Plagiarism Check_Building an IoT-Based Oyster Mushroom Cultivation and Control System and Its Practical Learning Effects on Students

By Anthony Anggrawan

WORD COUNT	9142	TIME SUBMITTED	11-AUG-2023 10:06AM
		PAPER ID	101917830

Building an IoT-Based Oyster Mushroom Cultivation and Control System and Its Practical Learning Effects on Students

Anthony Anggrawan[1], Christofer Satria[2], Muhammad Zulfikri[3]

[1] Department of Information Technology Education, Bumigora University, Mataram, Indonesia
[2] Department of Visual Communication Design, Bumigora University, Mataram, Indonesia
[3] Department of Computer Science, Bumigora University, Mataram, Indonesia

Abstract **–Whereas the Internet of Things (IoT) has become a research concern in education, the learning media in IoT is still minimal, and IoT-based research for education is still limited. It means that learning media and IoT research in education are still challenging for researchers. Bearing in mind mushroom cultivators do not understand what actions must be considered when cultivating mushrooms, and oyster mushroom cultivation frequently fails due to uncontrolled Baglog environmental conditions. Therefore this study aims to develop an IoT-based control system for oyster mushroom cultivation as a student practical lesson media and its learning effects for students. The research method combines experimental, surveys, and observation procedures. The research succeeded in carrying out educational activities with results that satisfied students and enabled most students to build an IoT-based control system and cultivate oyster mushrooms. This study's findings reinforce previous researchers' opinion that IoT technology has replaced traditional methods. Furthermore, the study's conclusions remove the dark side of concerns about the continuation of oyster mushroom production by previous researchers.**

Keywords **– Practical learning, control system, mushrooms, internet of things, education technology.**

DOI: 10.18421/TEMxxx-xx
https://doi.org/10.18421/TEMxxx-xx

Corresponding author: Anthony Anggrawan,
Department of Information Technology Education, University of Bumigora, Mataram, Indonesia.
Email: anthony.anggrawan@universitasbumigora.ac.id

Received: *xx Xxxx 2023.*
Revised: *xx Xxxx 202x.*
Accepted: *xx Xxxx 20xx.*
Published: *xx Xxxx 20xx.*

1. Introduction

Education is increasingly moving toward the digital age and as a result, the use of digital technology is extensive [1], [2], [3]. Currently, digital technology plays a dominant role in facilitating the learning process [4]. Previous research has also shown that students react positively to digital technology-based learning processes [5]. Meanwhile, IoT, one of the digital technology innovations, has become a research concern in education and the application of the latest technology [6]. IoT technology is developing rapidly, and its benefits can be highly accurate in various fields in real time [7], [8]. Moreover, IoT technology utilization allows control to be done automatically and monitored from anywhere [9] and supports heterogeneous automation models [10]. So that is why, teachers prepare students to enter changes from digital to digital systems IoT intelligent automation system [11]. But unfortunately, the learning media of IoT in education is still tiny, and IoT-based research for education is still limited [6].

Cultivating mushrooms often face difficulties for beginners. How to make it happen, and what needs to be paid attention to when cultivating mushrooms to be successful [12]. Besides that, the failure of oyster mushroom cultivation is often due to the Baglog environment condition, which does not support the growth of oyster mushrooms [13]. It means that the learning media for learning oyster mushroom cultivation and automatic control of environmental conditions in Baglog oyster mushroom cultivation is necessary. Moreover, educational activities for developing mushroom production are essential for the future sustainable development of mushroom production [14]. In addition, the development of educational technology has encouraged efforts to continuously update the use of technology as a learning medium in learning. In other words, advances in educational technology have demanded that school teachers use technology as learning media to improve the quality of delivering teaching information in the learning process [15]. Therefore, this study aims to build a learning media device for students using IoT digital technology to cultivate oyster mushrooms.

IoT is the future communication technology equipped with a microcontroller [16]. IoT technology has replaced the traditional method [17]. IoT can monitor and control other equipment and support the realization of intelligent systems in various fields, including education, health, and the environment [18], [19], [20], [21]. Besides that, the advantage of IoT is that it allows combining various other technologies to create effective and efficient models [22]. As a result, IoT has received significant attention worldwide as an advanced information technology revolutionary [23]. Moreover, the advancement of IoT technology provides a lot of research space for improvements in usage practices in developing digital learning media devices [24]. As a result, teaching media devices have become a significant concern for colleges today [25].

This study uses a microcontroller integrated circuit to embody the built system hardware control. The microcontroller is a microcomputer to carry out the desired operations according to the developed computer program and other supporting hardware. Microcontrollers usually use sensors to control and monitor controlled or monitored environments [26]. Microcontrollers are primarily for control, wireless, and automation systems [27]. The microcontroller type chosen to develop a one hundred percent control system is tailored to the needs.

The NodeMCU ESP32 microcontroller used in this study supports web servers and real-time work [28]. In addition, nodeMCU ESP32 is a combo system-on-chip microcontroller with low power consumption and cost [29], [30]. Besides that, the ESP32 microcontroller facilitates dual-mode blue tooth, large-capacity flash memory, and other interfaces [26]. Another advantage of NodeMCU ESP32 is that it has the best Radio Frequency (RF) capability and performance [31]. The ESP32 microcontroller is the successor of the ESP8266 microcontroller. Moreover, this ESP32 microcontroller provides an in-chip wifi module, so this microcontroller supports the creation IoT application system. Meanwhile, Oyster mushrooms are mushrooms that are widely cultivated throughout the world [32] and as edible mushrooms [33], [34]. Oyster mushrooms can be cultivated in many growing media, such as straw, sawdust, and rice husk [35]. Oyster mushroom is a favorite food because of their protein nutritional content as an immune boosting drug [36], [37], its taste [36], [38] and contains lots of fiber, minerals, vitamins [36], [39], carbohydrate, and essential amino acids [36]. In addition, oyster leaves are an important source for the human diet, anti-inflammatory, anti-diabetic, antifungal, antiviral, and antibacterial [33], [40]. It means the increase in oyster mushroom yields presents a solution to overcome malnutrition in most developing countries [38]. However, due to the lack of technological knowledge in mushroom cultivation, research on mushroom cultivation is necessary [41].

Oyster mushrooms can grow at temperatures between 18 to 30°C, with rapid growth of mycelium and substrate colonization [41], [42], [43], and in a humid or not dry and not wet environment [42]. Other researchers have also confirmed that humid climates positively affect fungal growth and colonization [38], [44]. Generally, suitable temperatures range from 25-30 °C [38] and 20-30 °C [44]. The pH concentration of the fungus is slightly acidic to slightly alkaline [45]. The suitable pH for the growth of oyster mushrooms is around 5.5 and 6.5 [46]. Watering conditions on Baglog mushroom seeds daily with a specific frequency create humidity conditions. Baglog's environment becomes humid by spraying water thrice daily and lighting around 300-500 lux [46].

This study developed a learning model to monitor fertility levels from Baglog (mushroom seedling container) based on the content pH (or power of Hydrogen), humidity, and temperature of Baglog from oyster mushroom cultivation. The embodiment of the IoT-based learning model for oyster mushroom cultivation developed in this study is a miniature model. The learning model developed is a learning medium for students to cultivate oyster mushrooms and a learning platform to build an IoT-based control system. In essence, for the cultivation of oyster mushrooms to be successful or for the mushrooms to grow fertile (quality), it is necessary to pay attention to the environmental conditions (pH, temperature, and humidity) of Baglog.

Generally, Baglog's environmental conditions in mushroom cultivation are usually only done by oyster mushroom farmers based on estimates and just experience. In contrast, as the oyster mushroom cultivation learning miniature device in this study, the IoT system will automatically control the Baglog's environmental conditions so that Baglog's pH, temperature, and humidity are controlled. This research aims to provide hands-on practical learning for students to build IoT-based control systems and cultivate mushrooms using the latest technology. In addition, a further implication of the results of this study is that the built miniature model is helpful as an example of a learning model for students about building IoT control circuit systems in mushroom cultivation and student practice media directly in mushroom cultivation.

Although there are relatively many previous studies related to mushroom cultivation, including research by [47], [15], [44], [40], and [14], none of them aim to be educational media tools for students as this research. Besides that, a previous study by

[42] and [48] on oyster mushroom cultivation, even though it was based on IoT, has the limitation of not controlling the pH of Baglog water, but only controlling humidity and temperature of Baglog. Besides, this previous research is not a prototype model for learning media and practices for students in building IoT and learning media for mushroom cultivation, as this article does. Likewise with previous studies, including the research conducted by [45], [32], [39], [46], [47], [15], [44], [36], [40], Okuda [14], [49], [37], [50], and [34] had the limitation of not testing the accuracy of the sensor system used, while this research completes the accuracy test of the sensors used. In short, the articles in this study are novel and unique compared to other articles. Besides that, this research makes a significant contribution as a learning medium for students and can be practiced in the community for mushroom cultivation for farmers.

The rest of the discussion structure in this paper is as follows: the second sub-section describes related works, whereas the third subsection discusses the research methodology. The fourth subchapter reveals the results of the research and its discussion. Finally, the fifth sub-section is the conclusion, which presents research findings, novelties, and suggestions for further study.

2. Related Works

Sulistyanto et al. [42] proposed using Fuzzy Logic to control the temperature and humidity of oyster mushrooms. However, this previous research did not test the temperature and humidity of system accuracy as the research in this article. Besides that, the prior research was not equipped with control over Baglog pH. Furthermore, the microcontroller used in the previous research is not the same type as the microcontroller used in this study. In addition, the difference between the previous research and the research in this article is that the previous research was not intended as a medium for student learning in mushroom cultivation as the research in this article (previous research did not asses the learning achievement of students in mushroom cultivation learning).

Lu [47] proposed a system for estimating the growth rate of fungi through the size and number of fungi-based deep-learning convolutional neural networks. Even though previous research has the same focus as the research in this article, namely related to mushroom cultivation, this earlier research proposed a system to estimate the speed of mushroom growth through the size and number of mushrooms. In contrast, the research in the article in this study tested the success of mushroom cultivation by automatically controlling the environmental conditions of Mushroom Baglog. Accordingly, this previous research did not have the same aims and methods as this article's. Eliyani et al. [15] explained the vital role of learning media in developing science. Previous research has different research methods and objectives from the analysis in this article. Previous research reviews existing research related to the development of learning media. The object of study in the last article is not associated with oyster mushroom cultivation or the use of IoT technology as research in this article.

Jenita Nongthombam et al. [44] reviewed the factors that cause disease in oyster mushrooms and effective ways to overcome them. The previous research had different methods and objectives than the research conducted in this article. The previous research was review research, while the research in this article is experimental. Besides that, prior research is not a study for learning models as the research carried out in this article. Meanwhile, Liu [25] proposed an online management platform structure to manage classroom usage based on IoT technology. This previous research has the same concern in developing IoT-based system devices as the research in this article. The difference lies in the objectives, objects, and research methods. The previous research was unrelated to oyster mushroom cultivation and did not build IoT devices except propose a design model for controlling class management.

Zawadzka et al. [40] conducted a study on the effect of light on the retention of vitamins, minerals, and polyphenols in the stems and caps of cultivated oyster mushrooms. The difference between this previous research and the research in this article is in the purpose of the study. The last study was not building a learning media on how to cultivate oyster mushrooms based on IoT, as in the article in this study, but rather evaluating the effect of cultivation on vitamins and minerals from oyster mushrooms. Meanwhile, a tool controlling temperature and humidity in oyster mushroom cultivation based on Arduino UNO is proposed [48]. However, this previous research did not test the system's pH, temperature, and humidity accuracy like the research in this article. Furthermore, the type of microcontroller used in this previous study differs from the type used. In addition, as examined in this article, previous research was not intended as a medium for student learning in mushroom cultivation and how to practice an IoT-based control system.

Nadzirah et al. [50] conducted training on oyster mushroom cultivation for students. This study provides training on the prospects for oyster mushroom cultivation. Thus this previous study is very different from this research which built a system for automatic control of the Baglog oyster mushroom environment and practicing oyster cultivation, which was not present in the previous study.

Table 1. Comparison between the latest prior related work and this article

Research by	Research Method	Use/Build Control System IoT				IoT Controller Type	System Accuracy test	Aims as Learning Media	Mushroom cultivation nursery trials	Description
		IoT	Sensor							
			pH	Humidity	Temperature					
Sulistyanto et al. (2018)	Experiment	Yes	No	Yes	Yes	Arduino Uno	No	No	No	Proposed the use of Fuzzy Logic to control the temperature and humidity of oyster mushrooms
Lu (2019)	System Design	No	No	No	No	None	No	No	Yes	Proposed a system that can predict the growth rate of mushrooms by measuring the size and calculating the number of mushrooms to use deep learning convolutional neural networks
Ediyani et al. (2020)	Review	No	No	No	No	None	No	No	No	Describe the importance of learning media in developing knowledge
Nongthombam et al. (2021)	Review	No	No	No	No	None	No	No	No	Reviewing the causative factors and how to control oyster mushroom disease.
Liu (2021)	System Design	Yes	No	No	No	None	No	No	No	Proposed an IoT-based class management embodiment that can control classroom utilization.
Zawadzka et al., (2022)	Evaluation	No	No	No	No	None	No	No	No	Evaluating the effect of light on mushroom cultivation on retention of vitamins, minerals, and polyphenols.
Desnanjaya and Sugiartawan (2022)	Experiment	Yes	No	Yes	Yes	Arduino Uno	No	No	No	Made a tool to monitor the temperature and humidity of oyster mushroom cultivation based on Arduino UNO.
Nadzirah et al. (2022)	Theory and Training	No	No	No	No	None	No	Yes	No	Conduct training on prospects for oyster mushroom cultivation
Sun (2022)	System Design	Yes	No	No	No	None	No	No	No	Analyzing the creation of digital media content by utilizing IoT
Okuda (2022)	Review	No	No	No	No	None	No	No	No	Reviewing the sustainable side of sustainable mushroom cultivation or production in the future
Our/this research	Experiment, Survey, and Observation	Yes	Yes	Yes	Yes	ESP32	Yes	Yes	Yes	Our research builds IoT-based learning media for oyster mushroom cultivation

In contrast, a digital media content creation system concerning advances in IoT technology, the Web, and fuzzy control [24]. This previous research has different methods, objectives, and objects studied compared to the research in this article. The similarity of prior research with this research lies only in the importance of the embodiment of a design system based on IoT technology. The future sustainability of mushroom cultivation or production is reviewed [14]. This previous research and the research in this article both focus on the development of mushroom cultivation but are entirely different in topic, objectives, and research methods.

A review of several recent related works shows that this article's research differs from previous research; specifically, the research method used combines experimental and survey procedures. Likewise, this study conducted field trials and accuracy tests on learning model devices built to control pH, humidity, and temperature in Baglog oyster mushroom cultivation. Another novelty of this research is that the system model produced is a miniature model of student learning media in mushroom cultivation and a learning model for building an IoT-based control system (see Table 1).

3. Research Methodology

This research combines experimental techniques, survey, and observation methods gather comprehensive data. The sequence of stages of the system design development of learning media devices for oyster mushroom cultivation based on the IoT used in this research is the Waterfall model. The waterfall model is a management model for developing systems [51], [52]. The process stages in the Waterfall model are sequential from the beginning to the next step [53]. The waterfall model process consists of five stages: requirement analysis, design, development, testing, and implementation, as shown in Figure 1 [52].

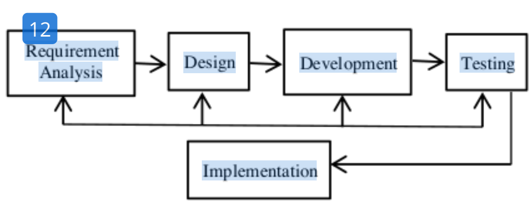

Figure 1. The Waterfall model of system development in this study

3.1. Research Design

The IoT control system used in this study for cultivating oyster mushrooms incorporates automation to regulate the pH of the water and ensure consistent temperature and humidity levels for cultivating oyster mushrooms. This automation is achieved through the collaboration with the system microcontroller designed in this study. The main component of the microcontroller system in this study is ESP32. In addition, ESP32 has Wifi and Bluetooth facilities [54].

The research employs two programming languages, namely C++ and PHP. Although there are various kinds of programming languages [55], each offers its advantages in application development programs [49]. The PHP coding language enables the embodiment of Web-based application programs. The coding program of the C++ programming language in this study plays a role in controlling the work of the microcontroller hardware in handling the work of all hardware supporting the work of sensors, lights, fans, and water pumps. In contrast, the PHP coding program played a role in the embodiment of the IoT system; in this case, the water pH level, temperature, and humidity of Baglog can be monitored via the website or the internet anytime and anywhere by a computer monitoring unit via the internet. C++ and PHP are popular programming languages used. Each computer programming language has its advantages in building application programs.

3.2. Research Participants

This study utilized a survey method to gather ordinal quantitative data. The survey data samples were 40 practicum class students, semester 6, 2021/2022 academic year, in the Informatics Technology study program at Bumigora University, Indonesia. The survey instrument used is a Likert measurement scale consisting of gradations from very satisfied to very dissatisfied, very capable, and very incapable. The survey was conducted to get students' opinions on learning to build IoT-based control hardware or on learning media for oyster mushroom cultivation, as well as, at the same time, knowing the level of student learning success through the learning media built in this study. In short, a survey questionnaire was intended to measure the effectiveness of student learning outcomes in building IoT systems and in oyster mushroom cultivation.

4. Result and Discussion

This subsection explains the research results according to this study's Waterfall system development model.

4.1. Requirement Analysis

The requirement analysis stage is the stage of determining the research or system requirements. The designed system is IoT-based, where the system can monitor pH, humidity, and temperature levels. Then the system built can neutralize abnormal pH, temperature, and humidity to normal (meet the requirements). It means that this research requires an intelligent or innovative application of system hardware control. The smart application built with the PHP programming language is to realize an IoT system, namely data on water pH, temperature, and humidity in Baglog, so that it can be monitored from a computer monitor anywhere via the internet.

Meanwhile, the C++ programming language regulates the work of sensor hardware and other devices on the NodeMCU ESP32 microcontroller in the system to control pH, temperature, and humidity in Baglog oyster mushroom cultivation. Through the ESP32 microcontroller, the C++ programming language application program built and installed in it detects the pH, humidity, and temperature level of Baglog oyster mushrooms produced by three sensors. The sensor inputs' pH, humidity, and temperature levels are the reference for the control program in the microcontroller to determine the pH of fertilizer or water for spraying Baglog Mushrooms and to stabilize Humidity and Temperature on Baglog Mushrooms. The best pH level in oyster mushroom cultivation is 5.5-6.5, humid Baglog conditions and an ambient temperature of 18-30°C.

4.2. Design

Figure 2 shows the method or stages of the student learning process in designing/building an IoT Baglog mushroom control system and cultivating oyster mushrooms.

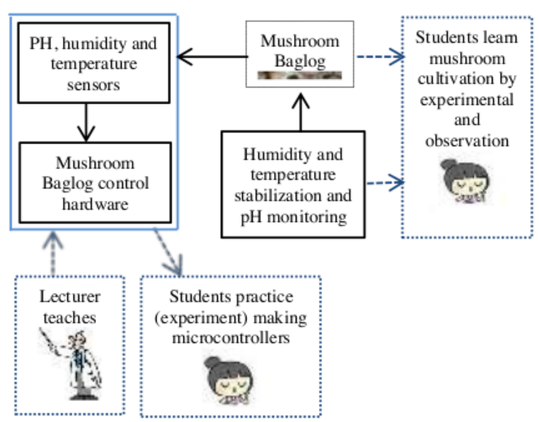

Figure 2. The stages of the student learning process in building the Baglog IoT system and cultivating oyster mushrooms

First, the lecturer directed students on how to make hardware and control software for mushroom cultivation; then, the lecturer described the students step by step how to cultivate mushrooms, starting from the oyster mushroom Baglog prototype until the mushrooms were ready for harvest. Then students in groups under the guidance of lecturers realize a miniature model of an IoT-based control system for cultivating oyster mushrooms. Briefly, the stages or learning models for students in developing IoT microcontroller technology and oyster mushroom cultivation, including knowing student learning success or student opinion responses to learning outcomes in this study, are shown in Figure 3.

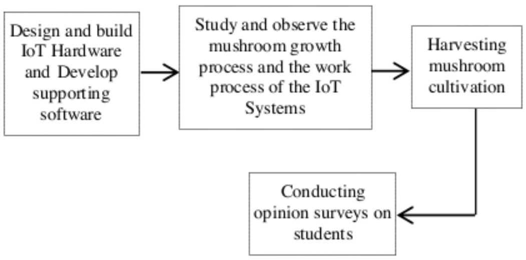

Figure 3. Learning stages of IoT design and mushroom cultivation for students

4.3. Development

At the development stage, the researcher built a hardware prototype of the oyster mushroom Baglog control system and demonstrated its construction to students. Table 2 shows the software requirements in this study. Meanwhile, Table 3 shows hardware requirements. The embodiment of the hardware in this study includes the design block diagram followed by a circuit board schematic design to control and facilitate Baglog's environmental needs automatically and monitor Baglog's environment, both pH, temperature, and humidity Baglog. Figure 4 and Figure 5 show the block diagram and circuit diagram of the IoT Microcontroller hardware for oyster mushroom cultivation.

Table 2. Required software

Software	Function
Arduino IDE (Integrated Development Environment) Software	Serves as a media editor for writing, compiling, and uploading the coding program that is built into the microcontroller board.
C++ and PHP computer language (coding program)	As a programming language for building application programs (coding programs) whose role is to regulate the work of circuits and hardware sensor systems to work as desired

Table 3. Required hardware

Device	Amount	Type/Specification	Function	Image
Humidity Unit	1	Moisture sensor FC-28 LM393 based design voltage: 3.3V-5V DC, Soil Probe dimension: Approx. 6cm x 3cm Board size: 3cm x 1.5cm	Detects humidity levels in the Baglog environment (hygrometer) or is a humidity sensor module	
pH Sensor unit	1	pH Electrode E201-BNC, Operating voltage: 3.3V-5V DC, Range: 0-14PH, Resolution: ±0.15PH, Response time: <1s, Measure temperature: 0-60°C	Serves to detect the pH level (Read the pH value of the water used watering the baglog)	
Temperature sensor	1	DS18B20, Operating voltage: 3V-5.6V DC. Conversion time: < 750ms, temperature range: -55 to 125°C, current consumption: 1 mA	As a digital temperature sensor to measure air temperature	
Water pump	1	A submersible pump, working voltage: 3-5V DC, Current Consumption: 120-330 mA	Pumping water to pour into the mushroom baglog oyster	
DC Fan	1	Li-ion battery fan, Input voltage 5V, Input current 0.5-1A	used for cooling air temperature	
DC light	1	Operating voltage: 5V DC	Useful for raising the air temperature	
Controller	1	ESP32, Xtensa dual-core, 32-bit LX6 microprocessor, 520KB SRAM, Wifi 802.11 b/g/n	As a controller for hardware to function in accordance with built software	

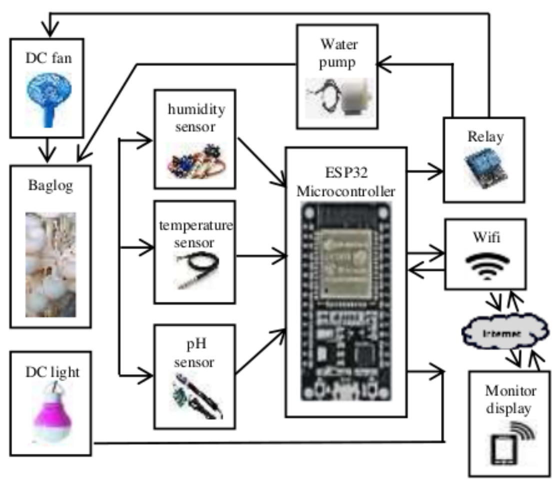

Figure 4. Block diagram of IoT microcontroller hardware for oyster mushroom cultivation

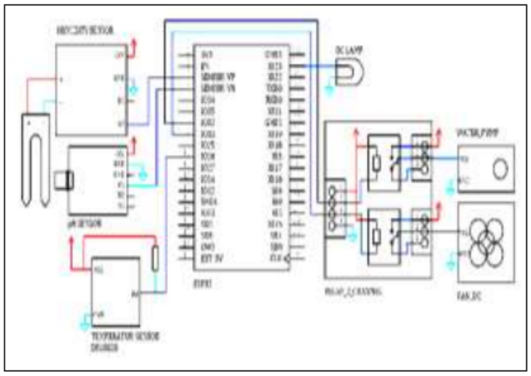

Figure 5. Circuit Diagram of IoT Microcontroller Hardware for Oyster Mushroom Cultivation

The system hardware works as follows: the display monitor (computer monitor screen) displays the level of water pH, temperature, and humidity in Baglog. Devices/computers can monitor from anywhere and at any time because the information from the pH, temperature, and humidity sensors in the ESP-32 microcontroller hardware unit is forwarded via internet wifi to be received by the monitor computer (IoT-based). When the microcontroller receives abnormal temperature sensor data (not according to the desired temperature reference), the microcontroller will turn on the fan to reduce the temperature level in Baglog or turn on the lights to increase the temperature in the Baglog environment. Likewise, if the humidity in Baglog is abnormal (out of the proper reference or Baglog has reduced water content), the microcontroller will spray water to increase Baglog humidity. Likewise, when the pH of the water does not meet the requirements, pH stability of the water is carried out so that Baglog is then sprayed with a pH that meets the required pH standard.

4.4. Testing

The requirement analysis stage is determining the research or system requirements. The designed system is IoT-based, where the system is able to monitor pH, humidity, and temperature levels. Then the system built can neutralize abnormal pH, temperature, and moisture to normal (meet the requirements). It means that this research requires intelligence or innovation.

The testing phase is the trial stage of the hardware prototype and the application program of the oyster mushroom Baglog control system that was developed. The results of the trials show that the system hardware and software systems can work according to design to control Baglog humidity and temperature and monitor the pH of Baglog water. The system works successfully at the desired Baglog temperature and moisture. When the temperature increases, the fan works, and the fan stops working when the temperature reaches the desired temperature level. Conversely, when the humidity in Baglog is low (dry), the system will drive a water pump to water Baglog.

The test results also show that the developed system controls Baglog water's pH well. This means that the pH of bag 27 water is controlled at the appropriate pH level. Table 4 shows the results of the work test of the Baglog air temperature control system and the Baglog air temperature control accuracy. As for testing the air temperature level of Baglog, whether it works at the desired temperature level by looking at the temperature displayed on the display monitor from the computer monitoring system unit.

Meanwhile testing the accuracy of the temperature produced by the Baglog air temperature control system is to compare it with the temperature produced by a thermometer. The highest error in measuring ambient temperature in Baglog is 7.14%, and the lowest error in measuring environmental temperature Baglog is 0%. It means the Baglog environmental temperature control system has an accuracy of up to 92.86%.

Based on the test results of Baglog's environmental temperature range, the temperature control system hardware developed in this study works well and manages to regulate Baglog's environmental temperature range between 26 to 29 degrees Celsius.

Table 4. Temperature control system test results

No	Thermometer temperature	Baglog temperature	Error	Being in the best temperature range in mushroom cultivation
1	29°C	28°C	3.45%	Yes
2	29°C	29°C	0.00%	Yes
3	28°C	27°C	3.57%	Yes
4	28°C	26°C	7.14%	Yes
5	26°C	26°C	0.00%	Yes
6	28°C	27°C	3.57%	Yes
7	26°C	26°C	0.00%	Yes
8	28°C	27°C	3.57%	Yes
9	26°C	26°C	0.00%	Yes
10	27°C	26°C	3.70%	Yes
….	….	….	….	….
27	29°C	28°C	3.45%	Yes
28	28°C	26°C	7.14%	Yes
29	28°C	27°C	3.57%	Yes
30	27°C	27°C	0.00%	Yes

The FC-28 moisture sensor helps measure Baglog's humidity conditions, whether moist, dry, or wet (see Table 5). If the humidity measurement value is below 300, Baglog is wet. If the sensor measurement value is between 300 to 700 it indicates that the Baglog is moist. Meanwhile, if the humidity sensor is above the value of 700, it shows Baglog is dry and requires watering. Table 6 shows the results of testing the working of the Baglog humidity control system and the results of testing the accuracy of the Baglog humidity regulator produced by the developed system. The condition of the moisture of the oyster mushroom Baglog is damp or works at the required humidity, namely not dry and not wet (see Table 6). The highest error in measuring humidity level in Baglog is 4.00%. In other words, the humidity control system in the oyster mushroom Baglog environment that was developed has an accuracy of 96.00%.

Table 5. The relationship between the analog value of the moisture sensor and Baglog humidity conditions

Analog value of Moisture sensor FC-28	Baglog humidity conditions
Under 300	Wet
300 to 700	Moist
Over 700	Dry

Table 6. Humidity control system test results

No	Moisture meter	Baglog Moisture	Error	Baglog humidity conditions
1	415	409	1.45%	Moist
2	330	323	2.12%	Moist
3	390	388	0.51%	Moist
4	385	376	2.34%	Moist
5	430	419	2.56%	Moist
6	330	323	2.12%	Moist
7	320	309	3.44%	Moist
8	425	415	2.35%	Moist
9	410	409	0.24%	Moist
10	435	430	1.15%	Moist
….	….	….	….	….
27	385	382	0.78%	Moist
28	325	312	4.00%	Moist
29	480	377	0.79%	Moist
30	405	400	1.23%	Moist

Table 7. Test results of the control system on the water pH level

No	pH meter (EZ9901)	Water pH	Error	Water pH level
1	5,89	5.83	1.02%	At the desired pH level
2	5,87	5.84	0.51%	At the desired pH level
3	5,89	5.86	0.51%	At the desired pH level
4	5,95	5.89	1.01%	At the desired pH level
5	5,89	5.86	0.51%	At the desired pH level
6	5,98	5.92	1.00%	At the desired pH level
7	6,02	5.94	1.33%	At the desired pH level
8	5,97	5.91	1.01%	At the desired pH level
9	5,96	5.95	0.17%	At the desired pH level
10	6,08	5.96	1.97%	At the desired pH level
….	….	….	….	….
27	6,14	6.03	1.79%	At the desired pH level
28	6,21	6.12	1.45%	At the desired pH level
29	6,13	6.06	1.14%	At the desired pH level
30	6,05	5.97	1.32%	At the desired pH level

The pH sensor helps check the pH level used to water the oyster mushroom Baglog. Table 7 shows the results of studying the water pH level of the control system developed. The pH level of the water used to water the oyster mushroom Baglog works at the pH level required for oyster mushroom cultivation (see Table 7). The highest error in measuring the water pH of Baglog is 1.97%. It means that the water pH control system on the oyster mushroom cultivation system developed has an accuracy of up to 98.03%.

The results of the sensor system accuracy test in this study not only show the performance of the sensors used in this study but also show the superiority of this research which was not carried out by all previous related studies, including research by Chang [45], Royse [32], Feeney et al. [39], Sultana et al. [46], Lu et al. [47], Ediyani et al. [15], Nongthombam et al. [44], Raman et al. [36] Zawadzka et al. [40], Okuda [14], Törős et al. [49], El-Ramady et al. [37], Nadzirah et al. [50] and Melanouri et al. [34].

4.5. *Implementation*

The implementation stage is the stage of embodiment of oyster mushroom cultivation and an opinion survey on satisfaction and the success rate of student learning in the practice of mushroom cultivation.

4.5.1. Oyster mushroom cultivation

The main implementation stage is the oyster mushroom cultivation stage. The implementation of oyster mushroom cultivation was carried out in two different containers or baglogs. The first is a Baglog container with manual control over water pH, temperature and humidity in Baglog. In contrast, the second is the Baglog container, with the management of water pH, temperature, and humidity controlled by a developed hardware and software system.

Figure 6. Baglog container with manual control over water pH, temperature, and humidity of Baglog

Figure 7. Baglog container with automatic control over water pH, temperature, and humidity of Baglog by developed hardware and software systems

Figures 8, 9, 10, 11, and 12 visually compared the development of oyster mushroom growth in Baglog between Baglog containers with manual control and automatic control over the water pH, temperature, and temperature humidity of Baglog. It is clear visually that the growth of oyster mushrooms whose Baglog is controlled by an automated IoT-based system is growing faster (faster harvest time). Besides that, the mushroom size for example, in terms of the speed of growth of oyster mushrooms, it takes one to get the size of the mushrooms that grow the same size, with manual control over water pH, temperature, and humidity in Baglog one month or 30 days.

In contrast, automatic control over water pH, temperature, and humidity in Baglog takes 27 days (see Figures 8 and 9). Another example: the speed of mushroom growth until ready for harvest by manually controlling water pH, temperature, and humidity in Baglog takes one month and 15 days. Whereas automatically controlling water pH, temperature, and moisture in Baglog takes only one month and three days (see Figures 11 and 12).

Figure 8. Oyster mushroom growth with manual control of water pH, temperature, and humidity in Baglog when it is one month old

Figure 9. Oyster mushroom growth with automatic control of water pH, temperature, and humidity in Baglog when it is 27 days old

Figure 10. Oyster mushroom growth with automatic control of water pH, temperature, and humidity in Baglog when it is one month old

Figure 11. Oyster mushroom growth with manual control of water pH, temperature, and humidity in Baglog when at the age of one month 15 days

Figure 12. Oyster mushroom growth with automatic control of water pH, temperature, and humidity in Baglog when at the age of one month and three days (ready to harvest)

In short, by processing Baglog oyster mushrooms with IoT-based automatic control of water pH, temperature, and humidity in Baglog, is proven to bring significant benefits for the community to be more successful in oyster mushroom cultivation. This finding reinforces the opinion of previous researchers that IoT technology has replaced traditional methods [17]. An important implication of this research is to provide scientific certainty that mushroom cultivation with an IoT-based microcontroller as a bright solution creates sustainable mushroom cultivation in the future and eliminates worries of stalled oyster mushroom production in the future.

4.5.2. A survey to find out the results of student practicum learning

The results of student practicum learning in building an IoT-based control system and cultivating oyster mushrooms (for one month and one week) showed that most students were very satisfied with the practical learning of building IoT and cultivating oyster mushrooms. Besides that, most of the students stated have the ability to build an IoT-based control system and also in oyster mushroom cultivation (see Table 8, Figure 13, Table 9, and Figure 14). The findings of this study succeeded in carrying out educational activities for developing mushroom production for students, which is a straightforward solution for creating sustainable mushroom production in the future. Or in other words, as a solution to solving the problem of the dark side of sustainable mushroom cultivation (mushroom production) in the future, as doubted by previous researcher Okuda [14].

Table 8. Students' satisfaction with practicum learning

Students Perception	Students' satisfaction with learning			
	In IoT-based control		In Cultivate oyster mushrooms	
	in number	In percent	in number	In percent
Very satisfied	18	45	24	60
Satisfied	15	37.5	11	27.5
Quite satisfied	6	15.0	5	12.5
Not satisfied	1	2.5	0	0
Very dissatisfied	0	0.	0	0

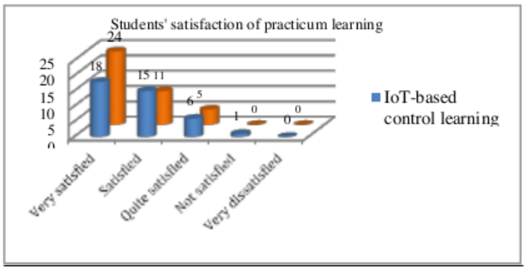

Figure 13. Students' perceptions of practicum learning to build a control system and cultivate oyster mushrooms based on IoT

Table 9. Students' ability level of practicum learning

Students Ability	Students' satisfaction in learning			
	In IoT-based control		In Cultivate oyster mushrooms	
	in number	In percent	in number	In percent
Very capable	10	25	17	42.5
Capable	22	55	20	50
Quite capable	8	20	3	7.5
Not capable	0	0	0	0
Very incapable	0	0.	0	0

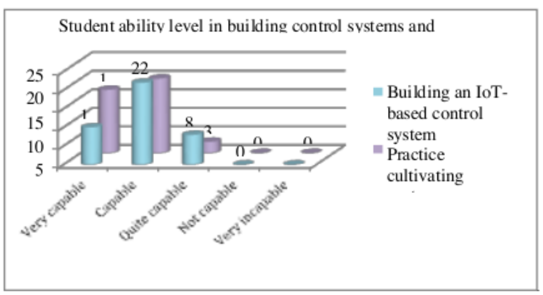

Figure 14. Students' perceptions of their ability to build an IoT-based control system and oyster mushroom cultivation

4. Conclusion

This research educational activities with satisfactory results for most students who learned by direct practice (experiments) to build IoT and cultivate oyster mushrooms. In addition, most students have the ability to build an IoT-based control system and demonstrated proficiency in oyster mushroom cultivation. Up to 45% of students are very satisfied, and 37.5% are satisfied with practical learning to build an IoT-based control system. Meanwhile, as many as 15% of students are quite satisfied learning to practice IoT-based system control. Student satisfaction in learning the practice of oyster mushroom cultivation is as much as 60% very satisfied, 27.5% satisfied, and as much as 15% quite satisfied.

In contrast, up to 25% of students are very capable, and 55% are capable of practical learning to build an IoT-based control system; Meanwhile, as many as 20% of students are quite capable of practical learning to build IoT-based system control. Student capability in learning the practice of oyster mushroom cultivation is as much as 42.5% very capable, 27.5% capable, and as much as 15% quite capable (please see Table 8).

This study found that the growth of oyster mushrooms whose Baglog was controlled by an automated IoT-based system grew faster (faster harvest), and the size of the oyster mushrooms produced was larger than Baglog whose environment was managed manually. In addition, the developed oyster mushroom cultivation environment temperature control system has an accuracy of up to 92.86%. Meanwhile, the control system built to control environmental humidity Baglog oyster mushroom has an accuracy of up to 96.00%, and the pH of the water for sprinkling Baglog oyster mushroom water has an accuracy of 98.03%.

This research has the advantage of testing the accuracy of the sensor system used. This advantage is not shared by all previous related studies. Besides that the study's findings reinforce previous researchers' opinion that IoT technology has replaced traditional methods. Another novel scientific finding in this study is the elimination of the dark side of stagnation in mushroom production to become a certainty for sustainable mushroom production in the future. The uniqueness of this research is its aim to build learning of oyster mushroom cultivation practices with an IoT-based control system that previous researchers have never done. The drawback of this research is that students practice learning only about cultivating oyster mushrooms in the prototype model and only on types of oyster mushrooms. In addition, experiments were only carried out on prototype models without paying attention to the size of the place from Baglog, production costs, and tested hardware durability, all of which are suggestions for further research.

References

[1] Van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. Computers in Human Behavior, 72, 577–588. https://doi.org/10.1016/j.chb.2017.03.010

[2] Rohles, B., Backes, S., Fischbach, A., Amadieu, F., & Koenig, V. (2022). Creating positive learning experiences with technology: A field study on the effects of user experience for digital

concept mapping. Heliyon, 8(4). https://doi.org/10.1016/j.heliyon.2022.e09246

[3] Teoh, C., Ho, S., Dollmat, K. S., & Tan, C. (2022). Ensemble-Learning Techniques for Predicting Student Performance on Video-Based Learning. International Journal of Information and Education Technology, 12(8), 741–745. https://doi.org/10.18178/ijiet.2022.12.8.1679

[4] Srivastava, K., & Dey, S. (2018). Role of Digital Technology in Teaching-Learning Process. IOSR Journal Of Humanities And Social Science (IOSR-JHSS, 23(1), 74. https://doi.org/10.9790/0837-2301057479Srivastava, K., & Dey, S. (2018). Role of Digital Technology in Teaching-Learning Process. IOSR Journal Of Humanities And Social Science (IOSR-JHSS, 23(1), 74. https://doi.org/10.9790/0837-2301057479

[5] Jones, C., & Shao, B. (2011). The Net Generation and Digital Natives Implications for Higher Education. Higher Education Academy, (June), 1–56.

[6] Madni, S. H. H., Ali, J., Husnain, H. A., Masum, M. H., Mustafa, S., Shuja, J., … Hosseini, S. (2022). Factors Influencing the Adoption of IoT for E-Learning in Higher Educational Institutes in Developing Countries. Frontiers in Psychology, 13(July), 1–22. https://doi.org/10.3389/fpsyg.2022.915596

[7] Malik, S., Dedeoglu, V., Kanhere, S. S., & Jurdak, R. (2019). TrustChain: Trust management in blockchain and iot supported supply chains. Proceedings - 2019 2nd IEEE International Conference on Blockchain, Blockchain 2019, (July), 184–193. https://doi.org/10.1109/Blockchain.2019.00032

[8] Powell, W., Foth, M., Cao, S., & Natanelov, V. (2022). Garbage in garbage out: The precarious link between IoT and blockchain in food supply chains. Journal of Industrial Information Integration, 25(May). https://doi.org/10.1016/j.jii.2021.100261

[9] Kumar, P. M., Hong, C. S., Afghah, F., Manogaran, G., Yu, K., Hua, Q., & Gao, J. (2022). Clouds Proportionate Medical Data Stream Analytics for Internet of Things-Based Healthcare Systems. IEEE Journal of Biomedical and Health Informatics, 26(3), 973–982. https://doi.org/10.1109/JBHI.2021.3106387

[10] Li, S., Zhang, B., Fei, P., Shakeel, P. M., & Samuel, R. D. J. (2020). Computational efficient wearable sensor network health monitoring system for sports athletics using IoT. Aggression and Violent Behavior, 101541. https://doi.org/10.1016/j.avb.2020.101541

[11] Joko, J., Putra, A. A. P., & Isnawan, B. H. (2023). Implementation of IoT-Based Human Machine Interface-Learning Media and Problem-Based Learning to Increase Students' Abilities, Skills, and Innovative Behaviors of Industry 4.0 and Society 5.0. TEM Journal, 12(1), 200–207. https://doi.org/10.18421/TEM121-26

[12] Anamosa. (2021). Common problems with growing oyster mushrooms. Oyster Mushroom Farming, 1–18..

[13] Suada, I. K., Sudarma, I. M., Kim, B., Cha, J., & Ohga, S. (2015). Fungal Contaminant Threaten Oyster Mushroom (Pleurotus ostreatus (Jacq. ex Fr.) Kummer) Cultivation in Bali. Journal of the Faculty of Agriculture, Kyushu University, 60(2), 309–313. https://doi.org/10.5109/1526343

[14] Okuda, Y. (2022). Sustainability perspectives for future continuity of mushroom production: The bright and dark sides. Frontiers in Sustainable Food Systems, 6(October), 1–7. https://doi.org/10.3389/fsufs.2022.1026508

[15] Ediyani, M., Hayati, U., Salwa, S., Samsul, S., Nursiah, N., & Fauzi, M. B. (2020). Study on Development of Learning Media. Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences, 3(2), 1336–1342. https://doi.org/10.33258/birci.v3i2.989

[16] Atzori, L., Iera, A., & Morabito, G. (2010). The Internet of Things: A survey. Computer Networks, 54(15), 2787–2805. https://doi.org/10.1016/j.comnet.2010.05.010.

[17] Puliafito, C., Mingozzi, E., Longo, F., Puliafito, A., & Rana, O. (2019). Fog Computing for the Internet of Things. ACM Transactions on Internet Technology, 19(2), 1–41. https://doi.org/10.1145/3301443

[18] Sumi, L., & Ranga, V. (2016). Sensor enabled Internet of Things for smart cities. 2016 4th International Conference on Parallel, Distributed and Grid Computing, PDGC 2016, 295–300. https://doi.org/10.1109/PDGC.2016.7913163

[19] Pardini, K., Rodrigues, J. J. P. C., Kozlov, S. A., Kumar, N., & Furtado, V. (2019). IoT-based solid waste management solutions: A survey. Journal of Sensor and Actuator Networks, 8(1), 1–25. https://doi.org/10.3390/jsan8010005 [20] H. Arasteh *et al*., "Iot-based smart cities: A survey," in *EEEIC 2016 - International Conference on Environment and Electrical Engineering*, 2016, no. June.

[21] Raaijen, T., & Daneva, M. (2017). Depicting the smarter cities of the future: A systematic literature review & field study. 2017 Smart Cities Symposium Prague, SCSP 2017 - IEEE Proceedings, 1–10. https://doi.org/10.1109/SCSP.2017.7973352

[22] Ou, Z., & Xie, X. (2012). Research on in-vehicle bus network based on internet of things.

Proceedings - 4th International Conference on Computational and Information Sciences, ICCIS 2012, 981–984. https://doi.org/10.1109/ICCIS.2012.245

[23] Jiang, B., Yang, J., Xu, H., Song, H., & Zheng, G. (2019). Multimedia data throughput maximization in internet-of-things system based on optimization of cache-enabled UAV. IEEE Internet of Things Journal, 6(2), 3525–3532. https://doi.org/10.1109/JIOT.2018.2886964

[24] Sun, Y. (2022). Research on the Method of Digital Media Content Creation Based on the Internet of Things. Computational Intelligence and Neuroscience, 2022, 1–10. https://doi.org/10.1155/2022/8529875

[25] Liu, J., Wang, C., & Xiao, X. (2021). Internet of Things (IoT) Technology for the Development of Intelligent Decision Support Education Platform. Scientific Programming, 2021, 1–12. https://doi.org/10.1155/2021/6482088

[26] Babiuch, M., Foltynek, P., & Smutny, P. (2019). Using the ESP32 microcontroller for data processing. Proceedings of the 2019 20th International Carpathian Control Conference, ICCC 2019, (May 2019). https://doi.org/10.1109/CarpathianCC.2019.8765944

[27] Salah, W. A., & Zneid, B. A. (2020). Evolution of microcontroller-based remote monitoring system applications. International Journal of Electrical and Computer Engineering, 9(4), 2354–2364. https://doi.org/10.11591/ijece.v9i4.pp2354-2364

[28] Allafi, I., & Iqbal, T. (2018). Design and implementation of a low cost web server using ESP32 for real-time photovoltaic system monitoring. 2017 IEEE Electrical Power and Energy Conference, EPEC 2017, 2017-Octob, 1–5. https://doi.org/10.1109/EPEC.2017.8286184

[29] Fabregat, G., Belloch, J. A., Badia, J. M., & Cobos, M. (2020). Design and Implementation of Acoustic Source Localization on a Low-Cost IoT Edge Platform. IEEE Transactions on Circuits and Systems II: Express Briefs, 67(12), 3547–3551. https://doi.org/10.1109/TCSII.2020.2986296

[30] Tueche, F., Mohamadou, Y., Djeukam, A., Kouekeu, L. C. N., Seujip, R., & Tonka, M. (2021). Embedded Algorithm for QRS Detection Based on Signal Shape. IEEE Transactions on Instrumentation and Measurement, 70. https://doi.org/10.1109/TIM.2021.3051412

[31] Fezari, M., & Zakaria, N. (2019). Comparative study between two Powerfull NodeMCU Circuits : ESP32 and Comparative study between two Powerfull NodeMCU Modules : ESP32 and ESP8266. WSN Applications, (April), 1–9.

[32] Royse, D. J. (2012). Influence of spawn rate and commercial delayed release nutrient levels on Pleurotus cornucopiae (oyster mushroom) yield, size, and time to production. Applied Microbiology and Biotechnology, 58(4), 527–531. https://doi.org/10.1007/s00253-001-0915-2

[33] Törős, G., El-Ramady, H., & Prokisch, J. (2022). Edible Mushroom of Pleurotus spp.:A Case Study of Oyster Mushroom (Pleurotus ostreatus L.). Environment, Biodiversity and Soil Security, 6(2022), 51–59. https://doi.org/10.21608/jenvbs.2022.117554.1161

[34] Melanouri, E. M., Dedousi, M., & Diamantopoulou, P. (2022). Cultivating Pleurotus ostreatus and Pleurotus eryngii mushroom strains on agro-industrial residues in solid-state fermentation. Part II: Effect on productivity and quality of carposomes. Carbon Resources Conversion, 5(1), 52–60. https://doi.org/10.1016/j.crcon.2021.12.005

[35] Pathmashini, L., Arulnandhy, V., & Wijeratnam, R. W. (2009). Cultivation of Oyster Mushroom (Pleurotus ostreatus) on Sawdust. Ceylon Journal of Science (Biological Sciences), 37(2), 177. https://doi.org/10.4038/cjsbs.v37i2.505

[36] Raman, J., Jang, K.-Y., Oh, Y.-L., Oh, M., Im, J.-H., Lakshmanan, H., & Sabaratnam, V. (2021). Cultivation and Nutritional Value of Prominent Pleurotus spp.: An Overview. Mycobiology, 49(1), 1–14. https://doi.org/10.1080/12298093.2020.1835142

[37] El-Ramady, H., Abdalla, N., Fawzy, Z., Badgar, K., Llanaj, X., Törős, G., … Prokisch, J. (2022). Green Biotechnology of Oyster Mushroom (Pleurotus ostreatus L.): A Sustainable Strategy for Myco-Remediation and Bio-Fermentation. Sustainability (Switzerland), 14(6), 1–21. https://doi.org/10.3390/su14063667

[38] Jongman, M., Khare, K. B., Loeto, D., & Behari Khare, K. (2018). Oyster mushroom cultivation at different production systems: A review. European Journal of Biomedical and Pharmaceutical Sciences, 5(5), 72–79.

[39] Feeney, M. J., Dwyer, J., Hasler-Lewis, C. M., Milner, J. A., Noakes, M., Rowe, S., … Wu, D. (2014). Mushrooms and health summit proceedings. *Journal of Nutrition*, *144*(7), 1–9. https://doi.org/10.3945/jn.114.190728

[40] Zawadzka, A., Janczewska, A., Kobus-Cisowska, J., Dziedziński, M., Siwulski, M., Czarniecka-Skubina, E., & Stuper-Szablewska, K. (2022). The effect of light conditions on the content of selected active ingredients in

anatomical parts of the oyster mushroom (Pleurotus ostreatus L.). PLoS ONE, 17(1 Januray), 10–12. https://doi.org/10.1371/journal.pone.0262279

[41] Girmay, Z., Gorems, W., Birhanu, G., & Zewdie, S. (2016). Growth and yield performance of Pleurotus ostreatus (Jacq. Fr.) Kumm (oyster mushroom) on different substrates. AMB Express, 6(1), 1–7. https://doi.org/10.1186/s13568-016-0265-1

[42] Sulistyanto, M. P. T., Harianto, W., Nugroho, D. A., Retandi, R. E., Akbar, A. K., & Tjahjanti, P. H. (2018). The controlling and monitoring system in oyster mushroom cultivation using fuzzy logic through web technology integrated with Internet of Things. MATEC Web of Conferences, 197, 0–3. https://doi.org/10.1051/matecconf/201819715002.

[43] Chitra, K., Dhanalakshm, K., Indra, N., & Ambethgar, V. (2021). Oyster Mushroom Cultivation with Reference to Climate. International Journal of Current Microbiology and Applied Sciences, 10(10), 307–313. https://doi.org/10.20546/ijcmas.2021.1010.038

[44] Nongthombam, J., Kumar, A., Ladli, Manikanta, B., Madhushekhar, M., & Patidar, S. (2021). A review on study of growth and cultivation of oyster mushroom. Plant Cell Biotechnology and Molecular Biology, 22(5), 55–65.

[45] Chang, S. T. (2007). Mushroom Cultivation Using the “Zeri” Principle: Potential for Application in B Razil. 19, 33–34.

[46] Sultana, R., Hossain, I., Saifullah, M. D., Amin, M. D., & Chakraborty, R. (2018). Influence of Substrate pH and Watering Frequency on the Growth of Oyster Mushroom. Int J Plant Biol Res, 6(4), 1097.

[47] Lu, C. P., Liaw, J. J., Wu, T. C., & Hung, T. F. (2019). Development of a mushroom growth measurement system applying deep learning for image recognition. Agronomy, 9(1), 1–21. https://doi.org/10.3390/agronomy9010032

[48] Desnanjaya, I. G. M. N., & Sugiartawan, P. (2022). Controlling and Monitoring of Temperature and Humidity of Oyster Mushrooms in Tropical Climates. Indonesian Journal of Electronics and Instrumenations Systems, 12(1), 1–11. https://doi.org/10.22146/ijeis.xxxx

[49] Törős, G., El-Ramady, H., & Prokisch, J. (2022). Edible Mushroom of Pleurotus spp.:A Case Study of Oyster Mushroom (Pleurotus ostreatus L.). Environment, Biodiversity and Soil Security, 6(2022), 51–59. https://doi.org/10.21608/jenvbs.2022.117554.1161

[50] Nadzirah, R., Savitri, D. A., & Novijanto, N. (2022). Oyster Mushroom Cultivation Training as Empowerment Program for Students of Foundation of Islamic Education and Social “Ar-Rohmah.” Warta Pengabdian, 16(2), 89. https://doi.org/10.19184/wrtp.v16i2.24621

[51] Dima, A. M., & Maassen, M. A. (2018). From waterfall to agile software: Development models in the IT sector, 2006 to 2018. impacts on company management. Journal of International Studies, 11(2), 315–326. https://doi.org/10.14254/2071-8330.2018/11-2/21

[52] Anggrawan, A., Mayadi, Satria, C., & Putra, L. G. R. (2022). Scholarship Recipients Recommendation System Using AHP and Moora Methods. International Journal of Intelligent Engineering and Systems, 15(2), 260–275. https://doi.org/10.22266/ijies2022.0430.24

[53] Bassil, Y. (2012). A Simulation Model for the Waterfall Software Development Life Cycle. International Journal of Engineering & Technology, 2(05), 3823–3830. https://doi.org/10.15680/ijircce.2015.0305013

[54] Anggrawan, A., Hadi, S., & Satria, C. (2022). IoT-Based Garbage Container System Using NodeMCU ESP32 Microcontroller. Journal of Advances in Information Technology, 13(6), 569–577. https://doi.org/10.12720/jait.13.6.569-577

[55] Anggrawan, A., Satria, C., Mayadi, & Dasriani, N. G. A. (2021). Reciprocity Effect between Cognitive Style and Mixed Learning Method on Computer Programming Skill. Journal of Computer Science, 17(9), 814–824. https://doi.org/https://doi.org/10.3844/jcssp.2021.814.824

Plagiarism Check_Building an IoT-Based Oyster Mushroom Cultivation and Control System and Its Practical Learning Effects on Students

ORIGINALITY REPORT

10%

SIMILARITY INDEX

PRIMARY SOURCES

1	repository.universitasbumigora.ac.id Internet	264 words — 4%
2	Anthony Anggrawan, Dian Syafitri C. S., Christofer Satria. "Developing Augmented Reality Learning and Measuring Its Effect on Independent Learning Compared to Traditional Learning", TEM Journal, 2023 Crossref	128 words — 2%
3	Viska Mutiawani, Al Misky Athaya, Kurnia Saputra, Muhammad Subianto. "Implementing Item Response Theory (IRT) Method in Quiz Assessment System", TEM Journal, 2022 Crossref	33 words — < 1%
4	journal.ugm.ac.id Internet	30 words — < 1%
5	www.mdpi.com Internet	18 words — < 1%
6	www.researchgate.net Internet	17 words — < 1%
7	journals.plos.org Internet	15 words — < 1%

8	ebin.pub Internet	14 words — < 1%
9	www.seeedstudio.com Internet	13 words — < 1%
10	Samia Aleem, LaShawndra S. Walker, Chi D. Hornik, Michael J. Smith, Chad A. Grotegut, Kristin E. D. Weimer. "Severe Congenital Syphilis in the Neonatal Intensive Care Unit", Pediatric Infectious Disease Journal, 2021 Crossref	12 words — < 1%
11	digilib.iain-palangkaraya.ac.id Internet	12 words — < 1%
12	lib.unnes.ac.id Internet	12 words — < 1%
13	me.me Internet	12 words — < 1%
14	www.polgan.ac.id Internet	12 words — < 1%
15	dir.indiamart.com Internet	10 words — < 1%
16	Das, N.. "Cultivation of Pleurotus ostreatus on weed plants", Bioresource Technology, 200710 Crossref	9 words — < 1%
17	Hua Yin, Wenlong Yi, Dianming Hu. "Computer vision and machine learning applied in the mushroom industry: A critical review", Computers and Electronics in Agriculture, 2022 Crossref	9 words — < 1%

18	niice.uthm.edu.my Internet	9 words — < 1%
19	www.diva-portal.org Internet	9 words — < 1%
20	"Inventive Communication and Computational Technologies", Springer Science and Business Media LLC, 2020 Crossref	8 words — < 1%
21	"Sustainable Cities and Communities", Springer Science and Business Media LLC, 2020 Crossref	8 words — < 1%
22	Liang Guo, Zhongliang Li, Rachid Outbib, Fei Gao. "Function approximation reinforcement learning of energy management with the fuzzy REINFORCE for fuel cell hybrid electric vehicles", Energy and AI, 2023 Crossref	8 words — < 1%
23	Sahar El-Nahrawy. "Potassium Silicate and Plant Growth - promoting Rhizobacteria Synergistically Improve Growth Dynamics and Productivity of Wheat in Salt-affected Soils", Environment, Biodiversity and Soil Security, 2022 Crossref	8 words — < 1%
24	eprints.ums.ac.id Internet	8 words — < 1%
25	eprints.walisongo.ac.id Internet	8 words — < 1%
26	jurnal.umpwr.ac.id Internet	8 words — < 1%

27	penerbit.uthm.edu.my Internet	8 words — < 1%
28	repository.unja.ac.id Internet	8 words — < 1%
29	solarlits.com Internet	8 words — < 1%
30	www.coursehero.com Internet	8 words — < 1%
31	www.jait.us Internet	8 words — < 1%
32	www.scilit.net Internet	8 words — < 1%
33	Naufal Ishartono, Rafiza binti Abdul Razak, Siti Hajar binti Halili, Yoga Dwi Windy Kusuma Ningtyas et al. "The Role of Instructional Design in Improving Pre-Service and In-Service Teacher's Mathematics Learning Sets Skills: A Systematic Literature Review in Indonesian Context", Indonesian Journal on Learning and Advanced Education (IJOLAE), 2022 Crossref	7 words — < 1%
34	Yasuhito Okuda. "Sustainability perspectives for future continuity of mushroom production: The bright and dark sides", Frontiers in Sustainable Food Systems, 2022 Crossref	6 words — < 1%

EXCLUDE QUOTES OFF
EXCLUDE SOURCES OFF