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Smart System for Differently-Abled Persons Applying Internet of Things (IoT)

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Abstract

This study investigates the potential of Internet of Things (IoT) to enhance daily life through the seamless connection of smart devices, with a primary focus on improving convenience and efficiency. It adopts an innovative approach that combines both descriptive and developmental methods to design a specialized system catering to the needs of differently-abled individuals. The research adheres to the Prototyping Model and culminates in the creation of an assistive device aimed at empowering differently-abled individuals to manage household appliances and room lighting. Various research techniques, such as interviews and surveys, are employed to enhance accessibility and control for this marginalized group, ultimately leading to an enhancement in their quality of life. The system leverages the ESP8266 microcontroller board, programmed through the Arduino IDE, to activate a four-channel relay module via the Blynk IoT mobile app, automation, or voice commands through Google Assistant. It operates seamlessly both online and offline, enabling users to control devices even without an internet connection. To sum up, this smart system offers a practical and user-friendly solution that significantly improves the lives of differently-abled individuals by addressing their distinct requirements and enhancing their control over household appliances and lighting.

Keywords: blynk, differently-abled persons, home automation, Internet of Things, smart system

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INTRODUCTION

Technology has been quickly growing, making a substantial number of changes globally. It has kept its phase of advancement and groundbreaking changes. The impossible before is now a realistic option for potential variations. It has resolved numerous problems faced by people in their everyday living, but it is still in search for solutions not just for the problem of today but also for the future. Be it in industry, security, tracking, and many others, technology has responded to major and minor challenges in all these branches.

Everyone agrees that one big contribution of technology is the Internet. It has a tremendous impact in people's daily lives. Internet dominates almost all things and events around the globe, be it in home, school, and global economy. It is one of the powerful creations that provides people infinite knowledge and entertainment. Nowadays, Internet plays a vital role in many areas such as in (a) connectivity, communication, and file sharing through the use of electronic mail, and online video call applications; (b) information, knowledge, learning, and entertainment by utilizing search engines, and free video sharing websites; (c) address, mapping, and contact information via Global Positioning System (GPS) technology; (d) selling, and making money by promoting business online, and doing other online services; (e) banking, bills, and shopping by accessing bank account online, and paying bills without going to official store or establishment;

and most especially in the field of (f) Internet of Things (IoT) where people can control their appliances at home remotely via smartphone or personal computer.

The IoT builds a world where all smart objects around the community are linked to the Internet and communicate with each other with least human being intervention (Atlam, et.al., 2018). Its fundamental goal is to create a better world for humans, where objects around the public know what they want, what they like, what they need, and act appropriately without explicit commands.

Nowadays, many researchers deal with smart systems at home. Home automation technology is continuously increasing and improving, making it easier for differently-abled people to live more comfortable lives in their homes by meeting their unique needs. Because of these projects, people can remotely control their appliances through the use of technology in the four corners of their homes, specifically with the help of mobile technology like tablets and smartphones. Hence, homeowners are elated, especially those differently-abled individuals who are not concerned anymore with their safety and security because of these modern technologies which help to assist them daily. They also hope that all problems and other unthinkable tasks at home can be solved and done as time passes by.

In the Philippines, there are millions of differently-abled persons. Some of these people are experiencing locomotor disability and even partial blindness. Due to their current situation, they are left behind in their houses because they cannot land a job, and as a result, one of their major problems while at home is their ability to control appliances or devices without struggling. The lack of family members to help, absence of assistive device, lack of physical strength, and the location of the switches to control are some of the problems being encountered by the differently-abled persons in controlling their home devices. This is where IoT takes place. The IoT is one of the solutions for the challenges that differently-abled individuals are facing. With the assistance of IoT, using of voice commands is viable, controlling of appliances remotely is feasible, in short, everything is possible. Furthermore, people away from their household can manage their home devices remotely with IoT, wherein the convenience factor to differently-abled persons or homeowners is immeasurable. Through smart systems, families can maximize their home security, improve appliance functionality, increased energy efficiency, and essentially, it saves valuable time, money, and effort.

With all the problems being encountered by the differently-abled persons, the researcher decided to develop a Smart System for Differently-Abled Person Applying Internet-of-Things (IoT). The system can be controlled via voice commands using Google Assistant, or through the Blynk IoT mobile application with the help of Wi-Fi connection. The automation feature of the Blynk IoT platform to control the home devices using the data gathered from the sensors was also incorporated in the study. People can also monitor the temperature, humidity, and the amount of light present inside their room. A support or additional features of the system were the controlling of home devices using an IR remote and manually via push buttons if there is no internet connectivity. This system will be a big help not only to those differently-abled persons but for homeowners, as well.

Objectives of the Study. The general objective of the study is to develop a smart system for differently-abled persons applying the Internet of Things (IoT). The study's primary objective is to address the subsequent research inquiries:

1. To determine the problems encountered by differently-abled persons in controlling their home appliances and room lights.

2. To identify the stages in the development of the Smart System for Differently-Abled Persons Applying the Internet of Things (IoT) using a Prototyping Model of the Software Development Life Cycle.

3. To determine the effectiveness of the Smart System for Differently-Abled Persons Applying Internet of Things (IoT) in terms of monitoring the:
   3.1. Room temperature;
   3.2. Room humidity; and,
   3.3. Presence of light inside the room.

4. To evaluate the level of acceptability of the Smart System for Differently-Abled Persons Applying Internet of Things (IoT) based on ISO 25010 in terms of:
   4.1. Functional suitability;
   4.2. Usability;
   4.3. Reliability; and,
   4.4. Portability.

5. To propose an implementation plan in the adaptation of the Smart System for Differently-Abled Persons Applying the Internet of Things (IoT).

METHODOLOGY

The researcher made use of the Descriptive and Developmental Methods of research for the purpose of realizing the goals of the study. The descriptive method was used to find the information needed for the specifications of the system and prototype. It was used to examine the functionality and reliability of the device. This was also used to analyze and interpret the data gathered from the respondents.

On the other hand, the developmental method is a systematic way of designing, developing, and operating the device to achieve the objectives of the study. This was used in developing the prototype that would improve the manual process of controlling home appliances and lights and would provide solutions to the problem of the differently-abled individuals.

The inputs of the study which served as the sources of data and skills as guides in the construction of the project were the knowledge requirements gathered from the internet, manuscripts, journals, and other helpful materials. The software requirements that were utilized in making the research are the Blynk IoT Cloud online platform, Blynk IoT mobile application, Arduino IDE, If This Then That (IFTTT) online automation tool, and the Google Assistant mobile application, and the hardware requirements were the laptop, ESP8266 microcontroller board, IR remote, sensors, four-channel relay module, and other identified hardware components. These requirements contributed to the design and creation of the prototype.

The Prototyping Model of the Software Development Life Cycle, as shown in Figure 1 below (Martin, 2019), was used as the throughput of the study. The first process was the Requirements Gathering and Analysis Phase. In this stage, the researcher defined the problem, conducted an initial investigation, and made some research about the problem and how to go about it. He also recorded all the valuable information related to the study. The second stage was the Quick Design Phase where the researcher reviewed all the gathered data, defined the requirements for the prototype, created the flow chart and diagrams for the study, and developed the preliminary design of the prototype. The Build the Initial Prototype Phase was the third step in the prototyping model. During this phase, the researcher finalized the source code, uploaded it to the ESP8266 board using the Arduino IDE, and soldered the materials into the printed circuit board (PCB). The researcher also connected all the components together based on the designed wiring diagram, created the user interfaces formulated the events for the automation feature on the Blynk IoT mobile application, and configured the IFTTT online automation tool for the voice commands via Google Assistant mobile application. After that, the features of the system were tested. The fourth process was the User Evaluation of the Prototype Phase. During this period, the expected users have tested and evaluated the prototype. The researcher also collected the feedback and tabulated the data gathered from the questionnaire. The next stage is the Refining Prototype Phase wherein the researcher has reviewed the evaluation of the users and has modified the prototype based on the recommendations and suggestions of the

users. The Implement Product and Maintain was the last process of the model. During this stage, the researcher started the development of the final system since all the requirements specified by the users were met. Then the output, the Smart System for Differently-Abled Persons Applying Internet of Things (IoT), has been presented to the end users for final evaluation. The feedback of the end users was used for further improvement of the system.

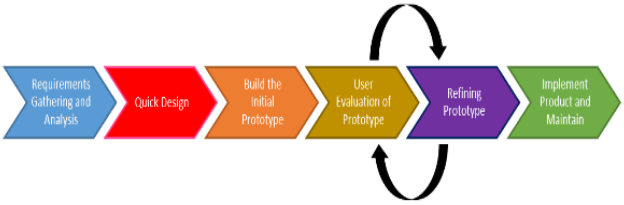

Figure 1
Prototyping Model Phases

RESULTS AND DISCUSSION

The researcher's data collection process involved the use of a questionnaire tailored to the specific requirements of the study. After gathering the necessary information, the data was meticulously organized and analyzed.

Table 1 shows the frequency distribution of the respondents according to the problems encountered by the differently-abled persons in controlling their home appliances and room lights. It can be observed that out of four problems listed the top 2 problems encountered by the respondents are lack of physical strength and absence of assistive device which garnered seventeen (17) votes or 34% and sixteen (16) votes or 32%, respectively.

Table 1
Frequency Distribution of Respondents according to the Problems Encountered by Differently-Abled Persons in Controlling Home Appliances and Room Lights

Problems Encountered	Frequency	Percentage
Lack of family members to help	7	14%
Absence of assistive device	16	32%
Lack of physical strength	17	34%
The switches to control are too far	10	20%
Total	**50**	**100%**

Based on the related literature obtained by the researcher, the problems faced by differently-abled people, especially those with a locomotor disability can be solved by employing IoT. Assistive devices such as smartphones or tablets can be used by differently-abled persons to control their home devices be it through an app or via voice commands. Thus, smart systems through IoT are currently being considered a significant way to care for differently-abled persons and ensure they can stay inside their homes at ease.

The evaluation results for the effectiveness of the Smart System for Differently Abled Persons Applying Internet of Things (IoT) in terms of monitoring room temperature, room humidity and presence of light inside the room as perceived by the two groups of respondents is shown in Table 2. The weighted mean, composite mean, and verbal interpretations are presented below.

Table 2
Effectiveness of the Smart System for Differently-Abled Persons Applying Internet of Things (IoT) in Terms of Monitoring Room Temperature, Room Humidity and Presence of Light inside the Room

Aspects	Differently Abled Persons		IT Experts		Overall	
	WM	VI	WM	VI	CM	VI
Room Temperature	4.76	Excellent	4.8	Excellent	4.77	Excellent
Room Humidity	4.68	Excellent	4.6	Excellent	4.67	Excellent
Presence of Light inside the Room	4.84	Excellent	5.0	Excellent	4.87	Excellent

Legend: WM – Weighted Mean; VI – Verbal Interpretation; CM – Composite Mean

The computed composite means for the effectiveness of the Smart System for Differently Abled Persons Applying the Internet of Things (IoT) in monitoring room temperature, room humidity and presence of light inside the room is 4.77, 4.67, and 4.87, respectively. This indicates that the respondents perceived the system as Excellent in monitoring the above-mentioned aspects.

Table 3

Evaluation of the Respondents for the Level of Acceptability of the Smart System for Differently-Abled Persons Applying Internet of Things (IoT) based on Applicable Characteristics under the Product Quality Model defined in ISO 25010

Criteria	Differently Abled Persons		IT Experts		Overall	
	WM	VI	WM	VI	CM	VI
Functionality Suitability	4.57	HA	4.87	HA	4.62	HA
Usability	4.59	HA	4.87	HA	4.63	HA
Reliability	4.6	HA	4.87	HA	4.65	HA
Portability	4.47	HA	4.87	HA	4.53	HA
OVERALL MEAN	4.56	HA	4.87	HA	4.61	HA

Legend: WM – Weighted Mean; VI – Verbal Interpretation; CM – Composite Mean; HA – Highly Acceptable

KNOWLEDGE AREAS	INITIATING	PLANNING	EXECUTING	MONITORING AND CONTROLLING	CLOSING
Project Integration Management	-Develop project charter	-Develop project management plan	-Direct and manage project work -Manage project knowledge	-Monitor and control project work -Perform integrated change control	-Close project or phase
Project Scope Management		-Plan scope management -Collect requirements -Define scope -Create work breakdown structure		-Validate scope -Control scope	
Project Schedule Management		-Plan schedule -Define activities -Sequence activities -Estimate activity durations -Develop schedule		-Control schedule	
Project Cost Management		-Plan cost management -Estimate costs -Determine budget		-Control costs	
Project Quality Management		-Plan quality management	-Manage quality	-Control quality	
Project Resource Management		-Plan resource management -Estimate activity resources	-Acquire resources -Develop team -Manage team	-Control resources	
Project Communications Management		-Plan communications management	-Manage communications	-Monitor communications	
Project Risk Management		-Plan risk management -Identify risks -Perform qualitative risk analysis -Perform quantitative risk analysis -Plan risk responses	-Implement risk responses	-Monitor risks	
Project Procurement Management		-Plan procurement management	-Conduct procurements	-Control procurements	
Project Stakeholder Management	-Identify stakeholders	-Plan stakeholder engagement	-Manage stakeholder engagement	-Monitor stakeholder engagement	

Figure 2

Project Management Process Groups

Source: https://business.adobe.com/blog/basics/life-cycle

The tabulated data, aiming to determine the composite means and overall mean of the relevant characteristics under the product quality model defined in ISO 25010, is illustrated in Table 3 on the previous page. Analysis of the table indicates that the respondents, comprising differently-abled persons and IT experts, exhibit an overall weighted mean of 4.56 and 4.87, respectively. These scores correspond to a verbal interpretation of Highly Acceptable, indicating a positive reception of the product's quality among the respective respondent groups.

Overall, the feedback from the respondents regarding the system resulted in a general weighted mean of 4.61, which was verbally interpreted as being Highly Acceptable. It is worth highlighting that both groups of respondents perceived all four relevant characteristics as highly acceptable. This clearly indicates that the researcher developed a meticulously designed system with exceptional quality that effectively caters to the requirements and expectations of its users.

Additionally, the researcher formulated an implementation plan that considered the five project management process groups delineated in the Project Management Book of Knowledge (PMBOK). These process groups encompass the initiating phase, planning phase, executing phase, monitoring and controlling phase, and closing phase. Each of these project management process groups consists of a series of interconnected processes that are essential for the successful completion of a project. Figure 2 provides an overview of the project management process groups and the corresponding knowledge areas of project management that will serve as the researcher's framework for implementing the project ("Project Life Cycle: A Guide to What it is and the 5 Life Cycle Stages," 2022). To manage properly the five groups, the knowledge areas are vital to be utilized.

In the initiating stage, the project manager will discuss with the project team the value of the Smart System for Differently-Abled Persons Applying Internet of Things (IoT) project, if the project is feasible, and the impact of the project on its identified users or stakeholders. Also, a business case will be created which includes the estimated costs and benefits of the project. Furthermore, a project charter, as shown in Fig. 11, will be drafted which discusses the scope, objectives, resources needed, milestones plan

and timeline, and many more. Everybody involved will be able to talk about their concerns and suggestions which is important in achieving the goal of the project.

PROJECT CHARTER	
Project Manager	Researcher
Project Sponsor	Homeowner/ Stakeholder
Project Resources	The team is composed of the Project Manager, Quality Controller, Electrician, and Purchasing Officer.
Project Objectives and Scope	The objective of this project is to install the Smart System for Differently Abled Persons Applying Internet of Things (IoT) in the bedroom of the intended users. The main aim of this project is to make the users feel comfortable in controlling the home devices inside their bedroom with the use of Blynk IoT mobile application and its automation feature and via voice commands using the Google Assistant mobile application through the help of Internet connectivity. Additionally, if the Internet connectivity is down, the users can use the IR remote and push buttons to control their home devices.

Project Milestones	Responsible Person	Timeline	Status	Target Completion Date	Date Started	Date Completed
Create and submit project inception report	Project Team	7 days				
Site/room inspection	Project Team	1 day				
Design the wiring diagram	Researcher and Electrician	1 day				
Identify and buy the needed materials	Researcher and Purchasing Officer	2-4 days				
Prepare the room for installation	Project Team	1 day				
Install the device	Researcher and Electrician	5 days				
Configure the device	Researcher and Quality Controller	2 days				
Test the device	Researcher, Quality Controller and Homeowner	1 day				
Maintain the device	Project Team	365 days				

FIGURE 3
Project Charter of the Smart System for Differently-Abled Persons Applying Internet of Things (IoT)

During the planning phase, the subsequent step in the project's progression, the focus shifts towards the development of a project schedule, which serves to proficiently manage various critical aspects, including time, costs, quality, changes, and other pertinent project-related factors. In this phase, the project manager assumes a central role and is tasked with overseeing resource management, while also defining the specific roles and responsibilities of each team member. Essentially, the project manager conducts a comprehensive evaluation of the project's time frame, budgetary requirements, and available resources, ensuring that these elements are meticulously aligned with the project's overarching objectives and goals. One valuable tool in planning the project's scope is the Work Breakdown Structure (WBS). This tool aids in organizing tasks, and procurement plans, and establishing communication channels and their frequency. Shown in Figure 4 is a sample wiring diagram for the installation of the Smart System for Differently-Abled Persons Applying the Internet of Things (IoT) inside a room.

The executing phase is typically the most extensive of the five stages. It involves the actual construction of the product and the implementation of the project plan. Effective communication between project teams and stakeholders is crucial during this phase. This stage is closely linked to the subsequent phase, which is monitoring and controlling. During this phase, the project manager is responsible for overseeing progress to ensure that everything remains on schedule and within budget. Continuous measurement of metrics is also performed to ensure that project milestones are being met.

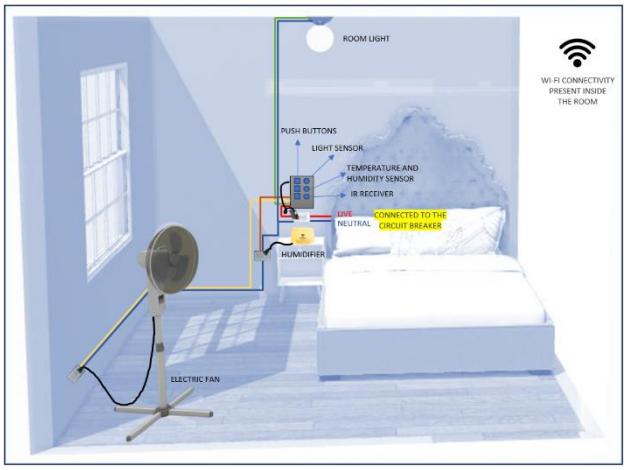

FIGURE 4
Sample Wiring Diagram for the Installation of the Smart System for Differently-Abled Persons Applying Internet of Things (IoT)

The final stage is the closing phase, where all activities are concluded, and the project is formally closed. Obtaining approval from users or stakeholders is a critical step in closing the project.

CONCLUSION AND RECOMMENDATIONS

The findings derived from the questionnaire responses of differently-abled individuals shed light on their primary challenges when it comes to managing home devices: a lack of physical strength and the absence of assistive devices. In response to these challenges, the Smart System for Differently-Abled Persons Applying Internet of Things (IoT) was meticulously developed, using the Prototyping model of the Software Development Life Cycle as a robust

framework. This innovative system promises to bring a new level of convenience and comfort to its users, significantly improving their ability to control home devices and offering them invaluable benefits.

A key element of the system's success lies in the effectiveness of its temperature and humidity sensor, as well as its light sensor. These components have proven highly capable of monitoring environmental conditions within a room, as attested by the feedback received from two distinct groups of respondents.

The evaluation of the Smart System for Differently-Abled Persons Applying Internet of Things (IoT) was conducted with rigor, involving differently-abled individuals and IT experts. Their unanimous consensus underscores the device's high acceptability in terms of functional suitability, usability, reliability, and portability, as measured through a structured questionnaire designed for this purpose.

The researcher's proposed implementation plan for adopting the Smart System for Differently Abled-Persons Applying the Internet of Things emerged as a valuable tool in bringing this system to life and making a positive impact on the lives of differently-abled individuals.

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