Integrated Smart System for Electrical Installation and Maintenance: An Instructional Trainer

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ABSTRACT

This study presents the development and evaluation of the integrated smart system for electrical installation and maintenance: an instructional trainer. The system will incorporate smart technology such that the users can control the device in four different ways through a touch switch, smartphone, local area network (LAN), and cloud. The design of the device was tested for performance metrics such as functionality, usability and safety. The performance of the developed device tested 99.02 % functionality rate with the mean of 4.96 and SD 0.14, while usability was tested 4.92 mean and SD 0.29 which concludes 98.04 % usability rate, and the developed device is 99.06% safe. The developed device is essential for electrical installation and maintenance students, showcasing the educational and practical applications in real world scenarios.

Keywords: smart system; electrical installation and maintenance; instructional trainer; functionality; usability; safety

INTRODUCTION

A broad category of technology advancements known as "smart systems" combines improved processing, connection, and automation to improve the effectiveness, practicality, and intelligence of many processes and objects in our daily lives. These systems use big data analytics, machine learning, artificial intelligence (AI), the Internet of Things (IoT), and other technologies to collect and analyze data, make decisions, and adjust to changing circumstances.

Through adaptable platforms and data-driven insights, intelligent technologies in education support personalized learning. They raise student participation and assist teachers in modifying their instructional strategies. Integrating smart systems in electrical installation and maintenance represents a paradigm shift in electrical engineering. The way electrical systems are built, implemented, monitored, and maintained will be revolutionized by this integration, which combines conventional electrical knowledge with automation and intelligent technology improvements.

Integrated smart systems mean adding intelligent networks, connected devices, and automated controls to existing electrical infrastructure. Several advantages result from this integration, including increased effectiveness, higher performance, and greater control over electrical systems.

It was with the aim of filling this pedagogical gap that “Integrated Smart System in Electrical Installation and Maintenance: An Instructional Trainer “was developed. This trainer module included the mock-up model and learning exercise materials, which served different activities for the students. This training module aimed to accelerate the learning assimilation of knowledge, skills, and attitudes of electrical installation and maintenance senior high school students. This is also essential for the teacher-trainer to facilitate learning situations efficiently and effectively.

The lack of instructional materials and equipment impacts educational quality (Bone, J., (n.d). Many schools that provide EIM NC II courses in DepED are confronted with issues such as a lack of materials, equipment, and facilities needed in the teaching-learning process and the new approach and teaching modalities required under the new normal education system. EIM trainers are usually big and heavy, consumables took a lot of budget each year. Early wear and tear of the electrical devices.

As a result, addressing the needs and developing the appropriate abilities and attitudes is difficult for both students and teachers. The innovation of devices will address the issue of instructional materials shortage and act as an intervention in the new teaching and learning setting.

Hence, to ease the burden, the proposed trainer of integrated smart systems in electrical installation and maintenance will replace the manual way of teaching and learning through this advancement of technology.

In developing the device integrated smart system for electrical installation and maintenance: an instructional trainer. The specification of the trainer was based on the following objective.

To design and fabricate an integrated smart system for electrical installation and maintenance: an instructional trainer.

To evaluate the performance of the trainer in terms of functionality, usability and safety.

The developmental method of research was used to conduct the study. The trainer was designed and developed according to the specifications and needs of the study.

This study employed a descriptive research method, which provides valuable insights into existing practices in the education system (Lochmiller & Lester, 2017).

In addition, descriptive research offers a methodical and accurate depiction of a particular subject. The study results can provide valuable insights into the performance of Integrated Smart System in Electrical Installation and Maintenance: An instructional trainer in improving the quality of electrical installation and maintenance training and preparing trainees for their future careers.

Related Studies

Romero (2020) in his book Towards the Characterisation of Smart System: A systematic literature review, said that Increasing the distance between the actual and virtual worlds is a goal for businesses and governments. Using the digital world to tackle different problems. Another aspect of the digital transition is a change in paradigm centered on the switch from computer-aided technologies to smart. Systems can be found in various fields, including intelligent manufacturing, smart cities, and Smart Solutions. In this case, investigating the conceptualization of smart systems is a topic discussed in the scientific literature to understand the features of such systems and the effects of using them. However, a comprehensive understanding of considering that most research focuses on particular fields.

Between 2018 and 2023 the penetration rate of electricity smart meters in the European Union (EU) is expected to grow from approximately 44% to 71%. The unprecedented development of smart metering (SM) as an ICT-enabled technological novelty is progressing in a complex, multi-actor innovation system, which EU-level institutions and policies strongly drive. Technology Innovation System (TIS) analysis of electricity SM development in the EU, focusing on regulatory aspects done comprehensive results. The innovation system identifies key elements (technologies and infrastructures; actors and networks; institutions and policies) characterizes their interaction based on an in-depth desk research and a critical assessment of regulations, statistics and primary and grey literature sources (e.g., market reports). (Maksymilian Kocha ´nski, K.K., & et al. 2020)

Dr. Jeff Galapon Pereyras (2020) The electrical wiring installation trainer is a valuable tool for students to learn and appreciate the subject, as well as for professors to demonstrate and evaluate students' performance during laboratory time. A developmental research approach was used in this study. The trainer was operated using a

220VAC (Volts-Alternating Current) power supply and was supported with an instructional module on electrical wiring installation. Faculty members from the College of Technology at Pangasinan State University (PSU) Lingayen Campus, who teach Bachelor of Industrial Technology (BIT) major in Electrical Technology, were consulted through demonstration, interview and consultation. It was found that the trainer can effectively simulate all of the activities listed in the module for electrical wiring installation, making it parallel to actual building wiring installation. The trainer is equipped with a low-current circuit breaker to ensure safe operations and prevent damage to all devices. It is capable of handling residential, commercial and industrial electrical wiring installation, troubleshooting, and commissioning.

METHODOLOGY

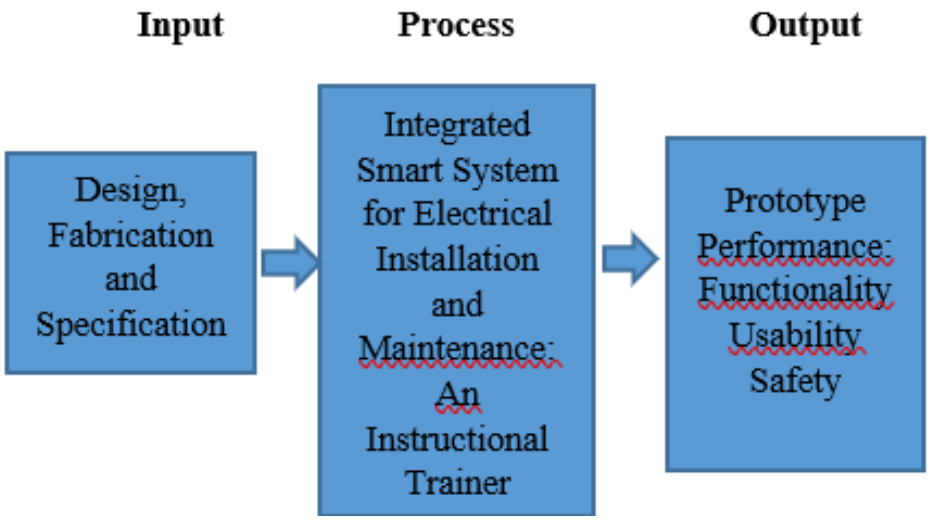

Figure 1. Methodology flowchart of the prototype

The methods starts with prototype design and specification and development followed with the fabrication of the prototype and lastly, the evaluation of functionality, usability and safety shown in figure 1.

A. Prototype Design Specification and Development

The trainer design and specifications are based on the existing electrical installation and maintenance activities. The developed device is use for educational purposes, the prototype aims to enhance the technological skills of the students, especially those pursuing Industrial Arts Track, Electrical Installation and Maintenance Strand.

Feature of the Prototype

The prototype features integrated smart system for electrical installation and maintenance, capable for controlling electrical devices in four different ways, namely through touch switch, smart phone, local area network (LAN) and cloud. The integrated smart system with the traditional electrical system present in the classroom. From 220 volts power supply it will pass to a circuit breaker to energize the power supply, 4 channel relay and Programmable IP port. The power supply will convert 220 volts AC to 24 volts DC output to power up the relay and programmable IP-port. The Relay will serve as a protective device to power up the energy consuming device found in the smart system being developed. Through this the 24 volts DC can now power up 220 volts consuming devices like Bulbs, Electric Fan, Air condition and etc. The programmable IP-port is the module that makes the system smart. IP Port with RS232, RS485 ports used for programming, controlling 3rd party device, and connect to free IOS iPhone, Ipad and android free application. One of the 3rd party device of my smart system is the ES - 10F with motion and light detecting ability, infrared emitters, digital inputs, 12 volts outputs, 32 logic lines is used in saving energy, audiovisual (AV) control security and automation. Terre 4 gang light switch with four touch RGB buttons, wall smart home panels, wired TIS-BUS or WIFI-TIS Air Connection, lights, curtain and scenes control. These are the parts and functions of the smart system being developed.

Table 1. Design specification and description of the trainer module.

1. 15A CB	Overload, Ground Fault and Short circuit protection.
2. TIS Power Supply Module	A. 24 volt DC 1.5 Amps to give all TIS Devices 24 volt power.
3. TIS Relay 4 Ch 10 Amps motor shutter control function	Economic Relay 10 Amps , good for lighting, and curtain control
4. IP-Comport Module	IP Port with RS232, RS485 Ports used for programming , controlling 3rd party device, and to connect free IOS iPhone I pad and android free application, Ready integration with cool master, UPB Lights, and others
5. TIS Terre 4 gangs Touch with Direct TIS Bus connection	Modular Touch panel with 4 Buttons with Direct Bus connection
6. TIS Energy Servant 10 Functions, Celling Mount Sensor	with PIR motion Sensor, lights intensity Sensor, Infrared control, 2 Digital Inputs, 12 volt Outputs, 32 logic lines, used for saving energy, AV control security and automation
7. 2pcs 5watts bulb	Lighting output
8. 2pcs lamp sockets	Securely holds the light bulbs in place
9. 1pc SPO	Provides electric power to 3 bar male plugs appliance
10. 1pc CO	Provide electric power to 2 bar male plug appliance
11. 1pc Power Cord	Transfer electrical power from a source
12. Microphone box	This will serve as the Kit of the system
13. 5mtr THHN # 14	This will cater all the wiring connections found in the system
14. DIN Rail	Attached inside the box to secure TIS modules.
15. 3m Electrical Tape	Protects electrical wires and cables from moisture and heat. It also holds wires in place.

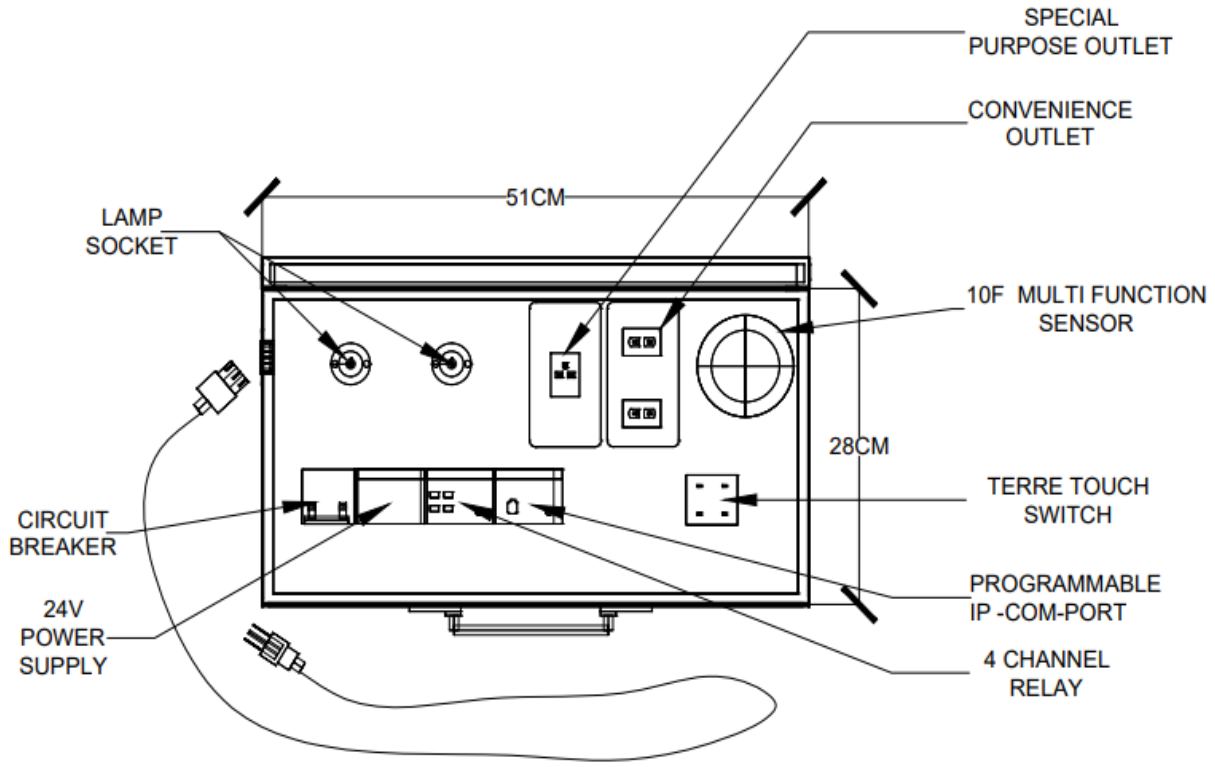

Figure 2. Top view of the Integrated Smart System for Electrical Installation and Maintenance: An Instructional Trainer (ISSEIM: AIT) and its parts.

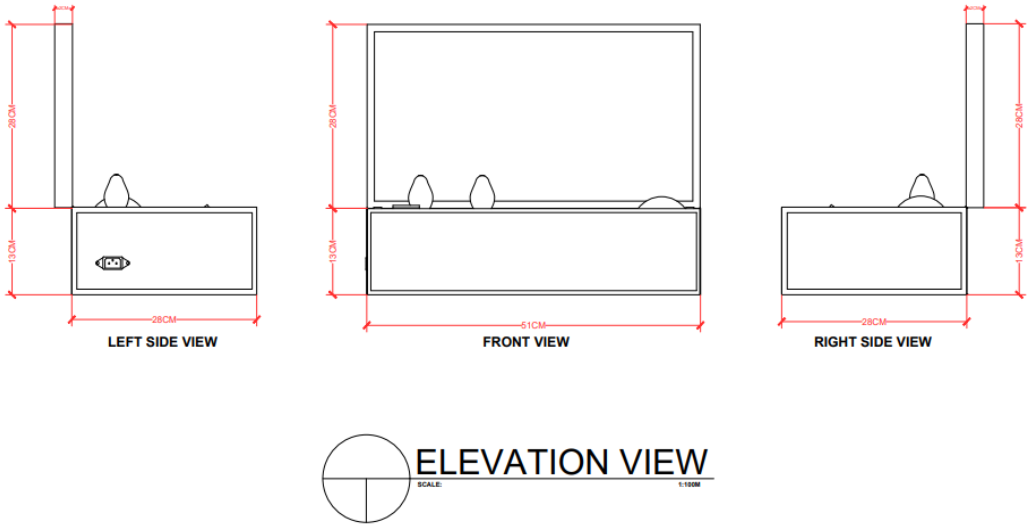

Figure 3. Elevation view of the Integrated Smart System for Electrical Installation and Maintenance: An Instructional Trainer (ISSEIM: AIT)

In designing the Integrated Smart System for Electrical Installation and Maintenance: An Instructional Trainer. I consider the size and compactness of the trainer considering its mobility and easy to use. I use 41x51x15cm microphone case for it is light and easy to transport from one place to another. Showing also the exact placement of the components of the integrated smart system for electrical installation and maintenance: an instructional trainer.

RESULTS AND DISCUSSION

This section focuses on the key observations made during the device operation, highlighting its performance and educational relevance. It examines how effectively measures the performance of the integrated smart system for electrical installation and maintenance: an instructional trainer in terms of functionality, usability, and safety. These observations provide insights into the device practical application, emphasizing its potential to enhance students' understanding of real-world electrical automation processes and smart systems controls.

Table 1. Distribution of statistics Frequency, percentage distribution, mean and standard deviation of respondents' evaluation on INTEGRATED SMART SYSTEM FOR ELECTRICAL INSTALLATION AND MAINTENANCE: AN INSTRUCTIONAL TRAINER

Description	Range	Frequency					Percentage Distribution	
Excellent	4.50-5.00	48					96.00	
Very Good	3.70-4.49	2					4.00	
Good	2.80- 3.69	0					0.00	
Moderate	1.90-2.79	0					0.00	
Low	1.00-1.89	1					0.00	
Mean 4.96 SD 0.14								
Descriptor		Score					Mean	SD
1. Functionality		5	4	3	2	1		
1.1 The developed device can be controlled through:								
a. Touch Switch		46	4	0	0	0	4.92	0.27
b. Smart Phone		48	2	0	0	0	4.96	0.19
c. Local Area Network		47	3	0	0	0	4.94	0.24
d. Cloud(accessed to the internet)		48	1	1	0	0	4.94	0.31
1.2 The developed device can….								

a. Turn on two lamps using touch switch channel one	49	1	0	0	0	4.98	0.14
b. Turn on two lamps with convenience outlet using touch switch channel two	49	1	0	0	0	4.98	0.14
c. Turn on two lamps with special purpose outlet using touch switch channel three	47	2	1	0	0	4.92	0.34
d. Turn on two lamps with convenience outlet and special purpose outlet using touch switch channel four	47	2	1	0	0	4.88	0.44
e. Trigger light using motion sensor	46	3	1	0	0	4.86	0.45
f. Turn on two lamps in 0-90 lumens	49	1	0	0	0	4.98	0.14
g. Turn off two lamps in 90-100 lumens	49	0	1	0	0	4.96	0.28
h. Save and program infrared emitters (IR) emitter found in the airconditioned unit and proceed to AC scheduling	47	3	0	0	0	4.94	0.23
i. Controlled in a TIS technology application installed in my phone through local area network.	47	1	1	0	1	4.86	0.63
j. Programmed through DevSearch software installed in my laptop	48	2	0	0	0	4.96	0.19
k. Turn the lamp on/off in different locations through the TIS technology application.	49	1	0	0	0	4.98	0.14

The table shows that the majority, ninety-nine point two (99.02%) of participants evaluated the integrated smart system for electrical installation and maintenance: an instructional trainer in terms of functionality, is excellent. The overall rating is excellent (mean=4.96). The standard deviation of 0.14 indicates that the participants of the integrated smart system for electrical installation and maintenance: an instructional trainer are similar to each other.

The score of the descriptors explains well that the mock-up is indeed excellent when it comes to its functionality. This means that low standard deviation indicates a remarkable consistency in performance and has a reliable system of works. It also describes minimal issues and errors, task are completed efficiently.

The result also implies that the instructional manual is very useful, as it helps the user simulate the different activities found in the manual. This confirms that “functional representation provides a package that shows the relationship among structure, function and behavior”(Keuneke, A. M., 1991. pp. 22-25).

Table 2: Distribution of statistics Frequency, percentage distribution, mean, and standard deviation of respondents' evaluation on INTEGRATED SMART SYSTEM FOR ELECTRICAL INSTALLATION AND MAINTENANCE: AN INSTRUCTIONAL TRAINER

Description	Range	Frequency	Percentage Distribution
Excellent	4.50-5.00	48	96.00
Very Good	3.70-4.49	2	4.00
Good	2.80- 3.69	0	0.00
Moderate	1.90-2.79	0	0.00
Low	1.00-1.89	0	0.00
Mean 4.92			
SD 0.29			

Descriptor/Evaluator Parameter	Score					Mean	SD
2. USABILITY	5	4	3	2	1		
2.1 The developed device can be used as a trainer to teach Electrical and Electronics Courses.	49	1	0	0	0	4.98	0.14
2.2 The developed device can be used in residential and commercial applications.	47	2	1	0	0	4.88	0.44
2.3 The developed device can also be used for energy saving.	46	2	2	0	0	4.86	0.45
2.4 The smart system is user-friendly.	48	2	0	0	0	4.96	0.19

2.5 The system provides clear instructions.	49	1	0	0	0	4.98	0.14
2.6 The smart system is easy to set up and configure.	46	2	1	1	0	4.86	0.53
2.7 The developed device is comparatively light and easy to transport from one place to another	46	3	1	0	0	4.9	0.36
2.8 The developed device has a full range of functionalities, providing comprehensive training without the bulk.	49	1	0	0	0	4.98	0.14
2.9 The trainer's compact design ensures it fits seamlessly into small spaces making it ideal for home and office use.	49	1	0	0	0	4.98	0.14
2.10 The lightweight and portable nature of trainer allows easy transportation and storage	44	5	1	0	0	4.86	0.40

Table 2 presents that the majority ninety-eight point four (98.4%) of participants evaluated the integrated smart system for electrical installation and maintenance: an instructional trainer in term of usability is excellent. The overall rating is excellent (mean=4.92). The standard deviation of 0.29 indicates that the participants of the integrated smart system for electrical installation and maintenance: an instructional trainer is similar to each other.

The result shows that the trainer achieved high usability, which indicates the system is user - friendly and effective. In addition having a low variability of standard deviation means usability scores are tightly clustered around the mean, indicating consistent performance. Moreover low standard deviations imply that the system is reliable.

Finally this tells that practical implications of the user is generally satisfied with the system usability. It indicates minimal room for improvements because it has a low standard deviation which means usability issues are rare and efforts should focus on refining existing features. This is an affirmation of what Okongo,R.B. et al (2015) found that learning experiences are fruitful when there are sufficient and suitable physical facilities and their absence could lead to low academic performance.

Table 3 Distribution of statistics Frequency, percentage distribution, mean and standard deviation of respondents' evaluation on INTEGRATED SMART SYSTEM FOR ELECTRICAL INSTALLATION AND MAINTENANCE: AN INSTRUCTIONAL TRAINER

Description	Range	Frequency	Percentage Distribution
Excellent	4.50-5.00	50	100.00
Very Good	3.70-4.49	0	0.00
Good	2.80- 3.69	0	0.00
Moderate	1.90-2.79	0	0.00
Low	1.00-1.89	0	0.00
Mean 4.98			
SD 0.14			

Descriptor/Evaluator Parameter	Score					Mean	SD
3. SAFETY	5	4	3	2	1		
3.1 The smart system includes adequate safety features to prevent accidents.	50	0	0	0	0	5	0
3.2 The developed device has a safety case that could make the trainer mobile and accessible to everybody	50	0	0	0	0	5	0
3.3 Users feel safe while using the smart system.	50	0	0	0	0	5	0
3.4 All wiring connections are isolated, properly installed and kept.	50	0	0	0	0	5	0
3.5 The developed device uses components within the approved standard, such as ISO and Philippine Standard.	49	1	0	0	0	4.98	0.14

Table 3 describes that ninety-nine point six percent (99.6%) of the participants evaluated the mock-up integrated smart system for electrical installation and maintenance: an instructional trainer in terms of safety, is excellent. The overall rating is excellent (mean=4.98). The standard deviation of 0.14 indicates that participants evaluated the integrated smart system for electrical installation and maintenance: an instructional trainer in terms of safety is similar to each other.

The scores of the descriptors or evaluation parameters explains welld that the mock-up is indeed excellent when it comes to safety. This promotes that the safety feature is an important factor to consider when dealing with electronic and electrical installation since electricity can kill if it is not dealt with according to standards. This also implies that the mock-up is safe to use because the connections are properly connected, insulated and isolated.The device was presented with labels of the parts. Thus, the use of the mock-up proves no serious risk to electrical related injuries.

According to Raza et al. (2017), individuals who find technology easy to use typically hold a more positive disposition towards utilizing it.

Figure 3 The overall design of the Integrated Smart System for Electrical Installation and Maintenance: An Instructional Trainer (ISSEIM: AIT)

CONCLUSION

The study concluded that the device is fully operational, meeting the required specifications based on a series of tests. The device performs well in terms of functionality, usability and safety.

This implies that the instructional trainer serves as the medium in the training and learning process of students' knowledge, skills and attitude. The instructional trainer enables the students to fully grasp, comprehend and appreciate the learning procedures that made them confident in performing integrated smart system for electrical installation and maintenance manual of activities. This was possible because they were exposed and have actual hands-on learning with the different series of exercises and activities.

In summary, the device provides a quality attribute, making it a valuable educational tool, providing teachers and students with a better understanding of electrical installation and maintenance in a smart and modern way of innovating and automation.

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