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# Smart and Safe Mock-up Design in Electrical Installation Training

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**Abstract:** This study aimed to design a smart and safe residential electrical mock-up system for Electrical Installation and Maintenance NCII training. The mockup was designed using a modular approach which would involve breaking down the system into smaller, self-contained modules that can be easily modified or replaced as needed. The smart technology includes lighting control, phone alert, controlled appliances, and motion detection while its safety features include safety switches, circuit breakers, fuses, ground fault circuit interrupters (GFCI), arc fault circuit interrupters (AFCI), and surge protectors. The design of the smart and safe mock-up system is an effective tool to enhance the skills of the students to practice, as well as safety and effectiveness of electrical installation and maintenance training. It is recommended that mock-up meets the required specifications and can be easily modified or adapted to meet changing requirements.

**Keywords:** *Electrical Installation, Mock-up Design, Training*

## 1. Introduction

The Technical Education and Skills Development Authority (TESDA) in the Philippines offers the Electrical Installation and Maintenance National Certificate II (EIM NCII). This program seeks to improve individuals' knowledge, abilities, and attitudes toward the installation, maintenance, and repair of electrical systems and equipment. Hands-on instruction in the installation, maintenance, and repair of electrical systems and equipment is included in the curriculum. The Electrical Installation and Maintenance National Certificate II (EIM NCII) curriculum of TESDA includes building wiring as one of the competences studied. The curriculum focuses on the installation of wire and related fittings, including wiring in buildings, residences, and other structures.

A smart mock-up is a virtual or physical replica of a building or space that is used for testing and validating different design and construction scenarios. Smart mock-ups can incorporate various sensors, data collection systems, and simulation tools to provide real-time feedback on building performance and functionality. The study of Elatrash et al. [1] describes the design and development of a smart mock-up for electrical installation and maintenance training, which includes the integration of smart technologies such as sensors, programmable logic controllers (PLCs), and data acquisition systems. The results showed that the smart mock-up was effective in providing a realistic and interactive learning experience for the students, as well as improving their understanding and performance of electrical installation and maintenance tasks. The study by Nguyen et al. [2] explored the use of smart mock-ups as a simulation-based design and construction tool for improving building performance. The researchers developed a prototype smart mock-up platform that incorporated various sensors and simulation tools to test and validate different design and construction scenarios in real-time. The study found that the use of smart mock-ups

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can result in significant cost and time savings, as well as improved building performance and functionality. Specifically, the researchers found that the use of smart mock-ups can reduce construction costs by up to 30%, improve energy efficiency by up to 50%, and reduce carbon emissions by up to 40%. The study conducted by Stadelmann and Holzer [3] explored the potential of using smart mock-ups to teach sustainable building design in the context of architectural education. The researchers developed a prototype of a smart mock-up system that allowed students to experiment with different design options and evaluate their environmental performance in real-time. The study involved a case study of a sustainable housing project in Switzerland, where students were tasked with designing and optimizing the building's energy performance using the smart mock-up system. The results of the study showed that the use of smart mock-ups was effective in promoting experiential learning and enhancing students' understanding of sustainable building design principles. The researchers also identified some challenges and limitations of using smart mock-ups, such as the need for technical expertise and equipment, the difficulty in simulating certain design aspects, and the potential for technology-related errors and glitches. Nonetheless, they concluded that smart mock-ups have significant potential for teaching sustainable building design and could help bridge the gap between theory and practice in architectural education.

In the context of the EIM program, smart mock-ups may be used to simulate different wiring scenarios and test the performance and functionality of electrical systems before actual installation. This study of Hernandez [4] describes the development of an electrical installation and maintenance mock-up trainer, which is a physical mock-up designed to simulate the actual electrical installation and maintenance tasks. The trainer consists of a panel board, a distribution board, and various electrical components and devices, such as switches, outlets, and circuit breakers. The study includes the design and construction process of the mock-up trainer, as well as its evaluation by experts and students. The results of the study showed that the mock-up trainer was effective in enhancing the students' knowledge and skills in electrical installation and maintenance. This study explored on mock-up design which integrates smart technology to enhance functionality and interactivity and safety features to promote safe practices in electrical installation and maintenance training.

## 2. Method

The following principle guided the design:

1. The mock-up is designed to be flexible and modular so that it can support various electrical setups and circumstances. This enables a more thorough and adaptable training experience.
2. It will simulate a real electrical system, with an emphasis on knowledge, choosing and installing wiring devices, installing lighting fixtures and switches, and notifying the completion of work on floor and wall mounted outlets and auxiliary outlets. There will also be a main distribution panel, subpanels, branch circuits, and electrical loads like lights, fans, and appliances. For the students, this results in a more practical educational experience.
3. Safety components including emergency stop buttons, safety switches, and circuit breakers should be included in the mock-up. This promotes safe practices in electrical installation and maintenance while also ensuring the safety of the trainers and trainees during the training.
4. Smart technologies including sensors, data collecting systems, and programmable logic controllers should be included in the mock-up (PLCs). This improves the mock-functionality and engagement while also giving the students real-time data and feedback.

## 3. Result

The Electromechanical Workshop of Don Bosco Technical Institute-Makati has wiring mock-up that includes a circuit breaker as shown in the figure 1. Using the conventional mockup, the trainees can practice in installing wiring devices of floor and wall mounted outlets, lighting fixtures/switches, and auxiliary outlets.

The smart and safe mockup design is shown in figure 2:


*Figure 1: Proposed Smart and Safe Mock Up*

The mockup will have lighting control, phone alert, controlled appliances, and motion detection as its smart technology features. A lighting control system is a networked lighting system that allows for centralized control and automation of lighting fixtures in a building or home. It typically includes a combination of sensors, switches, and software that enable users to adjust the lighting levels and settings according to their preferences or environmental conditions, such as time of day, occupancy, or daylight availability. With a lighting control system, users can program the lighting to automatically turn on or off, dim, or adjust color temperature based on the situation or desired ambiance. It can help to improve energy efficiency, reduce energy costs, and enhance the overall comfort and convenience of the living or working space. A phone alert in a smart house is a notification sent to a mobile phone to inform the user of an event or status change in the home automation system. This can include a wide range of alerts, such as security system notifications, motion detection alerts, temperature, or humidity alarms, and more. For example, if a smart security system detects a break-in or a suspicious activity in the house, it can send an alert to the homeowner's phone to notify them of the situation. Similarly, if a smoke detector senses smoke or fire in the house, it can send an alert to the homeowner's phone to warn them of the potential danger. Phone alerts in smart homes allow users to monitor and control their home automation systems remotely and stay informed about any changes or events happening in their homes in real-time, even when they are away from home. Controlled appliances in a smart house are electrical devices that can be remotely controlled and automated using a home automation system. These can include a wide range of appliances such as lights, thermostats, locks, cameras, home entertainment systems, and more. By integrating smart devices with a home automation system, users can control and monitor their appliances remotely using their smartphones, tablets, or voice assistants. For example, a user can turn on/off the lights or adjust the temperature of their home while they are away using a mobile app or a voice command. In addition, smart home automation systems can be programmed to automate tasks based on specific events or conditions. For instance, a user can set up a rule that automatically turns off the lights and locks the doors when they leave the house or turns on the lights and plays music when they arrive home. Controlled appliances in a smart house offer users convenience, security, and energy efficiency, making their homes more comfortable and sustainable. Motion detection in a smart house is a feature that allows for the detection of movement within a specific area or room of the house using sensors or cameras. These sensors or cameras can be integrated into a home automation system, which can trigger certain actions based on the detected motion. For example, motion detection can be used for security purposes, such as triggering an alarm or sending an alert to the homeowner's phone when someone enters a room or moves within a certain area. It can also be used to automate other tasks, such as turning on lights when someone enters a

room or adjusting the thermostat when someone leaves a room. Motion detection in a smart house is a useful feature for enhancing security, convenience, and energy efficiency. It provides homeowners with a more sophisticated way of monitoring and controlling their homes and can help to create a safer and more comfortable living environment. Safety components including emergency stop buttons, safety switches, and circuit breakers should be included in the mock-up.

## 4. Discussion

Designing a mock-up system that simulates the Electrical Installation and Maintenance NCII of TESDA requires careful planning, appropriate component selection, safety measures, testing and validation, instructional materials development, and instructor training. The design mock-up shall cover the three (3) core competencies of Electrical Installation and Maintenance NCII. A mock-up shall be designed using a modular approach which would involve breaking down the system into smaller, self-contained modules that can be easily modified or replaced as needed. Each module would have a specific function, such as power supply, circuit protection, or connectivity. The modules would be designed to be easily integrated with each other using standard connectors or mounting options. The choice of modular components would be critical in creating a flexible mock-up. Modular components would need to be easily replaced or modified to adapt to changing requirements. This would include using modular power supplies, modular circuit breakers, and modular connectors. Flexible wiring would also be essential for creating a flexible mock-up. This would include using wire harnesses with quick-release connectors, flexible conduit, and flexible cable trays. This would allow for easy modification and replacement of wiring as needed. The mock-up would also need to be designed with testing and validation in mind. Each module would need to be designed and tested independently, as well as tested as a whole system. This would ensure that the mock-up meets the required specifications and can be easily modified or adapted to meet changing requirements.

Safety components should be selected to address the identified hazards. This includes safety switches, circuit breakers, fuses, ground fault circuit interrupters (GFCI), arc fault circuit interrupters (AFCI), and surge protectors. The safety components should be incorporated into the mock-up design. This includes installing safety switches, circuit breakers, and other safety devices to ensure that the electrical system is safe to operate. The safety components should be tested to ensure that they are functioning properly. This includes testing GFCI and AFCI devices to ensure that they trip when a fault occurs. The study of Liu, Li and Wang [5] discusses the use of safety components such as GFCI, AFCI, and surge protectors in low-voltage distribution systems. The study found that the use of these safety components can significantly reduce the risk of electrical shock, electrocution, and fire. The study also highlights the importance of regular maintenance and testing of these safety components to ensure their proper functioning.

Smart technology can enhance the safety of a home by providing alerts and notifications for potential hazards such as smoke, carbon monoxide, and water leaks. Smart security systems can also provide increased protection against break-ins and burglaries. Integrating smart technology into a residential wiring mock-up can future-proof the home for upcoming technological advancements and developments, ensuring that the home remains up-to-date and relevant for years to come. This study provides a review of the integration of smart homes and the Internet of Things (IoT) for energy optimization. The study discusses the potential benefits of integrating smart technology into residential homes, including energy efficiency, increased comfort, and improved safety.

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