured the functionality of the device based on Garvin's quality dimensions, while the second part assessed its acceptability in terms of perceived utility, perceived convenience, and intention to use. An open-ended section was included to allow respondents to provide comments, recommendations, and suggestions for further improvement of the device.

2.6 Data Gathering Procedure

Data gathering began with the development of the Automated Automotive Wire Dispenser and Cutting Device, which involved sourcing materials, tools, equipment, and labor. A standardized questionnaire was then developed and validated to ensure that it accurately measured functionality and acceptability. Approval to conduct the study was secured from the campus chancellor due to the involvement of faculty and student respondents. The researcher personally administered the testing of the device and distributed the questionnaires to ensure proper guidance and prompt retrieval. Completed questionnaires were collected, and the data were tallied and tabulated for statistical analysis. The gathered data served as evidence for evaluating the device's functionality and acceptability.

2.7 Data Analysis Techniques

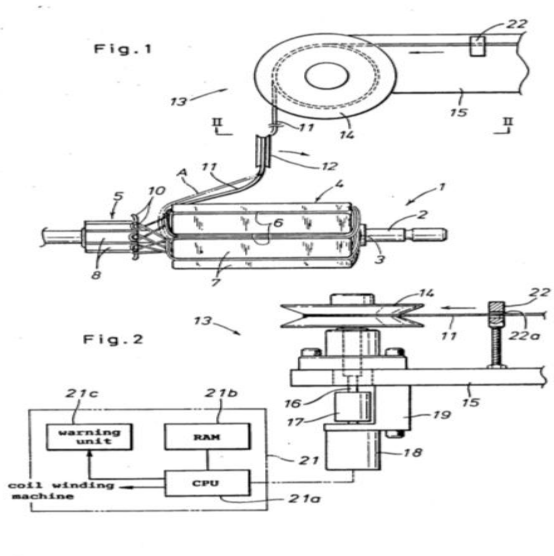
The weighted mean was used as the primary statistical tool to analyze the data obtained from the functionality and acceptability questionnaires. Parametric rating scales were applied to interpret respondent responses, with corresponding verbal descriptions indicating levels of functionality and acceptability. The results provided a quantitative basis for assessing the overall performance and user acceptance of the Automated Automotive Wire Dispenser and Cutting Device.

3. Results and Discussion

3.1 Development and Design of the Automated Automotive Wire Dispenser and Cutting Device

3.1.1 Predominant Designs Related to the Device

Several existing designs relevant to wire dispensing, measuring, and cutting were identified as prior art to the developed device. These included the wire handling machine shown in Figure 4, which evaluates machine operation through wire consumption measurement (Hongo and Kanal,1991); the automatic meter counting device in Figure 5, which enhances accuracy through sensor-based counting (Foo, 2013); the cable dispenser illustrated in Figure 6, which enables controlled cable payout without braking mechanisms (Chong, 1975); the automatic wire dispenser shown in Figure 7, which adjusts spool rotation based on wire tension (Jones, 1990); and the wire feeding and cutting machine in Figure 8, which integrates feeding, cutting, and wire ejection mechanisms (Benedict and Legaul, 1996).



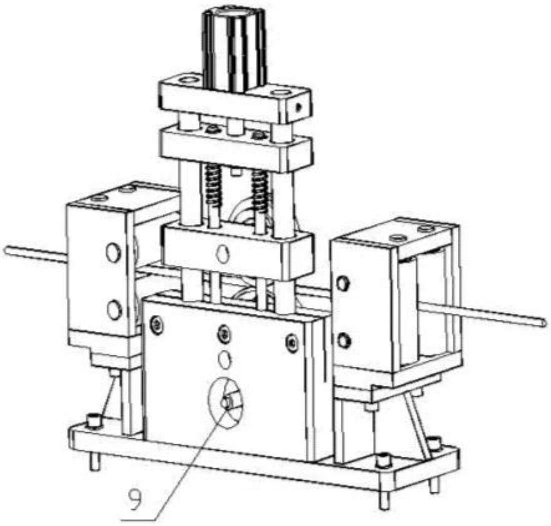
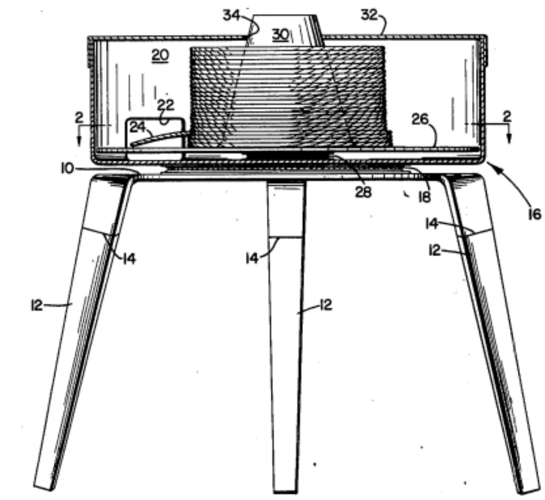


Figure 4
Wire Handling Machine
Inventors: Nobuhisa Hongo, Kenji Kanal
Patent Number: CN1025029619
Country of Origin: China
Date Patented: July 20, 1991

Figure 5
Automatic Meter Counting Device
Inventor: Charmey Foo
Patent Number: CN203337124U
Country of Origin: China
Date Patented: December 11, 2013



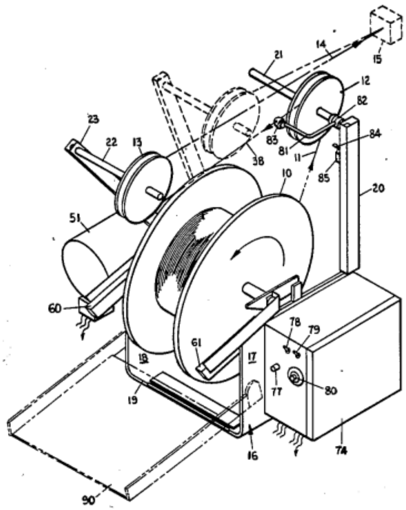


Figure 6
Cable Dispenser
Inventor: Robert S. Y. Chong
Application. No.: 546,604
Country of Origin: United States
Date Patented: October 28, 1975

Figure 7
Automatic Wire Dispenser
Inventor: Johnnie L. Jones
Patent Number: 4,699,945
Country of Origin: United States
Date Patented: February 13, 1990

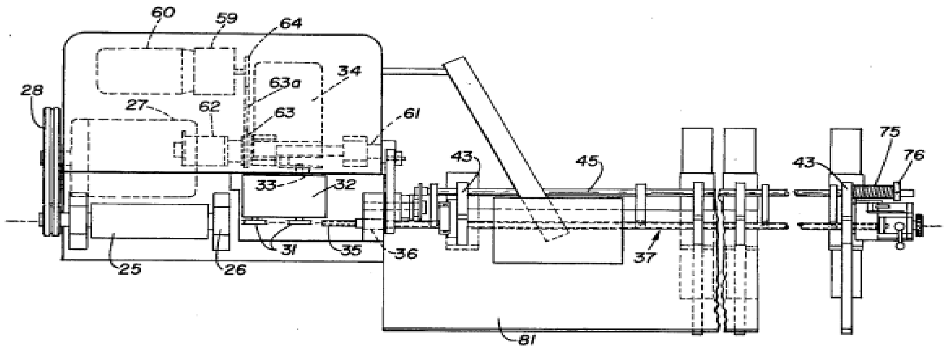


Figure 8
Wire Feeding and Cutting Machine
Inventors: Roger J. Benedict and Craig S. Legaul
Patent Number: 5,570,728
Country of Origin: United States
Date Patented: November 5, 1996

These designs emphasize automation, precision, and sensor integration as essential elements in wire-handling technologies. The developed Automated Automotive Wire Dispenser and Cutting Device reflects these principles by incorporating automated feeding, accurate length control, and cutting mechanisms adapted for automotive laboratory use. The reviewed designs served as technical references that guided the structural and operational development of the device.

3.1.2 Design and Features of the Developed Device

The developed device was presented using multiple design views. Figure 9 shows the perspective view highlighting the external components such as the frame, cutter, motors, keypad, LCD screen, and wire spool holder. Figure 10 presents the orthographic view, indicating dimensions of 18 inches in length, 24 inches in width, and 4.5 inches in height. Figure 11 illustrates the exploded view, detailing internal components including the frame, wire spool, motors, Arduino boards, keypad, LCD, relay modules, power supply, and cutting assembly. The device allows users to select wire color and length through the keypad and LCD interface, after which the wire is automatically dispensed and cut.

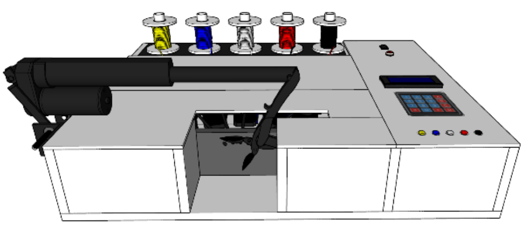


Figure 9
Perspective View of the Automated Automotive Wire Dispenser and Cutting Device

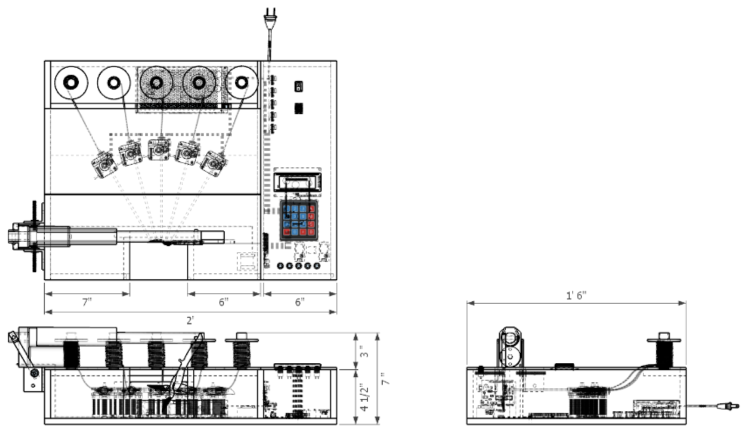


Figure 10
Orthographic View of the Automated Automotive Wire Dispenser and Cutting Device

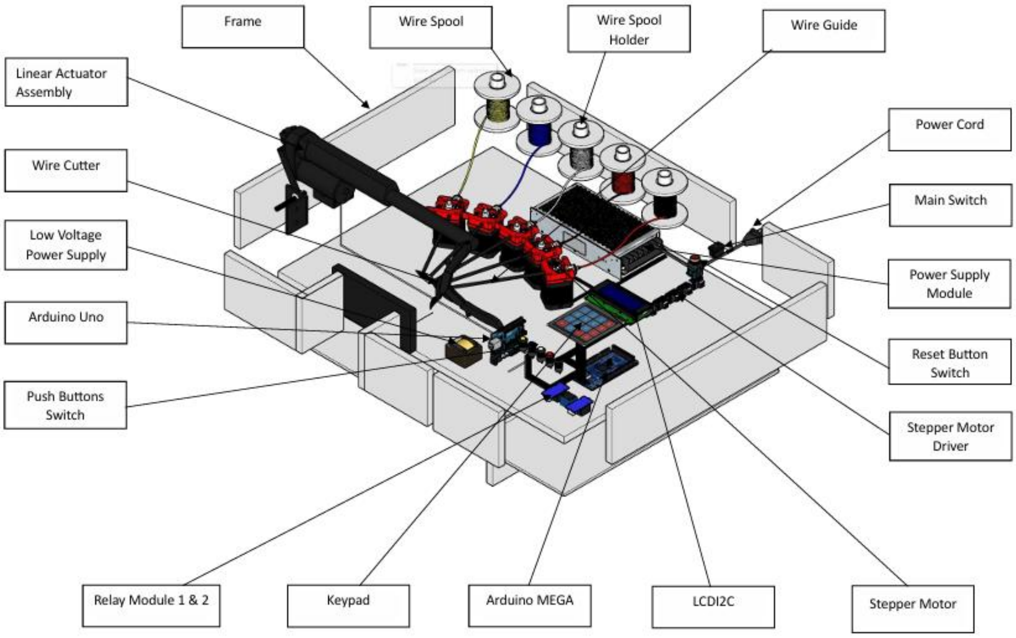


Figure 11
Exploded View of the Automated Automotive Wire Dispenser and Cutting Device

The design and feature set emphasize usability, automation, and operational clarity. The multiple design views demonstrate that the device was systematically engineered to ensure accuracy, efficiency, and ease of use. The inclusion of visual interfaces and control buttons supports smooth operation while minimizing manual effort and potential errors.

3.1.3 Technology Infusion

The device integrates microcontroller-based automation, sensor feedback mechanisms, electromechanical actuators, and a human–machine interface. The Arduino microcontroller coordinates system operations, while stepper and servo motors control wire feeding and cutting. The LCD display and keypad provide user input and real-time feedback during operation. This integration transforms traditional manual wire cutting into a streamlined automated process. The use of programmable logic, sensors, and actuators mirrors modern automotive and industrial systems, reinforcing practical learning in automation, embedded systems, and mechatronics. The device bridges traditional laboratory activities with contemporary technological practices.

3.2 Operation, Ergonomics, and Maintenance

The operation of the device follows a structured process from power connection and wire feeding to automatic dispensing, cutting, and shutdown. Fabrication, installation, programming, calibration, and maintenance procedures were clearly defined to ensure consistent performance. Ergonomic considerations included appropriate device height, accessible controls, clear display visibility, reduced noise, and protective enclosures around moving parts. These operational and ergonomic features ensure safe, efficient, and comfortable use of the device in laboratory settings. Proper maintenance procedures further support long-term reliability, usability, and sustainability of the device during repeated instructional use.

3.3 Extent of Functionality of the Device

3.3.1 Performance

Table 2

STATEMENTS	Mean	VD
Performance:		
1. The device is automatically dispenses and cuts an exact length of wire.	4.47	SA
2. The device works without human intervention.	3.99	MA
3. The device provides reasonable output.	4.49	SA
Sub-mean	**4.32**	**SA**

Legend:

Scale	Interval	Verbal Description
5	4.21 – 5.00	Strongly Agree
4	3.41 – 4.20	Moderately Agree
3	2.61 – 3.40	Agree
2	1.81 – 2.60	Disagree
1	1.00 – 1.80	Strongly Disagree

As shown in Table 2, the device obtained a sub-mean of 4.32, described as strongly agree. Respondents strongly agreed that the device dispenses and cuts exact wire lengths and provides reasonable output, while moderately agreeing that minimal human intervention is still required during operation. These findings indicate that the device effectively performs its primary functions with high accuracy and efficiency. The requirement for minimal human intervention reflects necessary operational input rather than a limitation of automation.

3.3.2 Features

Table 3

STATEMENTS	Mean	VD
Features:		
1. It can be set to show the length of wire to be cut.	4.90	SA
2. It has an automated function in measuring and cutting dispensed wire length.	4.89	SA
3. Its design is user-friendly.	4.80	SA
Sub-mean	**4.86**	**SA**

Table 3 shows that the features of the device achieved a sub-mean of 4.86, described as strongly agree. Respondents agreed that the device accurately displays wire length, automates measuring and cutting, and has a user-friendly design. The results suggest that the device's features enhance ease of use and operational clarity. Automated measurement and cutting promote consistency, while the user-friendly interface facilitates efficient interaction.

3.3.3 Reliability

Table 4

STATEMENTS	Mean	VD
Reliability:		
1. The device consistently operates without any issues.	4.29	SA
2. The device can dispense the appropriate color of the wire.	4.88	SA
3. The device can cut the appropriate wire length.	4.44	SA
Sub-mean	**4.54**	**SA**

Based on Table 4, the reliability aspect recorded a sub-mean of 4.54, described as strongly agree. Respondents observed consistent operation, accurate wire color dispensing, and precise cutting length. This indicates that the device performs reliably during repeated use, reinforcing confidence in its stability and functional accuracy.

3.3.4 Durability

Table 5

STATEMENTS	Mean	VD
Durability:		
1. The device consistently operates without any issues.	4.29	SA
2. The device can dispense the appropriate color of the wire.	4.88	SA
3. The device can cut the appropriate wire length.	4.44	SA
Sub-mean	**4.54**	**SA**

As presented in Table 5, durability obtained a sub-mean of 4.52, described as strongly agree. Respondents agreed that the device was fabricated using durable materials, designed for long-term use, and required minimal maintenance. These findings imply that the device is structurally sound and suitable for prolonged laboratory operation.

3.3.5 Serviceability

Table 6

STATEMENTS	Mean	VD
Serviceability:		
1. The device is easy to troubleshoot and repair.	4.34	SA
2. The device materials are locally available.	4.45	SA
3. The device maintenance procedure does not require an expert technician.	4.29	SA
Sub-mean	**4.36**	**SA**

Table 6 shows that serviceability achieved a sub-mean of 4.36, described as strongly agree. Respondents found the device easy to troubleshoot, maintain, and repair using locally available materials. This suggests that the device is practical and cost-effective, allowing maintenance without the need for specialized technical expertise.

3.4 Extent of Acceptability of the Device

3.4.1 Perceived Usefulness

Table 7

STATEMENTS	Mean	VD
Perceived Usefulness:		
1. The device is useful because it does not require human intervention.	4.10	MA
2. The device is useful because users can manage it.	4.67	SA
3. The device is useful in managing the random picking of wires.	4.79	SA
Sub-mean	**4.52**	**SA**

Legend:

Scale	Interval	Description	Interpretation
5	4.21 – 5.00	Strongly Agree	Highly Acceptable
4	3.41 – 4.20	Moderately Agree	Moderately Acceptable
3	2.61 – 3.40	Agree	Acceptable
2	1.81 – 2.60	Disagree	Less Acceptable
1	1.00 – 1.80	Strongly Disagree	Not Acceptable

Table 7 indicates a sub-mean of 4.52, described as strongly agree. Respondents found the device useful in managing wire selection and improving efficiency, although minimal human intervention was still required. These results show that users perceive the device as beneficial for automotive wiring tasks and supportive of improved productivity.

3.4.2 Perceived Ease of Use

Table 8

STATEMENTS	Mean	VD
Perceived Ease of Use:		
1. The operating procedure of the device is simple and easy to understand.	4.85	SA
2. The users can easily operate the device after a short training period.	4.74	SA
3. The cleaning and maintenance of the device is easy and simple.	4.74	SA
Sub-mean	**4.78**	**SA**

As shown in Table 8, perceived ease of use obtained a sub-mean of 4.78, described as strongly agree. Respondents agreed that the device was easy to learn, operate, clean, and maintain. This confirms that the device's design and operating procedure support effortless use, which contributes to high user acceptance.

3.4.3 Intention to Use

Table 9

STATEMENTS	Mean	VD
Intention to Use:		
1. I will use the device because it makes my tasks faster.	4.50	SA
2. The simple operation of the device makes me more willing to try and use it.	4.75	SA
3. The device reduces physical effort, making me more inclined to use it.	4.80	SA
Sub-mean	**4.68**	**SA**

Table 9 shows a sub-mean of 4.68, described as strongly agree. Respondents expressed strong willingness to use the device due to its efficiency, simplicity, and reduced physical effort. This reflects a positive attitude toward adoption of the device in automotive and technical laboratory environments.

3.5 Issues and Concerns Related to the Device

Table 10

Issues and Concerns of the Device
1. The circuit of the device could not operate if there was a power interruption because it was dependent on the power source from the grid, since there is no battery built into it.
2. The cutting mechanism of the device was a bit time-consuming since it could cut the wire for at least 5-6 seconds.
3. There were vibrations in the stepper motor of colors blue and yellow. There was minimal difference between the wire's intended length and the actual length dispensed and cut by the device during the actual conduct of the study.
4. Based on the survey conducted, the statement for the extent of its functionality, "the device works without human intervention," got a mean of 3.99, described as moderately agree, the lowest among those statements, particularly in the performance aspect.
5. Another was the statement for the extent of acceptability the statement in the perceived usefulness, "the device is useful because it does not require human intervention," got a mean of 4.10, which was describe as moderately acceptable and interpreted as moderately acceptable, the lowest among those statements particularly in perceived usefulness.

As presented in Table 10, minimal issues were identified, including dependence on grid power, a slightly time-consuming cutting process, minor motor vibrations, and small discrepancies between intended and actual wire length. Lower ratings were also observed in statements related to complete automation without human intervention. These concerns highlight potential areas for enhancement, such as incorporating a backup power source, improving cutting speed, and optimizing motor stability. Despite these issues, the overall findings demonstrate that the device remains functional, acceptable, and effective for its intended purpose.

4. Conclusion & Recommendations

The study concluded that the Automated Automotive Wire Dispenser and Cutting Device effectively achieved its intended purpose of accurately dispensing and cutting automotive wires, as evidenced by high weighted mean scores for functionality and acceptability. The results indicate that the device performs reliably, is easy to use, and is well received by both students and faculty, confirming its value as an instructional tool in automotive electrical laboratory activities. While overall performance was rated highly, slightly lower mean scores in specific performance and perceived usefulness indicators suggest that minor refinements could further enhance operational consistency and instructional value. Overall, the device demonstrates strong potential to improve accuracy, safety, efficiency, and technological integration in automotive technology education.

Based strictly on the study findings, it is recommended that the device undergo targeted improvements to enhance cutting efficiency, operational consistency, and perceived usefulness. Further testing and prolonged laboratory use are recommended to generate more comprehensive performance data and support incremental refinement of features, reliability, and efficiency. Additional evaluation focusing on effectiveness, efficiency, and educational impact under varied laboratory conditions is also recommended to better assess how the device supports instructional practices, student productivity, and learning outcomes in automotive technology education.

The study was limited by its short duration and its focus on a single campus with a specific group of student and faculty respondents, which constrained long-term performance evaluation and broader generalization of results. The assessment primarily relied on user perceptions of functionality and acceptability, limiting deeper analysis of long-term durability, efficiency under varying workloads, and extended educational impact. These limitations indicate the need for further studies involving longer testing periods, diverse settings, and expanded evaluation metrics.

Compliance with ethical standards

This study was conducted with due consideration for ethical research practices involving human participants. The research involved faculty members and students in an academic setting, and formal permission to conduct the study was obtained from the campus chancellor prior to data collection. The study procedures focused on the evaluation of a developed instructional device and the collection of respondent feedback through questionnaires.

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