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An Empirical Evaluation of Internet of Things (IoT) Smart Lights for Enhancing Instructional Quality in Electrical Technology Education

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Abstract

This study evaluated the instructional value and acceptability of Internet of Things (IoT) Smart Lights in Electrical Technology Education. A descriptive quantitative research design was used. Data were gathered from faculty members, students, and practitioners through a structured questionnaire. The study assessed the competencies developed by the respondents in design, construction, installation, and safety. It also examined the acceptability of the IoT Smart Lights based on functionality, consistency, perceived ease of use, perceived usefulness, and net benefits. The findings showed that the respondents developed a highly acceptable level of competency in design, construction, installation, and safety, with an overall mean of 4.43. The IoT Smart Lights were also rated highly acceptable for instructional use, with an overall mean of 4.91. Perceived ease of use obtained the highest rating, followed by perceived usefulness, net benefits, consistency, and functionality. These results indicate that the IoT Smart Lights can support hands-on learning, improve instructional delivery, strengthen safety awareness, and expose learners to automation-based electrical applications. However, further improvement may be made in safety reinforcement, circuit component identification, and voice-command responsiveness. The study concludes that IoT Smart Lights are suitable for classroom and laboratory integration in Electrical Technology Education.

Keywords: Internet of Things, Iot Smart Lights, Electrical Technology Education, Instructional Innovation, Technology Acceptance Model, Smart Lighting

1. Introduction

Background

The Internet of Things (IoT) has become an important technological direction in education because it allows physical devices, sensors, controllers, and digital platforms to communicate and support more interactive learning environments. In technical and engineering education, IoT is especially useful because it connects theoretical concepts with practical applications through real devices and observable system responses. Recent literature has shown that IoT-based instruction can strengthen STEM learning when it is supported by appropriate curriculum design, practical activities, and assessment procedures (Abichandani et al., 2022). Smart classroom studies have also shown that IoT can be used to improve the monitoring and control of educational facilities, including lighting systems, energy use, and classroom automation (Montalbo & Enriquez, 2020). In the same way, smart lighting systems have been tested in academic environments as open-source IoT applications that support efficient lighting control, monitoring, and technology-based learning (González-Amarillo et al., 2020). These developments indicate that IoT Smart Lights can serve not only as an automation tool but also as an instructional platform for Electrical Technology Education.

Rationale

Electrical Technology Education requires learning activities that develop both conceptual understanding and practical competence. Students must learn how electrical circuits, control systems, switching devices, sensors, and automation technologies work in real settings. However, conventional instruction may not always provide enough exposure to current smart technologies used in modern electrical installations. This gap supports the need to evaluate IoT Smart Lights as an instructional innovation. The Technology Acceptance Model also suggests that the successful use of any instructional technology depends on how users perceive its usefulness and ease of use (Davis, 1989). Recent educational technology literature confirms that technology acceptance remains a key concern in education because teachers and learners are more likely to adopt digital tools when these tools are perceived as useful, easy to operate, and relevant to learning tasks (Granić, 2023). Therefore, evaluating IoT Smart Lights through functionality, consistency, perceived ease of use, perceived usefulness, and net benefits provides a practical basis for determining whether the system is ready for classroom and laboratory integration.

Significance

This study is significant because it provides empirical evidence on the instructional acceptability of IoT Smart Lights in Electrical Technology Education. The findings may assist teachers in selecting technology-based learning tools that can improve lesson delivery, hands-on demonstration, and learner engagement. The study may also benefit students by exposing them to automation-oriented electrical applications that are aligned with current industry practices. For technical institutions, the study may support curriculum modernization by showing how IoT-based systems can be integrated into laboratory instruction to strengthen applied skills, safety awareness, and technological readiness. Previous studies have emphasized that IoT education can contribute to the development of practical STEM competencies and industry-relevant skills (Abichandani et al., 2022), while smart lighting applications in educational settings have demonstrated potential for improving efficiency, system monitoring, and environmental control (Montalbo & Enriquez, 2020; González-Amarillo et al., 2020). Thus, this study contributes to the growing body of research on IoT-supported instruction by presenting IoT Smart Lights as a practical, acceptable, and scalable instructional innovation for electrical technology learning.

Theoretical Framework

This study was anchored on the Technology Acceptance Model (TAM), which explains that technology adoption is shaped by users' perceived usefulness and perceived ease of use (Davis, 1989; Davis et al., 1989). In this study, perceived usefulness was used to determine whether the IoT Smart Lights improved work quality, promoted safety, enhanced learning, and increased efficiency. Perceived ease of use was used to determine whether the system was easy to learn, install, operate, and control through smartphone-based and voice-command functions.

The study extended TAM by including functionality, consistency, and net benefits because the IoT Smart Lights were evaluated not only as an instructional technology but also as an electrical prototype. Functionality was used to assess whether the system performed its intended operations, such as smartphone connection, API interaction, Wi-Fi or Bluetooth access, relay-based control, and Android compatibility. Consistency was used to assess whether the system remained stable during continuous use, wireless connection, and voice-command response. Net benefits were used to determine the broader instructional value of the system, particularly in knowledge development, automation learning, safety promotion, and accident prevention. These dimensions were supported by recent IoT and smart learning studies, which emphasize that technology acceptance depends on reliability, accessibility, task alignment, and perceived instructional value (Alhasan et al., 2023; Laksana et al., 2022; Sneesl et al., 2023).

TAM directly guided the construction of the research instrument, the organization of the results, and the interpretation of the findings. The questionnaire items were grouped according to five criteria: functionality, consistency, perceived ease of use, perceived usefulness, and net benefits. The broader perspective of IoT-based learning also framed the prototype as a hands-on instructional tool for developing competencies in design, construction, installation, and safety. Through the system, learners were able to connect electrical theory with practical automation tasks, consistent with studies showing that IoT-based instruction supports STEM and technical education through experimentation, authentic problem-solving, and competency-based learning (Abichandani et al., 2022; Montalbo & Enriquez, 2020; Zeeshan et al., 2022).

Overall, the framework assumed that the instructional acceptability of the IoT Smart Lights depended on both technical performance and user perception. High ratings across the five criteria indicated implementation readiness, while lower ratings pointed to areas for refinement, such as safety reinforcement, circuit component identification, and voice-command responsiveness.

Conceptual Framework

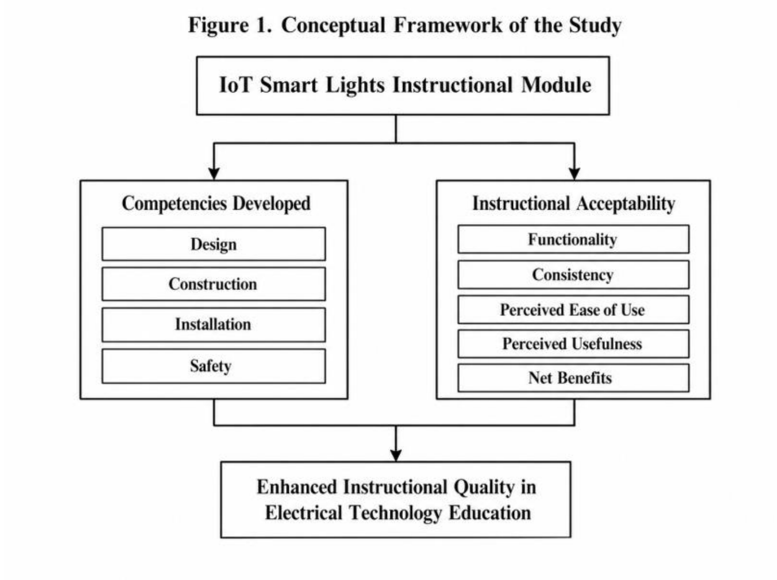

Figure 1. Conceptual Framework of the Study

Figure 1 presents the conceptual framework of the study. It shows that the IoT Smart Lights Instructional Module served as the central instructional intervention. The framework indicates that the module was evaluated through two major dimensions: competencies developed and instructional acceptability. The competencies developed included design, construction, installation, and safety, while instructional acceptability was assessed in terms of functionality, consistency, perceived ease of use, perceived usefulness, and net benefits. These two dimensions were expected to contribute to enhanced instructional quality in Electrical Technology Education. The figure therefore illustrates that the effectiveness of the IoT Smart Lights module was determined not only by the technical competencies it developed but also by the extent to which it was perceived as acceptable and useful for instructional use.

Statement of the Problem

This study aimed to evaluate the instructional value and acceptability of the IoT Smart Lights Instructional Module in enhancing instructional quality in Electrical Technology Education.

Specifically, it sought to answer the following questions:

1. What is the level of competencies developed by the respondents through the IoT Smart Lights Instructional Module in terms of:
   1.1 design;
   1.2 construction;
   1.3 installation; and
   1.4 safety?
2. What is the level of acceptability of the IoT Smart Lights Instructional Module for instructional use in Electrical Technology Education in terms of:
   2.1 functionality;
   2.2 consistency;
   2.3 perceived ease of use;
   2.4 perceived usefulness; and
   2.5 net benefits?

3. Based on the findings, how may the IoT Smart Lights Instructional Module contribute to enhanced instructional quality in Electrical Technology Education?

2. Literature Review

IoT in Technical and STEM Education

The Internet of Things (IoT) has become an important part of technical and STEM education because it allows learners to work with connected devices, sensors, controllers, software applications, and real-time data. In technical education, IoT supports practical learning because students can observe how hardware and software systems interact in real conditions. Abichandani et al. (2022) reviewed IoT curriculum, pedagogy, and assessment in STEM education and emphasized that effective IoT learning should combine low-cost hardware, open-source software, active learning, and direct assessment of student performance. This is relevant to Electrical Technology Education because students are expected to develop both theoretical knowledge and hands-on competence. IoT-based instructional tools can therefore help bridge classroom concepts and actual electrical automation practices.

Recent studies also show that IoT can improve learning environments by making classrooms more interactive, automated, and responsive. Montalbo and Enriquez (2020) developed an IoT smart lighting system for university classrooms using a NodeMCU device, Wi-Fi capability, a passive infrared sensor, and relay switching. Their system was designed to control, manage, and monitor classroom lights, especially to reduce unnecessary energy consumption. This shows that smart lighting can be used not only as an operational tool but also as a practical learning platform where students can understand automation, control circuits, monitoring, and energy efficiency.

Smart Lighting Systems as Instructional Tools

Smart lighting systems provide a useful context for Electrical Technology Education because they combine electrical installation, circuit control, embedded systems, wireless communication, and automation. González-Amarillo et al. (2020) presented Smart Lumini, an IoT-based open-source smart lighting system for academic environments. Their study showed how smart lighting could be used to control indoor lighting and support more efficient academic spaces. This type of system is relevant to the present study because IoT Smart Lights allow learners to see the direct relationship between electrical loads, switching devices, control signals, and lighting outputs. It also helps students understand how modern electrical installations are moving toward automation and intelligent control.

In addition, smart lighting systems can develop students' awareness of safety, efficiency, and responsible electrical practice. When students operate a lighting prototype through a smartphone, Bluetooth, Wi-Fi, relay shield, or voice command, they are not merely observing a device. They are also learning how electrical systems can be controlled safely through low-voltage control signals and programmed switching mechanisms. This supports the instructional value of the IoT Smart Lights module because it provides an applied platform for learning design, construction, installation, and safety.

Technology Acceptance and Instructional Use

The adoption of instructional technology depends not only on the technical quality of the device but also on how users perceive its value and usability. The Technology Acceptance Model explains that perceived usefulness and perceived ease of use are central factors in technology adoption (Davis, 1989; Davis et al., 1989). In education, this means that teachers and learners are more likely to use a technology when they believe that it improves learning and when it can be operated without unnecessary difficulty. Granić (2023) affirmed that technology acceptance remains a major framework for understanding how educational technologies are adopted and used in teaching and learning contexts.

For smart lighting systems, Laksana et al. (2022) applied the Technology Acceptance Model to examine smart lighting acceptance and found that system-related factors such as reliability and accuracy influence users' perceptions of usefulness and acceptance. This supports the present study's use of functionality, consistency, perceived ease of use, perceived usefulness, and net benefits as acceptability criteria. In an instructional setting, a prototype must be functional and stable before it can meaningfully support teaching. If the system frequently fails, disconnects, or becomes difficult to operate, it may reduce instructional time and weaken users' acceptance. Therefore, the evaluation of IoT Smart Lights must consider both user perception and technical performance.

IoT Smart Lights and Instructional Quality

Instructional quality in Electrical Technology Education can be improved when learning activities are practical, safe, standards-based, and aligned with current technological applications. IoT Smart Lights are relevant in this context because they expose learners to automation-based electrical systems. The module allows students to connect theoretical ideas about circuits, relays, microcontrollers, wireless communication, and lighting control with practical laboratory activities. This supports competency development because students are able to practice interpreting drawings, identifying components, operating the prototype, connecting through wireless interfaces, and observing safety procedures.

The literature suggests that IoT-based learning works best when students are actively involved in building, testing, operating, and evaluating systems. Abichandani et al. (2022) emphasized that IoT learning should involve hands-on tasks and authentic assessment, while Montalbo and Enriquez (2020) showed that smart lighting can be designed as a practical IoT application in classroom settings. Similarly, González-Amarillo et al. (2020) demonstrated that smart lighting can be used in academic environments through open-source IoT hardware. These findings support the present study's position that IoT Smart Lights can serve as a practical instructional module for improving learning engagement, technical competence, and instructional delivery in Electrical Technology Education.

3. Methodology

Research Design

This study used a descriptive quantitative research design to evaluate the instructional value and acceptability of the IoT Smart Lights Instructional Module in Electrical Technology Education. This design was appropriate because the study focused on describing respondents' perceptions, competency development, and acceptability ratings without manipulating variables or assigning respondents to experimental groups. Descriptive quantitative research is commonly used when the purpose is to measure existing conditions, summarize responses numerically, and interpret patterns through frequencies, percentages, means, and adjectival descriptions (Creswell & Creswell, 2018). In this study, the design was used to determine the level of competencies developed in design, construction, installation, and safety, as well as the level of acceptability of the IoT Smart Lights in terms of functionality, consistency, perceived ease of use, perceived usefulness, and net benefits. This is aligned with the uploaded manuscript's purpose of empirically evaluating IoT Smart Lights for instructional use in Electrical Technology Education.

Respondents of the Study

The respondents of the study were composed of faculty members, students, and practitioners with relevant exposure to Electrical Technology Education and IoT-based instructional systems. These groups were selected because they could provide informed judgments on the instructional use, technical performance, and practical value of the IoT Smart Lights module. Faculty members evaluated the module from an instructional and pedagogical perspective. Students provided feedback based on usability, learning experience, and competency development. Practitioners contributed technical insights based on field relevance, safety, and practical applicability.

Research Instrument

A structured questionnaire was used as the main instrument for data collection. The questionnaire was developed based on the study's conceptual framework and the Technology Acceptance Model. It was divided into two main parts. The first part measured the level of competencies developed by the respondents in terms of design, construction, installation, and safety. The second part measured the acceptability of the IoT Smart Lights Instructional Module using five criteria: functionality, consistency, perceived ease of use, perceived usefulness, and net benefits. These criteria were used because technology acceptance is commonly associated with users' perceptions of usefulness and ease of use, while IoT-based instructional tools also need to be evaluated in terms of technical performance, reliability, and instructional gains (Davis, 1989; Granić, 2023; Laksana et al., 2022).

IoT Smart Lights Prototype

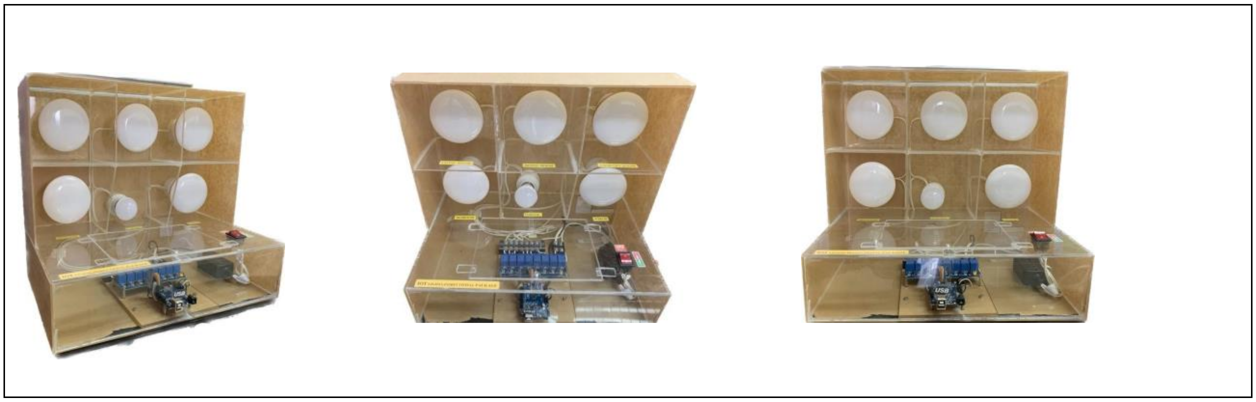

Figure 2. Prototype

The IoT Smart Lights prototype in figure 2 is an instructional device designed to demonstrate how a conventional lighting system can be controlled through Internet of Things technology. It combines LED lighting modules, relay switches, a Bluetooth module, an Arduino Uno R3 microcontroller, and a voice-controlled Android application. Through this setup, users can send commands from a smartphone to control different lighting units. The prototype helps learners observe the connection between voice input, wireless communication, microcontroller processing, relay activation, and lighting output. It also provides a practical way to understand electrical automation, circuit control, and safe switching of lighting loads. In Electrical Technology Education, the prototype serves as a hands-on learning tool that supports competency development in design, construction, installation, and safety.

IoT Smart Lights Flowchart / Operating Process

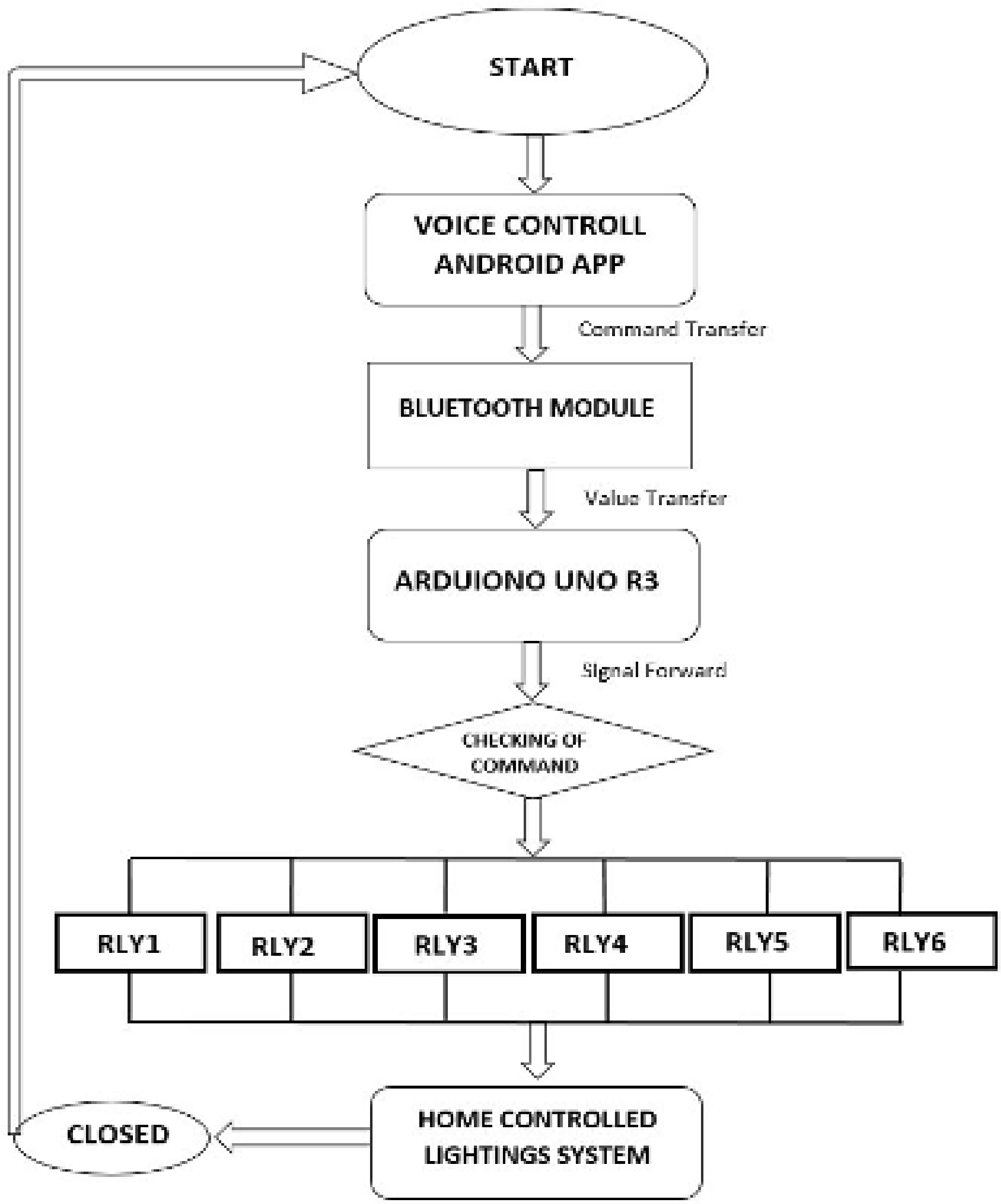

Figure 3. Operating Process

The IoT Smart Lights flowchart in figure 3 shows the operating process of the prototype from command input to lighting output. The process begins when the user gives a command through a voice-controlled Android application. The command is transmitted through the Bluetooth module to the Arduino Uno R3, which checks whether the command is correct. If the command is not recognized, the system returns to the start of the process. If the command is correct, the Arduino activates the appropriate relay channel from RLY 1 to RLY 6. The selected relay then controls the corresponding lighting unit in the Home LED Module Lighting System. This process demonstrates how voice command, wireless communication, microcontroller processing, and relay switching work together in an IoT-based lighting system.

Validation of the Instrument

The questionnaire was subjected to expert validation to ensure that the items were clear, relevant, and aligned with the purpose of the study. Experts in Electrical Technology Education, instructional technology, and research were asked to review the instrument. Their comments were used to improve the wording, organization, and relevance of the items. This process helped establish the content validity of the instrument before it was administered to the respondents. Content validation was important because the instrument had to measure both technical competencies and user acceptability in a clear and appropriate manner.

Data Gathering Procedure

Data gathering was conducted after the IoT Smart Lights Instructional Module had been introduced and demonstrated to the respondents. The respondents were given the opportunity to observe, operate, or evaluate the system based on its instructional and technical features. After this exposure, the structured questionnaire was administered. The respondents rated the module according to the competency indicators and acceptability criteria. The data gathered were then encoded, tabulated, and analyzed using descriptive statistics.

Data Analysis

The data were analyzed using frequency, percentage, weighted mean, and overall mean. Frequency and percentage were used to describe the responses when applicable. Weighted mean was used to determine the level of competencies developed and the level of acceptability of the IoT Smart Lights Instructional Module. The overall mean was computed to summarize the respondents' ratings for each major criterion. The results were interpreted using adjectival ratings such as Highly Acceptable, Highly Functional, Highly Consistent, Highly Usable, Highly Enhances, and Highly Impact, depending on the specific dimension being measured. This analysis allowed the study to present clear numerical evidence on the instructional value and acceptability of the IoT Smart Lights module.

4. Results

The results are presented according to the Statement of the Problem and the Conceptual Framework. The framework positioned the IoT Smart Lights Instructional Module as the instructional innovation evaluated through two major dimensions: competencies developed and instructional acceptability. The first result addresses the competency dimension of the framework.

4.1 Level of Competencies Developed Through the IoT Smart Lights Instructional Module

Table 1. Level of Competencies Developed by the Respondents Through the IoT Smart Lights Instructional Module

Competency Indicator	Mean	Adjectival Rating
Perform the activity with utmost safety in mind.	4.39	Highly Acceptable
Ability to interpret drawings based on ANSI standards.	4.47	Highly Acceptable
Ability to place dimensions on different views for direct measuring.	4.42	Highly Acceptable
Accurate use of lines and symbols.	4.46	Highly Acceptable
Ability to precisely use surface symbols and specifications.	4.44	Highly Acceptable
Ability to identify different parts of the IoT-based electrical circuit.	4.39	Highly

Competency Indicator	Mean	Adjectival Rating
		Acceptable
Perform activities in accordance with the IoT-based Smart Lights instructional module.	4.40	Highly Acceptable
Properly operate the IoT-based Smart Lights instructional module in accordance with the instructional manual.	4.46	Highly Acceptable
Properly utilize the IoT-based Smart Lights instructional module.	4.46	Highly Acceptable
Accurately connect to the IoT Smart Lights via Wi-Fi and Bluetooth.	4.44	Highly Acceptable
Overall Mean	**4.43**	**Highly Acceptable**

Table 1 shows that the respondents developed a highly acceptable level of competencies through the IoT Smart Lights Instructional Module, with an overall mean of 4.43. All indicators were rated Highly Acceptable, which indicates that the module supported the development of technical competencies related to design, construction, installation, and safety.

The highest mean was obtained by the indicator "Ability to interpret drawings based on ANSI standards" with a mean of 4.47. This result suggests that the module helped respondents understand and apply technical drawing standards, which are important in electrical technology instruction. The indicators "Accurate use of lines and symbols," "Properly operate the IoT-based Smart Lights instructional module," and "Properly utilize the IoT-based Smart Lights instructional module" also obtained high means of 4.46, showing that the respondents were able to apply technical and procedural skills in using the instructional module.

The lowest means were recorded for "Perform the activity with utmost safety in mind" and "Ability to identify different parts of the IoT-based electrical circuit," both with a mean of 4.39. Although these were still rated Highly Acceptable, the results imply that safety reinforcement and circuit component identification may still be improved. These areas are important because the conceptual framework identified safety as one of the major competencies developed through the module.

The findings indicate that the IoT Smart Lights Instructional Module contributed positively to the development of applied competencies in Electrical Technology Education. In relation to the conceptual framework, the module supported competency development by helping respondents perform tasks related to design, construction, installation, and safety. This finding provides empirical support for the first pathway of the framework, which links the IoT Smart Lights Instructional Module to the development of technical competencies.

4.2 Level of Acceptability of the IoT Smart Lights Instructional Module as to Functionality

Table 2. Level of Acceptability of the IoT Smart Lights Instructional Module as to Functionality

Functionality Indicator	Mean	Adjectival Rating
Connecting to the IoT Smart Lights via a smartphone is effective.	4.47	Highly Functional
IoT Smart Lights interact smoothly with the API installed in the phone.	5.00	Highly Functional
IoT Smart Lights can be accessed remotely via Wi-Fi or Bluetooth.	5.00	Highly Functional
IoT Smart Lights efficiently control AC voltage using a relay shield for enhanced safety.	4.46	Highly Functional
IoT Smart Lights are compatible with different smartphones using Android OS.	4.44	Highly Functional
Overall Mean	**4.67**	**Highly Functional**

Table 2 shows that the IoT Smart Lights Instructional Module was rated Highly Functional, with an overall mean of 4.67. This result indicates that the module performed its intended instructional and technical functions effectively. The findings also show that the respondents perceived the system as suitable for classroom and laboratory use in Electrical Technology Education. The highest ratings were given to API interaction and remote access through Wi-Fi or Bluetooth, both with a mean of 5.00. These results suggest that the module provided smooth digital control and reliable wireless access. This is important because the conceptual framework identified functionality as one of the key dimensions of instructional acceptability. A system that connects smoothly and responds through wireless control can support more interactive demonstrations and hands-on learning activities.

The indicator "Connecting to the IoT Smart Lights via a smartphone is effective" obtained a mean of 4.47, while "IoT Smart Lights efficiently control AC voltage using a relay shield for enhanced safety" obtained a mean of 4.46. These results suggest that the module was effective in linking smartphone-based commands with electrical switching functions. This supports the instructional goal of allowing learners to observe how low-voltage control signals can manage lighting loads through relay-based switching. The lowest mean was obtained by Android OS compatibility, with a mean of 4.44. Although still rated Highly Functional, this result suggests that compatibility with a wider range of devices may be strengthened in future versions of the module. This may improve flexibility for classroom use, especially when students use different smartphone models.

4.3 Level of Acceptability of the IoT Smart Lights Instructional Module as to Consistency

Table 3. **Level of Acceptability of the IoT Smart Lights Instructional Module as to Consistency**

Consistency Indicator	Mean	Adjectival Rating
The IoT Smart Lights do not break down even when used continuously throughout the day.	5.00	Highly Consistent
The IoT Smart Lights do not lose connection when connected through a smartphone.	4.84	Highly Consistent
The IoT Smart Lights efficiently recognize voice commands intended for their function.	4.79	Highly Consistent
The IoT Smart Lights effectively connect via Wi-Fi or Bluetooth.	5.00	Highly Consistent
The IoT Smart Lights respond to assigned voice commands.	4.93	Highly Consistent
Overall Mean	**4.91**	**Highly Consistent**

Table 3 shows that the IoT Smart Lights Instructional Module was rated **Highly Consistent**, with an overall mean of **4.91**. This indicates that the module performed reliably during instructional use and could be used repeatedly in classroom and laboratory activities with minimal disruption. The highest ratings were given to continuous operation and effective Wi-Fi or Bluetooth connection, both with a mean of **5.00**. These findings suggest that the module was dependable during extended use and maintained stable wireless connectivity. The ratings for voice-command response (**4.93**) and smartphone connection stability (**4.84**) also show that the system remained responsive and suitable for instructional demonstrations.

The lowest mean was recorded for voice-command recognition (**4.79**), although it was still rated **Highly Consistent**. This suggests that future improvements may focus on clearer command programming, better audio conditions, and stronger command-response calibration. Overall, the findings show that the module was operationally stable and supported instructional acceptability by maintaining dependable performance during repeated technical learning activities.

4.4 Level of Acceptability of the IoT Smart Lights Instructional Module as to Perceived Ease of Use

Table 4. **Level of Acceptability of the IoT Smart Lights Instructional Module as to Perceived Ease of Use**

Perceived Ease of Use Indicator	Mean	Adjectival Rating
Learning to operate the IoT Smart Lights is easy.	5.00	Highly Usable
Interacting with the IoT Smart Lights is convenient.	5.00	Highly Usable

Perceived Ease of Use Indicator	Mean	Adjectival Rating
Installing the API on a smartphone to operate IoT Smart Lights is effortless.	5.00	Highly Usable
Executing voice commands to control IoT Smart Lights is straightforward.	5.00	Highly Usable
Overall Mean	**5.00**	**Highly Usable**

Table 4 shows that the IoT Smart Lights Instructional Module was rated Highly Usable, with an overall mean of 5.00. All indicators obtained a mean of 5.00, which indicates that the respondents perceived the module as very easy to learn, install, interact with, and operate. The result suggests that the module did not create difficulty for the users during operation. Learning to operate the system was perceived as easy. Interaction with the system was also viewed as convenient. The installation of the smartphone API was rated effortless, and the execution of voice commands was considered straightforward. These results are important because ease of use is one of the main constructs of the Technology Acceptance Model. A system that is easy to use is more likely to be accepted and integrated into instructional activities.

In relation to the conceptual framework, perceived ease of use formed part of the instructional acceptability dimension. The perfect rating indicates that the IoT Smart Lights Instructional Module can be used without excessive technical burden. This allows both teachers and students to focus on electrical concepts, automation procedures, and hands-on competencies instead of spending too much time on system orientation or troubleshooting. The results indicate that the IoT Smart Lights Instructional Module has a strong usability profile. This supports its potential for classroom and laboratory integration in Electrical Technology Education. The result also suggests that the module can contribute to enhanced instructional quality because it allows smooth interaction, simple operation, and efficient use during technical learning activities.

4.5 Level of Acceptability of the IoT Smart Lights Instructional Module as to Perceived Usefulness

Table 5. **Level of Acceptability of the IoT Smart Lights Instructional Module as to Perceived Usefulness**

Perceived Usefulness Indicator	Mean	Adjectival Rating
IoT Smart Lights improve work quality.	4.93	Highly Enhances
IoT Smart Lights promote safety in electrical work.	5.00	Highly Enhances
IoT Smart Lights enhance learning.	5.00	Highly Enhances
IoT Smart Lights increase the chances of becoming more efficient at work.	5.00	Highly Enhances
Overall Mean	**4.98**	**Highly Enhances**

Table 5 shows that the IoT Smart Lights Instructional Module was rated **Highly Enhances** in terms of perceived usefulness, with an overall mean of **4.98**. This indicates that the respondents strongly viewed the module as useful in improving work quality, promoting safety, enhancing learning, and increasing efficiency in Electrical Technology Education. The highest ratings were given to safety promotion, learning enhancement, and work efficiency, each with a mean of **5.00**. This suggests that the module was perceived as a practical tool for safer and more effective technical instruction. The item on improving work quality obtained a slightly lower mean of **4.93**, but it remained highly rated. This implies that the module helped learners apply automation concepts, follow proper procedures, and connect electrical theory with practice.

The findings show that perceived usefulness strengthened the instructional acceptability of the module. The IoT Smart Lights Instructional Module may therefore support classroom and laboratory integration, particularly in lessons on automation, electrical control, safety, and smart lighting applications.

4.6 Level of Acceptability of the IoT Smart Lights Instructional Module as to Net Benefits

Table 6. **Level of Acceptability of the IoT Smart Lights Instructional Module as to Net Benefits**

Net Benefits Indicator	Mean	Adjectival Rating
The IoT Smart Lights greatly enhance knowledge among people learning IoT-based electrical applications.	5.00	Highly Impact
The IoT Smart Lights provide a strong foundation for understanding and learning automation.	5.00	Highly Impact
The IoT Smart Lights promote safety for electrical connections.	5.00	Highly Impact
The IoT Smart Lights help avoid fire disasters and accidents related to electrical malfunctions.	4.93	Highly Impact
Overall Mean	**4.98**	**Highly Impact**

Table 6 shows that the IoT Smart Lights Instructional Module was rated **Highly Impact** in terms of net benefits, with an overall mean of **4.98**. This indicates that the respondents perceived the module as highly beneficial for learning IoT-based electrical applications, understanding automation, promoting safe electrical connections, and reducing risks linked to electrical malfunctions. The highest ratings were given to knowledge enhancement, automation learning, and safety promotion, each with a mean of **5.00**. The item on preventing fire disasters and accidents obtained a slightly lower mean of **4.93**, but it remained highly rated. This suggests that the module supported safety awareness and risk reduction, although future use may include stronger safety drills and hazard identification activities. The results show that the net benefits of the module strengthened its instructional acceptability. The IoT Smart Lights Instructional Module may therefore contribute to enhanced instructional quality by supporting knowledge development, automation learning, and safety-oriented practice in Electrical Technology Education.

4.7 Summary of the Acceptability of the IoT Smart Lights Instructional Module

Table 7. **Summary of the Acceptability of the IoT Smart Lights Instructional Module for Instructional Use in Electrical Technology Education**

Acceptability Criterion	Mean	Adjectival Rating
Functionality	4.67	Highly Acceptable
Consistency	4.91	Highly Acceptable
Perceived Ease of Use	5.00	Highly Acceptable
Perceived Usefulness	4.98	Highly Acceptable
Net Benefits	4.98	Highly Acceptable
Overall Mean	**4.91**	**Highly Acceptable**

Table 7 shows that the IoT Smart Lights Instructional Module obtained an overall mean of 4.91, interpreted as Highly Acceptable, indicating that the module was suitable for instructional use in Electrical Technology Education. Among the five criteria, perceived ease of use obtained the highest mean of 5.00, showing that the module was easy to learn, install, operate, and control. Perceived usefulness and net benefits both obtained a mean of 4.98, suggesting that the module was valuable for improving learning, safety, efficiency, automation knowledge, and electrical work quality. Consistency obtained a mean of 4.91, indicating reliable performance during repeated use, while functionality obtained the lowest mean of 4.67, although it remained highly acceptable. This suggests that minor refinements may still be made in device compatibility, relay-based safety control, and smartphone connection. Overall, the findings confirm that the module met the instructional acceptability indicators in the conceptual framework and may support enhanced instructional quality in Electrical Technology Education.

4.8 Contribution of the IoT Smart Lights Instructional Module to Enhanced Instructional Quality

The results show that the IoT Smart Lights Instructional Module may contribute to enhanced instructional quality by strengthening both technical competency development and instructional acceptability. Based on the conceptual framework, these two dimensions serve as the main bases for determining the instructional value of the module.
First, the module contributed to competency development by helping respondents develop skills in design, construction, installation, and safety. The overall competency mean of 4.43 indicates that the module supported hands-on learning and practical application. The respondents were able to interpret technical drawings, use lines and symbols, identify circuit parts, operate the module, and connect the system through Wi-Fi and Bluetooth. These competencies are important because Electrical Technology Education requires learners to apply technical concepts in actual or simulated electrical systems.

Second, the module contributed to instructional quality through its high level of acceptability. The overall acceptability mean of 4.91 shows that the IoT Smart Lights were perceived as functional, consistent, easy to use, useful, and beneficial. The highest rating was obtained by perceived ease of use, which means that the system was easy to learn, install, operate, and control. This can improve instructional delivery because less time may be spent on technical orientation and troubleshooting. More time may be used for demonstration, practice, and analysis of electrical automation concepts.

Third, the module may enhance instructional quality by linking classroom instruction with current technological applications. The system allows learners to observe how smartphone control, voice commands, wireless communication, relay switching, and lighting outputs work together. This supports more meaningful learning because students are exposed to automation-based electrical applications that are relevant to modern industry practice.

Finally, the findings also show areas for further improvement. The slightly lower ratings in safety emphasis, circuit component identification, functionality, and voice-command recognition suggest that future versions of the module may include stronger safety routines, clearer component labeling, improved compatibility, and more stable command-response features. These refinements may further improve the module's instructional value.

Overall, the IoT Smart Lights Instructional Module may enhance instructional quality in Electrical Technology Education by providing a practical, acceptable, and technology-based learning tool. It supports competency development, improves usability, strengthens safety awareness, and introduces learners to smart electrical automation. This confirms the final pathway of the conceptual framework, where competency development and instructional acceptability lead to enhanced instructional quality in Electrical Technology Education.

5. Discussion

The findings show that the IoT Smart Lights Instructional Module supported the development of competencies in design, construction, installation, and safety. The overall mean of 4.43 indicates that the respondents were able to develop a highly acceptable level of technical competence through the module. This result suggests that the module provided a practical learning environment where electrical concepts were applied through observable automation tasks. The high ratings in interpreting drawings, using lines and symbols, operating the module, and connecting the system through Wi-Fi and Bluetooth indicate that the module strengthened both technical understanding and procedural skills. This supports the role of IoT-based instruction in technical education, where learning becomes more meaningful when students interact with actual devices, control systems, and automation processes.

The results also show that the IoT Smart Lights Instructional Module was highly acceptable for instructional use. The overall acceptability mean of 4.91 indicates strong user approval across functionality, consistency, perceived ease of use, perceived usefulness, and net benefits. This means that the module was not viewed only as a working prototype. It was also perceived as a useful instructional tool. The perfect rating for perceived ease of use suggests that users could learn, install, operate, and control the system with minimal difficulty. This is important in classroom and laboratory settings because instructional time can be affected when a technology is difficult to operate. A simple and usable system allows teachers and learners to focus more on electrical concepts, automation principles, and hands-on practice.

The high ratings for perceived usefulness and net benefits further suggest that the module was seen as valuable for improving learning, safety, work quality, efficiency, automation knowledge, and electrical connection practices. These findings are consistent with the Technology Acceptance Model, which explains that users are more likely to accept and use a technology when they perceive it as useful and easy to operate (Davis, 1989; Davis et al., 1989). The results also support recent literature showing that technology acceptance in education is influenced by the alignment between the tool, the learning task, and the users' perceived instructional benefit (Granić, 2023). In this study, the IoT Smart Lights module was accepted because it provided visible instructional value and practical relevance to Electrical Technology Education.

The findings also confirm the importance of functionality and consistency in using IoT-based instructional tools. The module was rated highly functional, with strong results in API interaction, wireless access, smartphone connection, and relay-based control. It was also rated highly consistent, particularly in continuous operation and Wi-Fi or Bluetooth connectivity. These results suggest that the system was technically dependable for repeated classroom and laboratory use. This is important because instructional technologies must perform reliably during demonstrations and skill-based activities. Unstable devices may interrupt the lesson and reduce learning time. The results are consistent with studies showing that IoT systems in educational environments must be reliable, accessible, and task-aligned to support effective adoption and instructional use (Alhasan et al., 2023; Laksana et al., 2022; Sneesl et al., 2023).

However, the findings also reveal areas that may be strengthened. The relatively lower means for safety emphasis and circuit component identification, although still highly acceptable, suggest that future implementation should provide stronger safety routines and clearer component-level instruction. In the same way, the lower rating for voice-command recognition indicates that command clarity, classroom noise control, and system calibration may be improved. These areas do not weaken the overall acceptability of the module. Rather, they point to specific refinements that can make the module more effective and safer for instructional use.

Overall, the discussion confirms the logic of the conceptual framework. The IoT Smart Lights Instructional Module contributed to enhanced instructional quality through two related pathways. First, it supported the development of competencies in design, construction, installation, and safety. Second, it demonstrated instructional acceptability in terms of functionality, consistency, perceived ease of use, perceived usefulness, and net benefits. These findings suggest that the module is suitable for classroom and laboratory integration in Electrical Technology Education, especially for lessons involving smart lighting, automation, wireless control, relay switching, and electrical safety.

6. Conclusion

This study evaluated the instructional value and acceptability of the IoT Smart Lights Instructional Module in Electrical Technology Education. The findings showed that the module supported a highly acceptable level of competency development in design, construction, installation, and safety, with an overall mean of 4.43. This indicates that the module helped respondents apply technical concepts through hands-on activities related to electrical drawings, circuit identification, module operation, wireless connection, and safe work practices.

The findings also showed that the IoT Smart Lights Instructional Module was highly acceptable for instructional use, with an overall mean of 4.91. The module was rated highly in terms of functionality, consistency, perceived ease of use, perceived usefulness, and net benefits. Among these criteria, perceived ease of use obtained the highest rating, which suggests that the system was easy to learn, install, operate, and control. The high ratings for perceived usefulness and net benefits further indicate that the module was viewed as valuable for improving learning, safety, work efficiency, and understanding of automation-based electrical applications.

Based on the findings, the study concludes that the IoT Smart Lights Instructional Module is a practical and acceptable instructional tool for Electrical Technology Education. It can enhance instructional quality by linking electrical theory with applied automation tasks. It can also support safer and more interactive learning in classroom and laboratory settings. However, further refinements may still be made in safety reinforcement, circuit component identification, device compatibility, and voice-command responsiveness to maximize its instructional effectiveness.

7. Recommendations

Based on the findings and conclusion, the following recommendations are offered.

First, the IoT Smart Lights Instructional Module may be integrated into Electrical Technology Education as a practical learning tool for lessons on smart lighting, circuit control, relay switching, wireless communication, and automation. Its high ratings in competency development and instructional acceptability suggest that it can support hands-on learning and improve instructional delivery.

Second, instructors may use the module to strengthen students' competencies in design, construction, installation, and safety. Activities may include interpreting electrical drawings, identifying circuit components, connecting the system through Wi-Fi or Bluetooth, operating the module, and applying safety procedures during laboratory work.
Third, safety instruction may be reinforced when the module is used. Since safety obtained one of the relatively lower means, future implementation may include safety checklists, hazard identification tasks, lockout and tag out reminders, and guided discussion on electrical risks. This will help students develop stronger safety awareness while using IoT-based electrical systems.

Fourth, the module may be improved by adding clearer labels for circuit components and by providing a more detailed instructional manual. This may help students identify parts of the IoT-based electrical circuit more accurately and support better troubleshooting skills.
Fifth, the voice-command feature may be refined. Improvements may include clearer command programming, improved microphone sensitivity, better calibration, and testing under actual classroom noise conditions. These refinements may strengthen system responsiveness and improve user experience.

Sixth, future researchers may conduct a comparative or quasi-experimental study to determine whether the IoT Smart Lights Instructional Module significantly improves students' actual learning performance compared with conventional instruction. Larger samples and longer implementation periods may also be used to strengthen the generalizability of the findings.

Seventh, technical institutions may consider developing similar IoT-based instructional modules for other areas of electrical technology, such as energy monitoring, motor control, home automation, and smart safety systems. This may help modernize laboratory instruction and prepare learners for current industry practices.

Declaration

Author Contributions

Ronilo Achmad S. Cuachon served as the main researcher and lead author of the study. He conceptualized the research, developed the IoT Smart Lights instructional module, coordinated the evaluation process, analyzed the data, prepared the initial manuscript, and integrated the revisions. The remaining authors contributed to the study through technical review, instrument preparation, validation support, data-gathering assistance, interpretation of results, literature review, manuscript formatting, and final review of the article. All authors reviewed and approved the final version of the manuscript for publication.

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Conflict of Interest
The authors declare that they have no conflict of interest related to the conduct, authorship, or publication of this study.

Ethical Considerations
The study was conducted with due consideration of research ethics. Participation was voluntary. The respondents were informed about the purpose of the study before data collection. The data were treated with confidentiality and were used only for academic and research purposes.

Use of Artificial Intelligence
Artificial intelligence tools were used only for language refinement, grammar checking, formatting assistance, and improvement of manuscript readability. The authors remained fully responsible for the intellectual content, research design, data analysis, interpretation of findings, and final approval of the manuscript. No artificial intelligence tool was used to generate, fabricate, alter, or manipulate research data.

Data Availability
The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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These are the sources cited in the rewritten sections so far, aligned with the uploaded IoT Smart Lights manuscript and the added methodology source.