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Sensor Learning Application for Precision Agriculture

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Abstract: This paper presents a Sensor Learning Application for Precision Agriculture that will assist students in getting live data (from the temperature, soil moisture, and humidity sensors) for efficient environment monitoring, which will enable them to increase their understanding of the purpose of learning. The Sensor Learning Application for Precision Agriculture is proposed, where the three sensor kits have been developed as a teaching tool to help students gain the optimum knowledge for real-world application. The agriculture site was developed to describe the real situation to students with the aim for students to experience the use of sensors for real application and to ensure students do not learn only theoretically; they can be exposed to the real environment to collect the data. Sensor Learning Application is hybridized with different sensors, which are the Sun Heat Sensor Detector, Soil Moisture Sensor Kit, and Sensor Monitoring Devices integrated with a Wi-Fi module using ESP32 that will yield a live data feed using Blynk software. This project supports the Sustainable Development Goals (SDG) that successfully increase the quality of education, provide the sensor trainer kit, and indirectly achieve sustainable energy, economic growth, and social sustainability at the agriculture project site.

Keywords: Sensor, agriculture, teaching tool

1. Introduction

The Sustainable Development Goals (SDG) have been a goal for the green revolution and it contains 17 SDGs. These objectives, which cover societal, economic, and environmental aspects, are interconnected (Laumann et al., 2022; Huang et al., 2021). Complex interlinkages, key objectives, and nexuses among the Sustainable Development Goals and climate change. This project is related to SDG-4 (quality education). The goal of SDG 4 (Four) is to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, with an emphasis on education. "A plan of action for people, planet, and prosperity" is what the 2030 Agenda for Sustainable Development is all about. To achieve SDG-4, students need to have three learning objectives, namely cognitive, socio-emotional, and behavioural. Through this project, students can achieve cognitive learning outcomes by learning the functions and uses of sensors in agriculture, which can help students understand the important role of education and lifelong learning opportunities through formal (classroom) and informal (real-world application) learning. In addition, socio-emotional learning outcomes can be achieved when students recognise the importance of their own skills to improve their lives, especially for employment and entrepreneurship. This project is learning in real-world application (Cimino et al., 2023), where students use the skills of using sensors to ensure that the crops on the agriculture site are growing well, and indirectly, the plants can be harvested and students can sell them to generate income. Students can achieve behavioural learning (Trigwell et al., 2013) outcomes when they can use all opportunities for lifelong education, where they can use the skills, they must cultivate their own crops after graduation and use the knowledge gained while studying to promote sustainable development.

In order to make SDG-4 a success, the researcher would like to disseminate a study regarding the development of three sensor kits (the Sun Heat Sensor Detector, Soil Moisture Sensor Kit, and Sensor Monitoring Devices), which were tested in the agricultural sector. Agricultural sites are developed to ensure that teaching and learning in real-world applications can be carried out well. These three sensor kits were developed to help the Industrial Electronics course, where students have to learn the topic of sensors and carry out practicals based on it. The problem faced by students is fully understanding the function and operation of the sensor, because the function of the sensor is poorly understood by only learning theory. Based on the Industrial Electronic syllabus, students need to achieve course learning outcomes

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(CLO) that involve sensors, that is, for CLO 1, students need to explain the function of operational sensors; for CLO 2, students need to be able to display types of sensors according to the operational principle, where they need to do a practical task to test the sensor. As for CLO3, students need to comply with the sensor in various circuits. It becomes a problem for the students because the experiments that are conducted involve simulation and the development of simple circuits that have limited data based on the buzzer's output only (there is no accurate data). In addition to observing students' CLO achievements, a questionnaire was also conducted on respondents who took the Industrial Electronics course code. The questionnaire was made to improve teaching and learning and to understand the learning methods expected by students. Through the questionnaire, 84.5% stated that the most difficult topic was the sensory topic; 87.9% chose learning through real-world application; 74.1% stated that learning in theory alone is not enough to help students understand; and 75.9% think that learning through real-world application is more effective and emotional control is better, providing a more optimal understanding by adding hands-on skills and more effective and interactive learning.

This project aims to ensure that students do not only learn theoretically in class; they also need to be exposed to the real environment to test and understand the function of sensors and get accurate data. Blynk is an IoT platform for iOS or Android smartphones that is used to control Arduino, Raspberry Pi and NodeMCU via the Internet (Polymeni et al., 2022). In addition, this project also aims to ensure that students can understand the function of the sensor and obtain data from it. This agricultural project is developed and sustained to ensure that the teaching and learning process can be carried out every semester. Because of this, researchers have developed an agricultural site and the chronology project site, starting by detecting the hot temperature from the sun and then sending a signal for the watering process, as well as measuring the soil moisture level and also ensuring that the plants grow well. Students can record readings from the sensors involved, such as the soil moisture sensor, temperature sensor, humidity sensor, and pH sensor. Learning becomes more interactive with the presence of different sensors and Wi-Fi modules that will produce a live data feed using Internet of Things (IoT) software where students can record sensor readings in a database and also control crop systems remotely (Chatterjee et al., 2023). Therefore, the objective of this study is to develop teaching and learning tools (three sensor kits) that are used at agricultural project sites, complete with added value that uses Blynk as a control and monitoring system.

2. Methodology

The entire study is divided into two parts: 1) the development of an agricultural project site to ensure that students experience the real environment; 2) the development of three sensor kits (the sun heat sensor detector, soil moisture sensor kit, and sensor monitoring devices), which will be a teaching tool for students to understand the function of each sensor and get accurate data readings. The development of research based on scientific engineering method studies is very easy to identify the problem and make testable explanations and predictions of the data collected (Pandey & Pandey, 2021; Park et al., 2020; Liyang et al., 2018). This study starts with observations, experiments, and ends with data collection. Therefore, this study was applied to the concept of scientific engineering in the development of teaching tool devices in agriculture application.

2.1 The Development of Agricultural Project Site

The agricultural project site was developed on an area of 36 feet by 36 feet. A total of 120 polybags are used as plant medium. Sustainable agriculture aims to improve the health of the green environment (Yurui et al., 2021), increase economic growth (Montagnini & Metzel, 2017), and promote social (Barrios et al., 2020) and transform agriculture to build locally relevant food systems that strengthen the economic (Wezel et al., 2020). In this study, agriculture crops such as cucumber in 2021 and corn in 2022 were used. As a test of the soil moisture sensor, several parameters have been used, such as different types of soil (cocopeat, black soil, red soil, husk), water flow rate according to the suitability of soil moisture, and the difference between plants in the greenhouse that receive different amounts of sunlight. The difference in sunlight can also be measured by using a temperature sensor. In addition, researchers have developed a piping system that is used to flow water to plants (Bouma et al., 1997). Pipes are used to connect the water pump and an irrigation controller from the tank to the garden. A dripper is used along with 16mm pipe for each polybag. The main tank, with a water capacity of 600 gallons, is mixed with organic fertilizers. The pH value of the water in the tank will be measured by a pH sensor, and the water level in the tank will also be measured using an ultrasonic sensor (Song et al., 2023). Water will flow from the main pipe according to the time that has been set in real time, or the user can control the water flow using the Blynk IoT application. Blynk IoT platform offers a full suite of software that shows prototype, deploy, and remotely manage connected electronic devices at any scale (Murdan & Ramphul, 2023; Karanjkar & Kumawat, 2022). Design of a smart baby cradle using Blynk and local customer priorities. In this study Blynk IoT showed commands to turn on the pump and open the valve if the temperature is too high and the soil moisture is reduced.

2.2 The Development of Teaching Tools

To develop an effective and interactive teaching tool for students to use, researchers have prepared three sensor kits, which are the Sun Heat Sensor Detector, Soil Moisture Sensor Kit, and Sensor Monitoring Devices. This three-sensor kit has a clear connection where the Sun Heat Detector will detect hot temperatures and compare the growth of plants exposed to direct sunlight and sheltered plants. Next, when the temperature data is received, the soil moisture kit will instruct the valve to flow water to the plant field, and the soil moisture will be recorded. The recorded soil moisture will be compared to the soil moisture of the plant in the greenhouse. The Greenhouse Monitoring Device also works to test humidity and temperature sensors.

2.2.1 The Sun Heat Sensor Detector

Fig. 1 shows the flow chart of Sun Heat Sensor Detector used to determine the temperature from the sunlight. This is because the collected data from the kit will be used to analyze the effect of heat on crops. It uses the ESP32 as the microcontroller to transfer the collected data. A DS18B20 waterproof temperature sensor has been chosen to be used in its circuit.

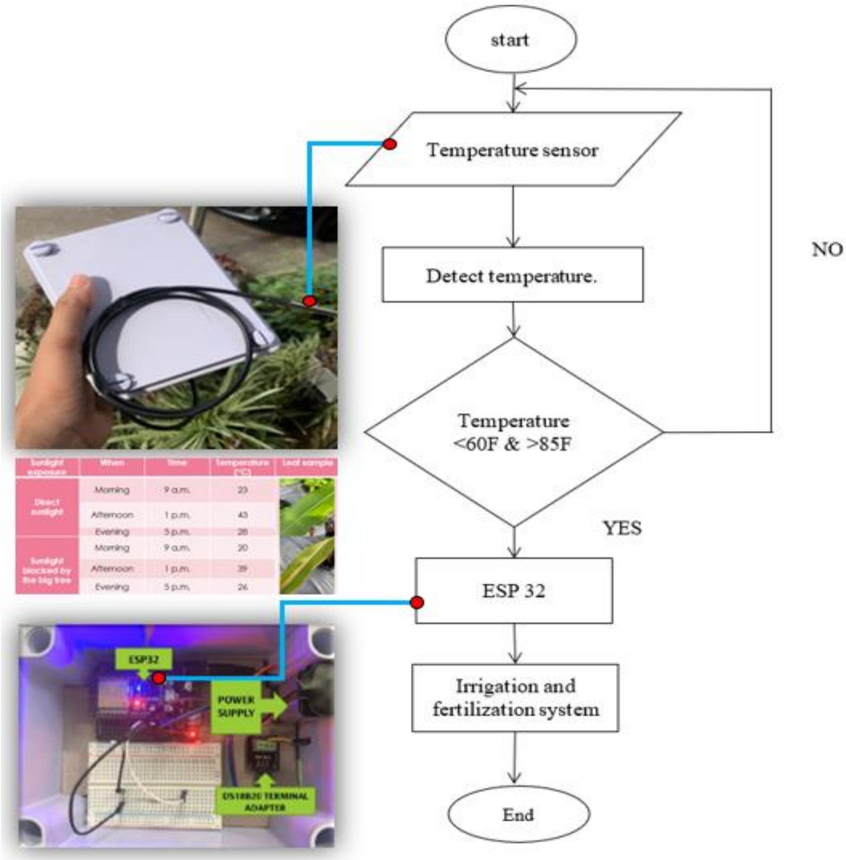

Fig. 1: The sun heat sensor detector

The product uses a "155mm x 115mm x 80mm" PVC enclosure box to keep all the electronic components. On the side of the box, it has a DS18B20 temperature sensor that is used to measure the environment's temperature. The sensor has a usable temperature range of -55 to 125 °C (-67 °F to +257 °F). Aside from that, the ESP32 microcontroller was used in this product. ESP32 can perform as a complete standalone system or as a slave device to a host MCU, reducing communication stack overhead on the main application processor. ESP32 can interface with other systems to provide Wi-Fi and Bluetooth functionality through its SPI and SDIO interfaces. This product is powered by a 9-volt battery, which is an electric battery that supplies a nominal voltage of 9 volts. Actual voltage measures 7.2 to 9.6 volts, depending on the battery.

2.2.2 Soil Moisture Sensor Kit

Fig. 2 shows the flow chart of Soil Moisture Sensor Kit that operates by receiving a signal from the temperature sensor, activating the solenoid valve to open and allow water to flow. If the ambient temperature is above 30 degrees Celsius, then the signal will be sent to the solenoid valve, and it will water the seedlings twice a day. If the normal temperature is around 20 to 30 degrees Celsius, then the solenoid valve will be active only once a day, and once a week, the mixture of fertilizer and water mixed in the mixture tank will be connected to the pipe and then to the plant to fertilize the tree.

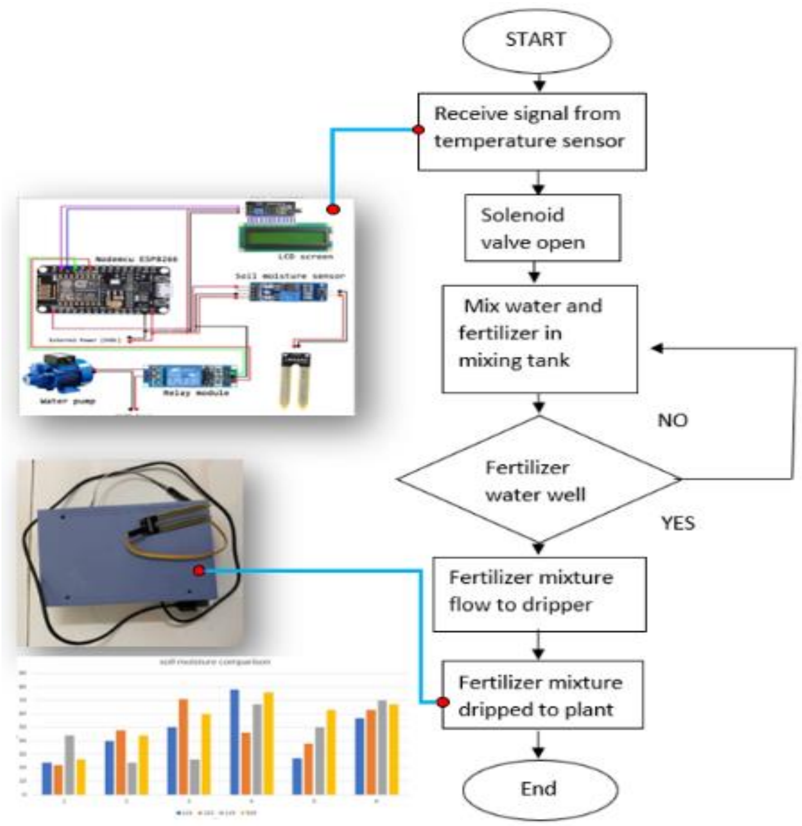

Fig. 2: The soil moisture sensor kit

2.2.3 Sensor Monitoring Devices

Fig. 3 shows the flow chart of Sensor Monitoring Devices equipped with soil moisture sensor and a DHT11 sensor. A data cable is used to transfer data and power up the product. A power jack allows a 7–12 VDC power adapter to be powered. This product is powered by plugging into the DC power jack. The voltage requirement is 7–12 VDC because the Arduino Node MCU ESP8266 has a voltage regulator that converts to 3.3 V, and it takes less than 20 seconds to connect to the Blynk 2.0 via Wi-fi.

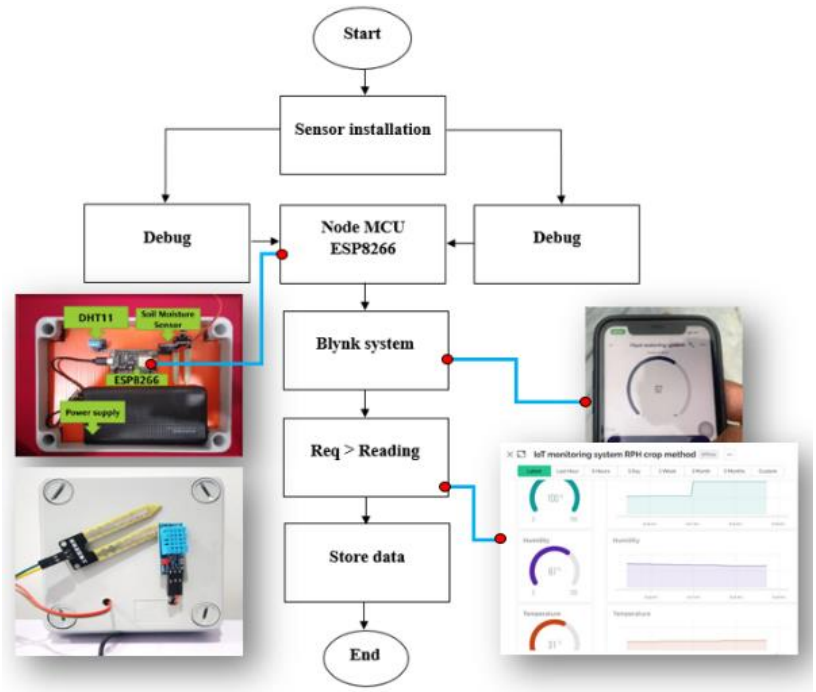

Fig. 3: Sensor monitoring devices

3. Results and Discussion

This three-sensor kit has been successfully used as a teaching tool for the Industrial Electronics subject. In addition, it can have an impact on other subjects such as electronic systems, electrical technology, digital systems, and embedded system application. This impact is beneficial for students as they master hands-on skills (Gunther et al., 2018). The effectiveness of these teaching tools is measured by using an evaluation indicator from the Kirkpatrick model on the students' reactions, knowledge, skills, and attitudes. This feedback helps Department Heads, Mechatronics Programme Heads, Course Coordinators, and Course Lecturers evaluate the effectiveness of this method (learning in real-world application) and determine a comprehensive plan to improve the teaching and learning process (Chen, 2023; Nižetić et al., 2020). Table 1 shows the feedback on the effectiveness of the research from 61 students who took the Industrial Electronics course, consisting of 70.5% male respondents and 29.5% female respondents.

Table 1 explains the development of sensor kits and real-world application learning have improved students' performance in four areas: reaction, knowledge, skills, and attitude. Through Table 1, it clearly shows 82% of the effectiveness of the lecturer's delivery using the right teaching tools in the appropriate period of time. In addition, 80.3% agreed that learning through real application can contribute to a better teaching and learning process. 83.6% stated that learning through real application can improve the results of students' handwork optimally and 80.3% the effectiveness of students' attitudes that clearly show an interest in learning.

Table 1: Effectiveness of teaching tools in real application

Item evaluation		Percentage of effectiveness (%)
Students' reactions	Comply with the course content	77.0
	Achievement of learning outcomes	80.3
	Lecturer delivery techniques	82.0
	Suitability of teaching and learning period	82.0
	Real Application teaching and learning methods are very helpful	80.3
	Teaching Aids - sensor kits are very interactive	78.7
Knowledge	This real application method provides complete knowledge	77.0
	This real application method increases understanding and knowledge	78.7
	Real application provides benefits and helps in the teaching and learning process	80.3
	Real application can improve the quality of learning	77.0
Skills	Real application method can improve students' hands-on skills	83.6
	Skill in handling various sensors can help continuous understanding	78.7
	The skill of obtaining data can provides understanding of function/operation sensors	80.3
Attitudes	Real application increases the feeling of curiosity and fun to learn	80.3
	Real application helps students focus and better emotional control	78.7

The effectiveness of learning in real-world application also had an impact on the Continuous Quality Improvement (CQI) and Course Outline Review Report (CORR). Fig. 4 shows excellent improvement in student achievement and group attainment, as proven by the increase in the average achievement of each course outline (CLO1-CLO3) compared to the previous semester.

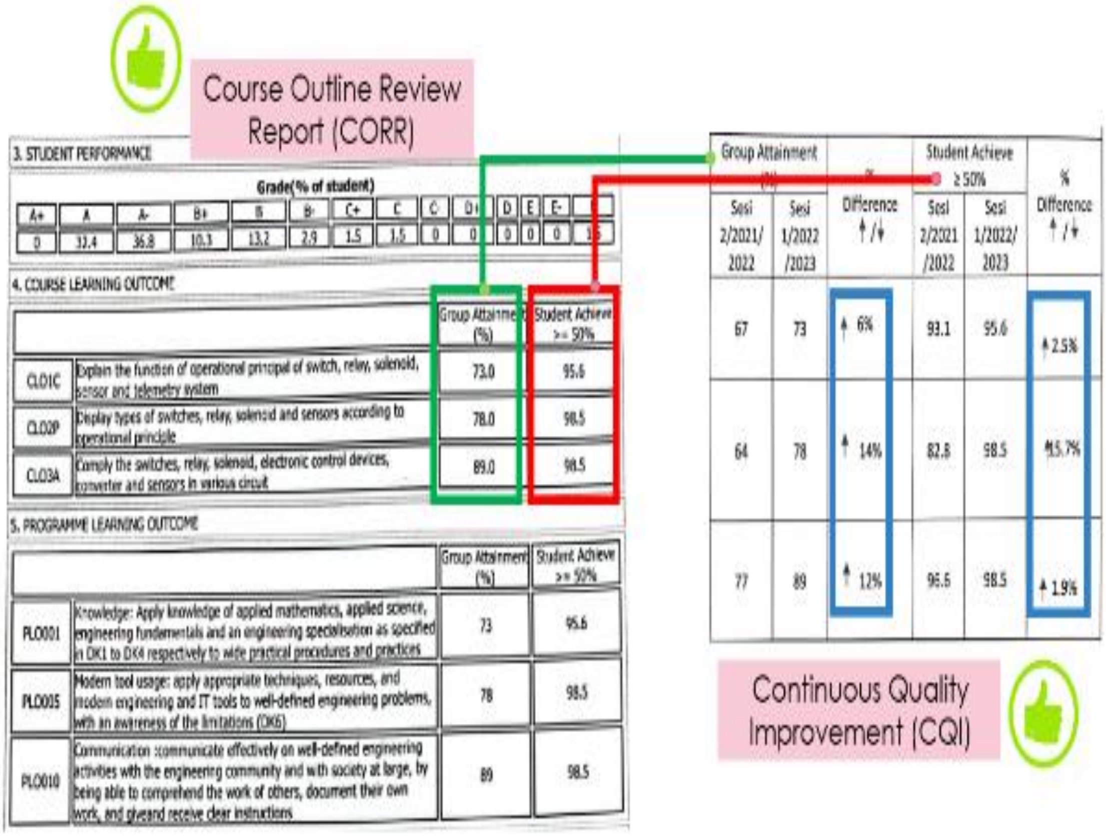

Fig. 4: Effectiveness on student achievement

4. Conclusion

The sensor kit device is an innovation in teaching and learning that introduces learning in a real-world application. Three sensors have been developed to ensure that students get exposure to the functions of sensors and how to operate them. Students who have experience with real-life situations using sensors can help improve their skills optimally. Students can also apply existing knowledge as an opportunity towards lifelong learning after completing their studies. This learning process has achieved quality education in the Sustainable Development Goal (SDG) for the 4th element. The introduction of real-world applications is an effort to make the learning process more realistic. The development of the agriculture site has helped students experience the real situation. In addition to gaining knowledge of sensor functions, getting accurate sensor data readings, understanding how sensors operate, and gaining additional knowledge by learning the process of controlling and monitoring plants using the Blynk application, students also gain preliminary knowledge about the Internet of Things (IoT).

After successfully achieving SDG-4 quality education, this project has also successfully helped achieve other SDG goals. For example, SDG-7, affordable and clean energy, can be achieved when this project uses eco-friendly materials such as portable solar to generate electricity in the farm area. This project uses cocopeat as a soil medium that can be recycled to plant trees. In addition, this project is user-friendly because the use of paper has been changed to Blynk control and data is recorded to a database in real time. SDG-8: Decent Work and Economic Growth can also be successfully achieved because when the teaching and learning process involves sensors, an agriculture site is automatically controlled by sensors, starting with water control in the tank, watering time, soil moisture, temperature, water pH, and others. Sensory control can produce healthy and quality plants. Healthy plants are harvested by students and sold to generate income. Continuous projects can increase economic growth and have an impact on the local community. Impact on society can be a success for SDG-11: Sustainable Cities and Communities, i.e., researchers can help small and medium farmers develop their own land for agriculture using a simple system with sensor applications.

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