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The Adoption of Internet of Things in Water Quality Measurement Community Service Project

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ABSTRACT

Integrating Internet of Things (IoT) technology into education is increasingly vital in supporting environmental sustainability and developing green skills among students. This community service program focused on utilising IoT for water quality monitoring as part of extracurricular activities in a vocational school. The program aimed to enhance students' understanding of environmental conservation and provide practical skills aligned with Industry 4.0 standards. The activities included preparation, IoT workshops, and hands-on implementation in the field, focusing on real-time monitoring of water parameters such as pH, Total Dissolved Solids (TDS), and temperature using IoT-based sensors. The results indicated that students became more aware of environmental issues and developed practical IoT and data analysis competencies. This initiative also highlighted the importance of IoT in enhancing competitive skills in the job market, particularly in sectors requiring sustainable practices. The adoption of IoT in education, especially in green skill camps, offers significant potential to prepare students for future challenges in environmental management and technological innovation.

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1. INTRODUCTION

The adoption of IoT for water quality measurement is one tangible example of the use of this technology in environmental conservation efforts. IoT sensors, such as pH, TDS (Total Dissolved Solids), and temperature sensors, can monitor water quality in real-time. The pH sensor measures the water's acidity level, while the TDS sensor detects the total amount of dissolved solids. Based on research by Revansyah et al. (2023), clean water that is suitable for consumption has a maximum TDS limit of 500 mg/l with a pH range between 6.5 and 8.5. Data obtained from these IoT sensors can be analysed to quickly and accurately identify environmental problems, enabling better decision-making in water resource management.

In the Green Skills Holiday Camp activity held in the Pusur River area, Tulung, Klaten, and Central Java, participants were invited to learn and practice IoT technology in evaluating water quality. This activity aims to increase participants' awareness of the importance of preserving the environment and provide them with relevant knowledge and practical skills that can be developed in the future.

As global awareness of the negative impacts of human activities on the environment increases, the

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demand for implementing environmentally friendly sustainable practices is increasingly pressing. Green skills, such as the ability to reduce environmental impacts, manage resources efficiently, and develop and implement green technologies (Sabarudin, 2024), are essential competencies that vocational education graduates must possess. Implementing IoT technology in teaching green skills provides students with in-depth practical experience, making them better prepared to contribute to realising a green and sustainable economy.

The introduction and application of IoT technology in vocational education offers several benefits. First, this activity increases students' understanding of the importance of technology in environmental management. Second, IoT sensors allow students to learn how to monitor water quality parameters such as pH, temperature, and dissolved substance content (Putra et al., 2023). Third, data analysis from IoT sensors provides accurate information about water conditions, which can be used as a basis for decision-making in water resource management. Students can become active agents of change in environmental conservation efforts by understanding how IoT technology works and its benefits.

2. LITERATURE REVIEW

THE ROLE OF THE INTERNET OF THINGS IN THE INDUSTRIAL REVOLUTION 4.0

The term Industrial Revolution 4.0 was first introduced in 2011 at the Hannover Messe, an international industrial exhibition held in Hannover, Germany (Sutrisno, 2021). This era is characterised by a strong integration between digital and physical technologies, as well as artificial intelligence (AI) and other technologies, such as the Internet of Things (IoT), to achieve higher production efficiency and form a more comprehensive connectivity network (Megawati & Lawi, 2021). The Industrial Revolution 4.0 has significantly changed various industrial sectors, from manufacturing to services, by enabling automation and real-time data analysis, which ultimately increases productivity and reduces operational costs. In the development of the Industrial Revolution 4.0, the Internet of Things (IoT) plays an important role, especially in the manufacturing industry. IoT enables the integration of data from cyber technology to support sustainable operations and improve the planning and intelligent control capabilities of software-based machines (Moktadir et al., 2018). Through the IoT system, not only can users monitor and control the system, but devices can also exchange information or even give commands to other devices connected via the internet network and have an IP address (Wilianto & Kurniawan, 2018). IoT has now become a part of everyday life, often without realising it, in various sectors, such as construction, energy, household, health, industry, transportation, trade, security, and network technology (Wilianto & Kurniawan, 2018).

UTILISATION OF IOT IN WATER MANAGEMENT

Drinking water can come from various sources, such as wells, rivers, springs, and Drinking Water Companies (PAM). Each water source has different qualities, depending on environmental conditions and human activities (Utami et al., 2023). Moreover, according to the Indonesian government, Indonesia has at least 70,000 rivers with about 46% of them polluted, an example of such a case is the winongo river in the city of Yogyakarta (Yogafanny, 2015). Therefore, real-time water quality monitoring is critical to ensure that water is safe and meets health standards, especially for daily consumption needs and the ever growing ecotourism of Indonesia (Tallar & Sunaris, 2019). In a study conducted by Anindhita Lestari and Anggi Zafia (2022) in Cendana Village, in Cendana Village, an Internet of Things (IoT)-based water quality monitoring system was successfully developed for the Community-Based Drinking Water and Sanitation Provision Program (PAMSIMAS). This system uses sensors to measure turbidity, total dissolved solids (TDS), and water pH, which are connected to a NodeMCU microcontroller. The data collected by the sensors is then sent to a website platform for

real-time remote monitoring. The study's results showed that this monitoring system achieved a success rate of 86.6%, with an error rate of 13.3%. The use of IOT for water quality control also extends to keeping the water parameters such as the base and temperature ideal for fish farms (David & Iriana, 2024) and as previously mentioned, IOT has roles benefiting developing areas with its ability to monitor rivers and environments in real-time (Alam, Islam, Nayan, & Uddin, 2025a; 2025b). Although IOT is able to help in monitoring water quality in various areas and bodies of water, it is most imperative that the population utilising IOT is aware on how to operate or act upon the result of its monitoring. Therefore, the addition of implementing the IOT to an easy to use and understand application is also a matter of importance. Along with using microcontroller boards and sensors, using Blynk to connect the monitoring device to the IOT makes the usage of IOT much easier because of its user interface (Yaacob et al., 2025; Al Mamun et al., 2024).

THE IMPORTANCE OF DEVELOPING GREEN SKILLS

Green skills are skills needed to produce environmentally friendly products or services. These skills are critical to be developed through education to support the creation of a sustainable society, produce human resources (HR) who care about the environment, and maximise economic value while minimising negative impacts on the environment. For example, in Malaysia, the Ministry of Energy, Green Technology, and Water (KeTTHA) has implemented various programs to develop green skills in the community (Mangambe et al., 2021).

Industrial progress, especially in the 21st century, has brought significant efficiency and effectiveness to various sectors of human work. However, this progress also has the potential to increase environmental damage if not accompanied by awareness of economic sustainability and environmentally friendly practices. According to research by Haloho et al. (2023), the quality of the global ecosystem has declined by 69% due to uncontrolled industrial growth, especially in developing countries. To address this challenge, the concept of Education for Sustainable Development (ESD) has been introduced since the early 1980s, to integrate green skills into education, especially at the vocational education level. Vocational education is vital in sustainable development because it can acquire and apply green concepts in learning. Therefore, developing awareness and green skills for students and teachers is crucial to balancing industrial progress and environmental sustainability (Hendratni et al., 2024). Applying green skills not only helps overcome the negative impacts of the industry but also ensures the sustainability of natural resources in the future.

3. METHOD OF IMPLEMENTATION

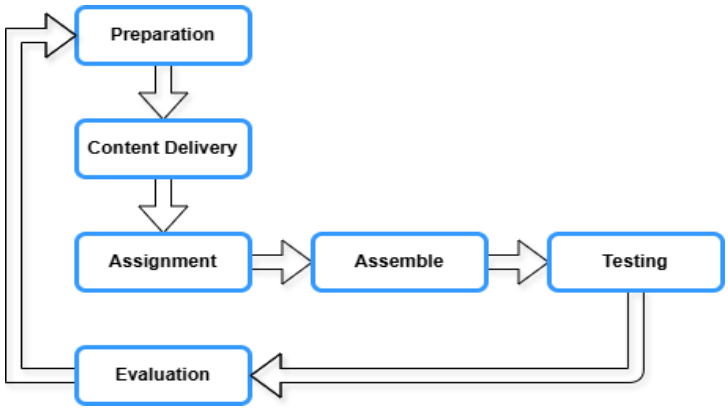

***Figure 1**. Process flow diagram for IoT training*

PREPARATION PHASE

In the preparation session, coordination activities were carried out with the supervising lecturer in planning activities. Coordination was carried out several times to discuss activities, materials and activity implementation schedules. The session results determined that for the adoption of the Internet of Things to vocational school students, a water sensor demonstration tool was used and that the material provided was an introduction to the Internet of Things.

Since a river was the learning setting, it was determined that water quality measurements were taken from 4 variables: pH, temperature, discharge and water current. To obtain these variables, related sensors were used, where the sensors were assembled using the esp32 microcontroller and the output from the sensor using Blynk software. For this reason, demonstration tools were prepared, consisting of a laptop, pH sensor, temperature sensor, TDS meter, microcontroller flowmeter, power bank, jumper cables, and five acrylic containers each for practice. In addition, an Internet of Things learning module was also created, which explains how to assemble the sensor. Figure 1 depicts the IoT prototype.

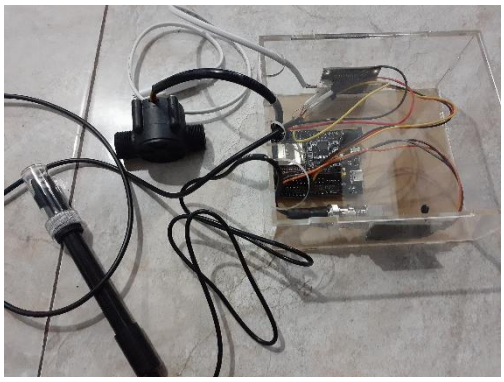

Figure 2*. The IoT prototype*

CONTENT DELIVERY PHASE

In The content delivery phase, explain the uses, benefits, and assembly of IoT-based sensors were explained. Students are gathered in a hut to be presented with the material. The IoT material presented is based on the IoT module that has been created, so students form groups and are lent a copy of the IoT module. The module is also displayed via a projector in front of students.

The presentation of the material begins with an introduction to the students. Then, it explains what IoT was. The presentation also explains each component of the sensor that will be assembled. To facilitate the explanation, teaching aids are provided so that students can directly see the IoT sensor's components, as depicted in Figure 2.

Figure 3. *Content Delivery*

ASSIGNMENT PHASE

Students were assigned to make an IOT sensor during the assignment phase according to the teaching aids explained in the material session. Starting from making the Blynk application and assembling the sensor. As the work progresses, students can ask questions if they do not understand or are confused about assembling the sensor. At this stage, 2 hours are given to assemble and understand how the sensor works and its function.

(a) (b)

***Figure 4**. Green Skill Camp activities*

In the subsequent procedure, the assembled sensor is tested directly into the river, where the value of the water can be seen from the suitability of the assembled sensor. Upon this time, students show the results of their learning and understanding of the assembled IOT sensor. Figure 4 illustrates the student who tested the IoT prototype.

***Figure 4**. Prototype testing*

4. RESULTS AND DISCUSSION

Community service activities at Kipas 17 implemented one of the IoT modules prepared. Twenty-five vocational school students participated in the camp. The majority of the students (15) were from schools in Central Java, Indonesia. While the rest of them were from Madiun District in East Java. Despite being familiar with digital technology, all of them have not been involved in robotics or Internet

of Things activities. The twenty-five participants' profiles are presented in Table 1.

Table 1. Camp participants' profile

NO	PARTICIPANT' ID	GENDER	SCHOOL REGION
1	Participant A	Female	East Java
2	Participant B	Male	East Java
3	Participant C	Female	East Java
4	Participant D	Male	East Java
5	Participant E	Female	East Java
6	Participant F	Male	East Java
7	Participant G	Female	East Java
8	Participant H	Female	East Java
9	Participant I	Male	East Java
10	Participant J	Male	East Java
11	Participant K	Male	Central Java
12	Participant L	Male	Central Java
13	Participant M	Male	Central Java
14	Participant N	Male	Central Java
15	Participant O	Male	Central Java
16	Participant P	Male	Central Java
17	Participant Q	Male	Central Java
18	Participant R	Male	Central Java
19	Participant S	Male	Central Java
20	Participant T	Male	Central Java
21	Participant U	Male	Central Java
22	Participant V	Male	Central Java
23	Participant W	Male	Central Java
24	Participant X	Male	Central Java
25	Participant Y	Male	Central Java

The module was prepared in printed and electronic form in portable digital format (pdf) files. The evaluation was conducted by asking participants to fill in feedback via Google Form. Participants answered questions related to the green skill camp activities they participated in. The following are the impacts of the Green Skill training summarised from the responses of the activity participants.

PARTICIPANT'S ATTITUDE TOWARD THE ENVIRONMENT

Some participants experienced a change in mindset after the training, especially regarding the negative impacts of human activities on the environment. Before the training, some participants admitted they were unaware of the importance of maintaining river cleanliness. However, after the training, that awareness grew with a deeper understanding of the ecosystem.

As conveyed by Participant U, "*Before I participated in the activity, I often threw garbage into the river without feeling guilty, but after participating in the activity, I felt guilty for throwing garbage into the river, polluting the river and damaging the ecosystem.*"

This shows that the training increased participants' awareness of individual responsibility in protecting the environment and creating more sustainable behaviour.

TECHNICAL SKILLS DEVELOPMENT AND TEAMWORK

The training encouraged teamwork and collaboration, as evidenced by participants' responses that working in a team with clear job descriptions helped achieve goals. In practising programming IoT, participants developed skills they did not previously have.

Participant K stated, "*What I felt was a collaboration carried out by participants (in the form of a team) who practised with appropriate job descriptions so that they got the desired results.*"

In addition, Participant R stated how IoT taught them new technical skills they did not previously know. "*Before the training, I did not know the names of the turbine parts or how to assemble and program IoT. During the training, I was confused, but an instructor helped me solve the problem. After the training, I learned how the turbine works and how to place/install the turbine in the right place.*"

This confirms the importance of instructor support in helping participants master complex technical skills, such as programming and assembling IoT.

IOT MASTERY AS THE KEY TO COMPETITIVE ADVANTAGE

This training provides technical skills and an understanding of the competitive advantages gained from IoT mastery, especially in the context of environmental sustainability. Participants gain a deeper understanding of the importance of applying IoT skills in real-world situations, which will be helpful in the future.

As expressed by Participant K, this training "*strengthens the understanding of the Internet of Things for participants, learning to work together, and getting to know the surrounding environment which is carried out with camping activities that go well.*"

Participant K also conveyed similar things about the perception of the importance of IoT in everyday life and how this training provides them with skills that can be applied in the community. "*Gaining knowledge from the Internet of Things that can be disseminated to the surrounding community, close friends, or become one's own experience.*"

These skills will be valuable assets in an industry increasingly focused on sustainability and using technology in natural resource management.

UNDERSTANDING THE IMPORTANCE OF GREEN SKILLS

The training also helped participants understand green skills and how IoT can be used to manage water resources and the environment. Participants learned how to use IoT for water quality monitoring, which can be essential to their future careers.

According to Participant R, the training provided new insights into "*IoT Water Quality, types of waste that should be recycled, and how to recycle waste*." A similar opinion was expressed by Participant D, who said that participants in the activity also learned the importance of loving the environment and how they can become agents of change. "*The activity taught us that we must love the environment; if not us, then who else*."

The training emphasized the importance of IoT technical skills and opened participants' minds to their role in protecting the environment. Mastery of IoT allows them to solve environmental problems efficiently and prepare themselves to compete in a job market that increasingly demands green technology-based solutions.

5. CONCLUSION

This community service activity introduces IOT to students who have not previously studied it in extracurricular activities at non-formal schools at the high school level. Mastery of IoT through green skills training equips participants with a competitive advantage in facing an increasingly focused industry on sustainability. Mastery of IoT through green skills training provides relevant technical skills, increases participants' awareness of environmental issues, and prepares them to compete in a world of work that increasingly demands technology-based skills and sustainability. This training provides a deep understanding of how technology can be applied to environmental conservation and how these

skills will be beneficial in the future.

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