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Use of the Internet of Things (IoT) in the Context of Ubiquitous Learning in Higher Education

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ABSTRACT

Background. The use of the Internet of Things (IoT) in Ubiquitous Learning in higher education is increasingly important along with the development of 21st century internet technology. Reliance on the internet for information creates a new paradigm in learning, where IoT plays a key role supporting an equitable and integrated learning experience. Universities as centers of higher education need to adopt solutions using IoT technology to overcome problems in the context of Ubiquitous Learning.

Purpose. The purpose of this research is to identify solutions that can be adopted by universities to overcome Internet of Things problems in the context of Ubiquitous Learning.

Method. This research uses a quantitative methodology with a survey method approach. A total of 30 students were randomly selected as samples to provide adequate representation. The data analysis technique uses the Miles Huberman technique, involving the stages of data reduction, data presentation, and drawing conclusions. A questionnaire was developed to explore students' perceptions and experiences regarding the use of IoT in the learning process.

Results. From the analysis results, the majority of students show a good understanding of IoT concepts and are actively involved in learning using this technology. Although some face obstacles, the majority of respondents believe that the use of IoT can increase learning effectiveness and really hope that there will be increased student engagement through IoT technology. These results provide a strong basis for developing better implementation strategies, encouraging universities to continue to innovate in integrating IoT technology to improve student learning experiences in the future.

Conclusion. Universities are advised to continue to innovate, integrating IoT strategically to improve the student learning experience. This shows the significant impact of IoT in designing the future of learning in higher education.

KEYWORDS

Higher Education, Internet of Things, Ubiquitous Learning

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INTRODUCTION

The educational paradigm shift towards digital and 21st century learning requires universities to integrate advanced technology, including the Internet of Things

(IOT), in the learning process (Malik et al., 2022). A well-connected educational infrastructure can make a major contribution to creating Ubiquitous Learning experiences that enable access to learning materials anywhere and at any time. Despite its positive potential, there are still a number of problems that need to be overcome to maximize the use of IoT in the context of higher education (Herrera-Pavo, 2021).

Infrastructure limitations are one of the main problems faced by higher education institutions in adopting IoT (Oliveira et al., 2021). Some institutions may still not have adequate networks or devices that support IoT connectivity. This limitation can hinder the implementation of the Ubiquitous Learning concept which relies on continuous connectivity. Therefore, investment in sophisticated technological infrastructure is needed so that universities can optimize the potential of IoT in providing a more dynamic learning experience.

Apart from infrastructure limitations, lecturer skills are also a focus of attention. Utilizing IoT in a learning context requires a deep understanding of the technology (Huseien & Shah, 2022). Lecturers need to be involved in ongoing training and professional development to be able to integrate this technology into their teaching methods (Agustini et al., 2019). Lack of skills and understanding of lecturers can be a major obstacle in designing and managing IoT based learning, so improving qualifications and understanding of technology needs to be the main focus in preparing teaching staff for the digital era (Fernández-Batanero et al., 2022).

Resistance to change from some parties, including students and staff, is also a significant challenge (Mohammadi et al., 2021). Students who are unfamiliar with technology-based learning or who have resistance to change may express discomfort or resistance to the use of IoT in learning contexts. Therefore, it is important to understand the psychological and social factors that may influence student acceptance and participation in IoT-based learning.

The inability of higher education institutions to overcome these challenges may result in students being unprepared to face an increasingly digitalized world of work (Nafea & Toplu, 2021). Therefore, this research will try to answer the question of how universities can optimize the use of IoT in the context of Ubiquitous Learning, identify obstacles that need to be overcome, and provide solutions that can be implemented.

This research has high urgency because overcoming these problems will opens up opportunities to improve the quality of learning in higher education, prepare students with relevant skills for the future, and increase the overall competitiveness of higher education institutions. Thus, it is hoped that this research can make a significant contribution in advancing the world of education in this digital era. In this context, the research will focus on collecting data through a quantitative survey of 30 students at universities. The survey will be conducted via WhatsApp groups by filling out a questionnaire on Google Form, allowing for efficient and representative data collection. It is hoped that the survey results will provide an in-depth understanding of student perceptions, experiences and expectations regarding the use of IoT in learning in higher education.

By detailing the research background, problems faced, and research methods to be used, this research aims to detail the context and urgency of the use of IoT in the context of Ubiquitous Learning in higher education. The next step is to engage with previous literature to build a theoretical foundation and understand the contribution of this research to a better understanding of the application of IoT in higher learning.

At a global level, technological developments and digital transformation have become key drivers in changing the way education is implemented and accessed (Butt, 2020). The Internet of Things (IoT), as an integral part of the technological revolution, has had a significant impact on various sectors, including the world of education (Zahedi & Dehghan, 2019). Along with that, the

concept of Ubiquitous Learning emerged as a response to demands for learning that is more flexible, affordable and accessible anywhere.

In creating a strong foundation for this research, it is necessary to understand that IOT involves connections between physical devices via the internet, enabling automatic and efficient exchange of data (Jia et al., 2019). When applied in an educational context, IoT can expand the traditional boundaries of learning, opening up new opportunities to deliver innovative learning experiences. The incorporation of the concept of Ubiquitous Learning in this framework further broadens the scope of learning, making knowledge accessible across different times and places (Shea et al., 2022).

It is important to note that universities, as higher education institutions, have a crucial role in adapting and adopting this technology (Oliveira et al., 2021). By understanding the background to the shift in the educational paradigm, especially in the context of higher education, further understanding can be found regarding the urgent need to integrate IoT in the learning process (Valdés et al., 2021). In line with this change, problems arise and become obstacles that need to be overcome. Technological infrastructure limitations, especially in terms of connectivity and devices, can limit the full potential of Ubiquitous Learning applications involving IoT. Although some universities may have invested in technology, many still face challenges in providing an environment that supports IoT connectivity as a whole (Ruan et al., 2019).

Lecturers, as learning facilitators, are also a critical element in the success of this implementation (Pimentel et al., 2019). Lecturer skills in understanding and using IoT technology in learning are important factors that can influence the success or failure of this implementation (Anthony et al., 2022). Therefore, training and development of lecturers in this regard is an indispensable step to ensure that they can maximize the potential of IoT in supporting Ubiquitous Learning.

In addition, resistance to change from students and staff can be a major obstacle in the implementation process. Students may have a preference for traditional learning methods or may feel uncomfortable with the adoption of technology in their learning process. Therefore, efforts to increase digital literacy and make students aware of the positive benefits of using IoT in learning need to be strengthened.

Previous research has intensively studied the concept of smart homes as an important domain in Internet of Things (IoT) applications. A smart home is a connected environment where all kinds of devices interact with each other over the Internet, providing automation to make the home smarter and more connected. However, the rapid technological developments in IoT also raise major concerns regarding user privacy and security, especially due to its ability to be controlled remotely. Therefore, the rapid technological growth in IoT faces a number of challenges, such as how to provide safe and privacy-assured services to home users as well as how to manage smart homes successfully under controlled conditions to prevent personal information leakage or data theft. Various previous studies have presented various approaches to overcome the problems listed. This research study will analyze smart home approaches, their challenges, and provide possible solutions to overcome these problems, while illustrating open issues that still need to be resolved (Almusaylim & Zaman, 2019).

Previous research further in the Internet of Things (IoT) revolution has permeated many aspects of daily life. One increasingly popular IoT application domain is wellbeing, which aims to offer new services, including physical intelligence (smart fitness). This paper focuses on physical intelligence, covering IoT-based solutions for this domain as well as the impact of artificial intelligence and social-IoT. IoT-based physical intelligence is divided into three categories: fitness

trackers (including wearable and non-wearable sensors), movement analysis, and fitness applications. Data collected from IoT-based physical intelligence and users can be used to improve training performance through artificial intelligence (AI)-based algorithms. Sensor-to-sensor connections are another topic that can be implemented by social-IoT which can share data, information, and user training experiences from different places and times. In this study, a comprehensive review of various types of fitness trackers and fitness apps was conducted, followed by a review of AI algorithms used in physical intelligence scenarios. Finally, an in-depth discussion of the benefits and potential problems of physical intelligence is presented, while identifying and proposing a short list of existing and potential gaps in future employment (Farrokhi et al., 2021).

Previous research has further observed that Internet of Things (IoT) technology is increasingly prominent in the current stage of social development. Various sectors have begun to implement IoT integration technology, with the aim of driving industrial modernization, intelligence and digitalization. In this context, attributing high-risk network activities to entities has become a key issue in advancing industry development. However, at this stage, security issues in the development of IoT technology have contradictions that are difficult to overcome. Facing this situation, how to make system defense smart and replace manual monitoring has become the future direction in the development of security architecture. This article combines existing security research to explore the possibility of using deep learning (DL) in improving IOT security architecture. This article discusses how IoT can identify and respond to cyberattacks, as well as how to encrypt data transmission at the edge. In addition, this article discusses security research in various application fields, such as Industrial IOT, Internet of Vehicles, smart grid, smart home, and smart medical. Next, we summarize areas that can be improved in future technology development, including sharing computing power through central device edge network processing units (NPUs), combining environmental simulation models with real environments, as well as malicious code detection, intrusion detection, production safety, vulnerability detection, fault diagnosis, and blockchain technology (Li et al., 2022).

From the three previous studies above, it can be concluded that the development of Internet of Things (IoT) technology has become an integral part of various aspects of life, including physical intelligence, security, and implementation in various sectors such as industry, health, and home intelligence. Security issues in IoT technology development are a significant challenge, but research indicates potential solutions through the integration of deep learning, data encryption, and intelligent monitoring. The use of IoT in areas such as physical intelligence and smart fitness shows positive impacts, but also raises concerns regarding privacy. Therefore, a thoughtful approach is needed to overcome this dilemma and ensure sustainable adoption of IoT technology. Regarding further research, identifying solutions that can be adopted by universities to overcome IoT problems in the context of Ubiquitous Learning is important. Higher education institutions need to consider aspects of security, privacy and intelligent use of IoT technology to support equitable and effective learning at all levels of education.

Looking at the general picture of this problem, a holistic and integrated solution is needed. Investment in adequate technological infrastructure, continuous lecturer training, and outreach programs for students to increase understanding and acceptance of change are steps that can be taken. In this context, this research aims to identify solutions that can be adopted by universities to overcome Internet of Thins problems in the context of Ubiquitous Learning in higher education.

This research can be a basis for further research in this field. The results obtained can be a basis for developing educational policies at the tertiary level and can provide guidance for similar institutions that are or will carry out a transformation towards IoT and Ubiquitous Learning-based

learning. Thus, it is hoped that this research can make a positive contribution in responding to and overcoming learning challenges in the digital era and advancing the quality of higher education as a whole.

RESEARCH METHODOLOGY

This article's research methodology will adopt a quantitative research design with a survey method approach (Roberts et al., 2019). The research object will focus on students in higher education. The number of samples to be taken is 30 respondents, chosen randomly to cover representative variations. The data analysis technique that will be used is the Miles Huberman technique, which includes data reduction, data presentation and conclusion drawing stages.

First, the research will begin by developing a questionnaire that covers aspects related to the use of the Internet of Things (IoT) in the context of Ubiquitous Learning. This questionnaire will focus on students' perceptions and experiences regarding the use of IoT in the learning process. The questionnaire will be distributed via the student WhatsApp group by including a form link, which will then be filled in by respondents as a technique for obtaining data.

After data collection is complete, data analysis will be carried out according to the Miles Huberman technique (Batubara et al., 2021). The initial step involves data reduction, namely organizing and sorting data to identify patterns and main findings. Furthermore, the data will be presented using tables and graphs to make interpretation easier.

Finally, conclusions will be drawn based on data analysis, by evaluating the implications of research results for the use of IoT in learning in higher education environments. This methodology is expected to provide an in-depth understanding of students' views and experiences regarding the use of IoT in the context of Ubiquitous Learning, contributing to policy development and technology implementation in higher education environments.

RESULT AND DISCUSSION

Internet of Things (IoT)

The Internet of Things (IoT) represents a transformative paradigm in the realm of technology, shaping the way devices and objects connect, communicate, and share data within a vast network (Kassab & Darabkh, 2020). At its core, IoT refers to the interconnectedness of physical devices through the internet, enabling them to collect and exchange information autonomously. This network extends beyond traditional computing devices, encompassing everyday objects embedded with sensors, actuators, and connectivity capabilities (Lesch et al., 2023).

In essence, IoT transforms mundane objects into intelligent entities capable of sensing, processing, and responding to their environment (Chatfield & Reddick, 2019). These objects can range from household appliances and wearable devices to industrial machinery and smart city infrastructure. The overarching goal is to enhance efficiency, productivity, and user experiences by fostering seamless communication and data sharing among these interconnected entities.

The foundation of IoT lies in the deployment of sensors and actuators on physical objects, enabling them to gather real-time data and effect changes in their surroundings (Arshi & Mondal, 2023). This continuous flow of information forms the backbone of smart systems, where data is processed, analyzed, and utilized to make informed decisions or trigger automated actions (B. Rawat et al., 2020). The integration of IoT into various domains, such as healthcare, agriculture, transportation, and urban planning, has the potential to revolutionize industries and improve the quality of life.

Security and privacy concerns accompany the proliferation of IoT, given the massive volume of sensitive data generated and transmitted (Gupta & Quamara, 2020). Addressing these challenges is integral to the responsible development and deployment of IoT technologies (Islam et al., 2021). As IoT continues to evolve, it opens up new possibilities for innovation, shaping a future where our physical surroundings seamlessly integrate with the digital realm, creating a more interconnected and intelligent world.

User Knowledge and Experience Related to IoT in Learning

The first question regarding knowledge and experience of using the Internet of Things in learning is: To what extent do you understand the concept of the Internet of Things (IoT) in the context of learning in higher education? With the following answer options: Completely Don't Understand, Don't Understand, Medium, Understand and Very Understand. With the following answer results:

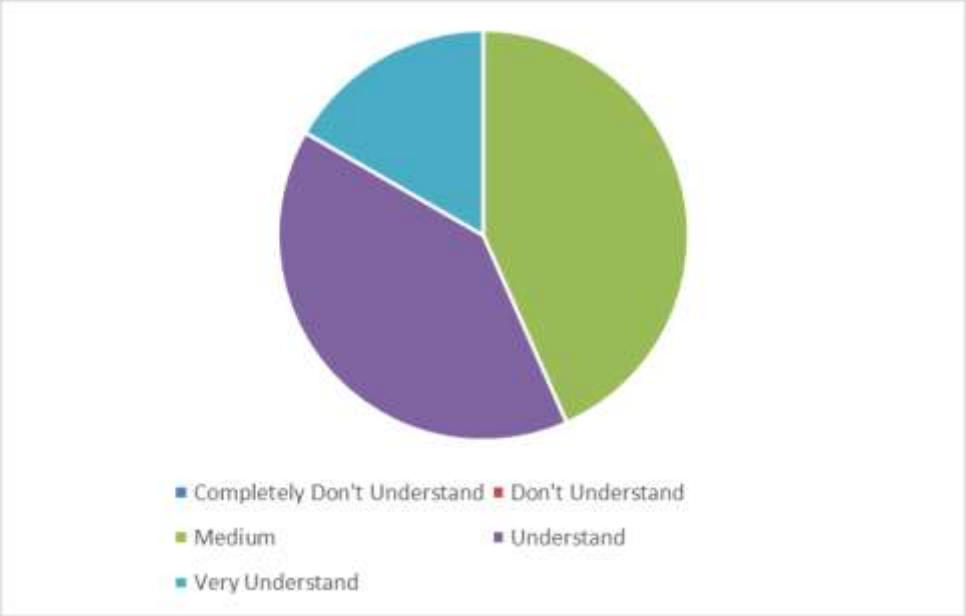

Figure 1. Respondents' responses in understanding the concept of the Internet of Things (IoT) in the context of higher education learning

From the results of the questionnaire analysis, it can be concluded that the majority of respondents have a fairly good level of understanding regarding the concept of the Internet of Things (IoT) in the context of learning in higher education. A total of 13 respondents said they had moderate understanding, 12 people said they understood, and 5 people said they really understood. It is important to note that the majority of respondents rated themselves with a fairly positive level of understanding, which indicates a good level of awareness and familiarity regarding the IoT concept. This good understanding can be an important asset for optimizing the use of this technology in the learning context.

However, the number of respondents who rated their understanding as moderate or very unclear gives an indication that there are some students who may need additional help or further information related to concepts IoT Therefore, holding additional information sessions or workshops that focus on IoT concepts in learning can be a useful step.

These results can also provide a basis for developing learning materials that are appropriate to students' level of understanding. Thus, concrete steps can be taken to increase students'

understanding of IoT concepts, which in turn can support more effective adoption in the learning context in higher education.

Next question, Have you ever used or been involved in learning involving IoT technology in College? With the following answer options: Never, Sometimes and Often. With the following answer results:

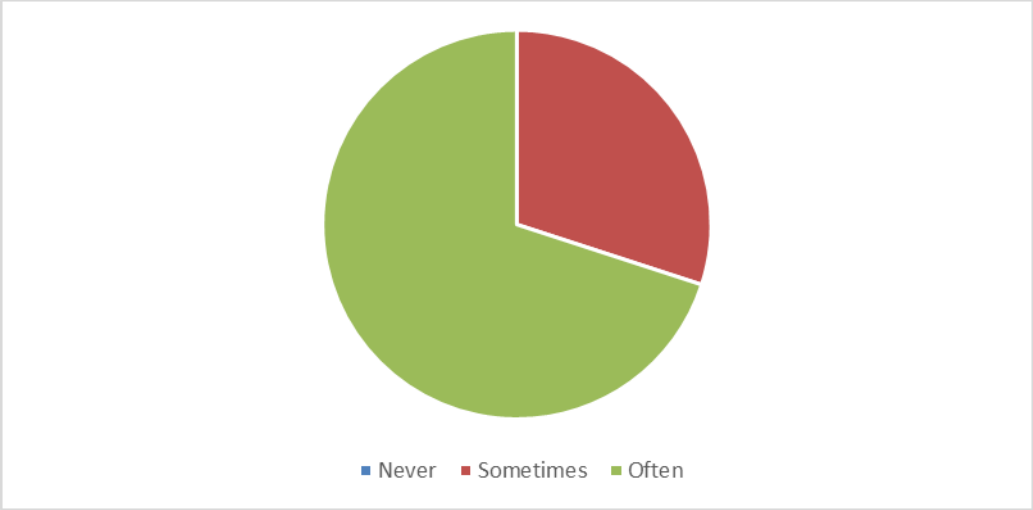

Figure 2. Respondents using or involved in learning involving IoT technology in higher education

From the results of the questionnaire analysis, it can be seen that the majority of respondents, namely 21 people, stated that they often use or are involved in learning involving Internet of Things (IoT) technology in higher education. On the other hand, 9 respondents stated that they were sometimes involved.

This result reflects a fairly high level of participation in the use of IoT technology in the context of learning in higher education. The majority of respondents who stated that they were frequently involved indicated that the use of IoT in the learning process was considered something normal or routine for most respondents.

It is important to identify and further analyze how IOT technology is used in the learning context by respondents who stated that they are frequently involved. This can provide deeper insight into the concrete experiences and benefits gained from using this technology in higher education settings. Further analysis can help develop strategies to further maximize the potential of IoT technology in supporting the learning process in higher education.

Next question, Do you face any obstacles or challenges in using IoT technology in learning? With the following answer options: Yes and no. with the following answer results:

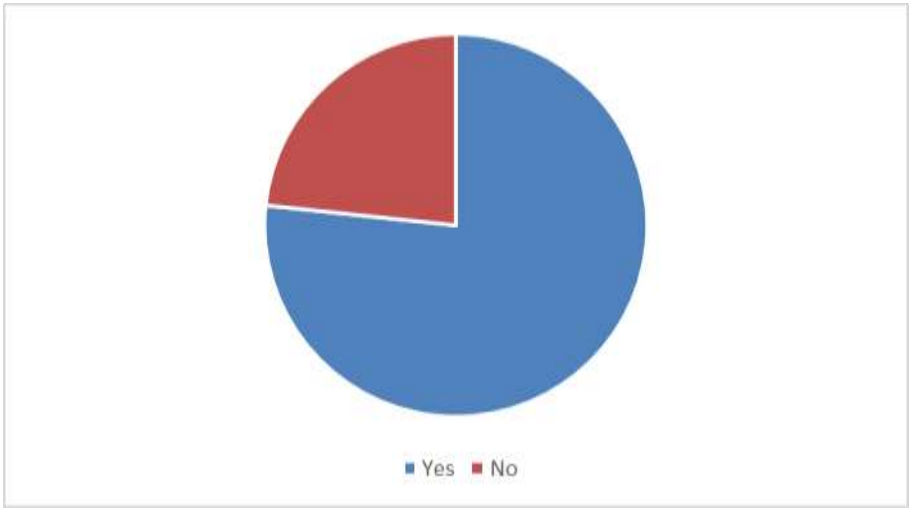

Figure 3. Respondents face obstacles or challenges in using IoT technology in learning

From the results of the questionnaire analysis, it can be seen that the majority of respondents, namely 23 people, stated that they did not face any obstacles or challenges in using Internet of Things (IoT) technology in learning. In contrast, 7 respondents stated that they faced obstacles or challenges.

Even though the majority of respondents did not face obstacles, it is important to understand certain resources or factors that might cause a small number of respondents to feel obstacles. Identification and further understanding of these obstacles can provide valuable insights for improving the use of IOT technology in learning contexts.

In follow-up, it may be useful to conduct in-depth interviews or focused discussions with respondents who report facing obstacles. This can provide additional information about the nature and sources of obstacles, as well as provide a basis for developing strategies or solutions that can improve the experience of using IoT technology in learning in higher education.

Perceptions and Expectations Regarding Effectiveness and Future Development

The first question related to students' perceptions and hopes regarding the effectiveness of learning in the future, with the question being: To what extent do you believe that the use of the Internet of Things (IoT) can increase the effectiveness of learning in higher education? With the following answer options: Do not believe, lack of confidence, neutral, believe and strongly believe. With the following answer results:

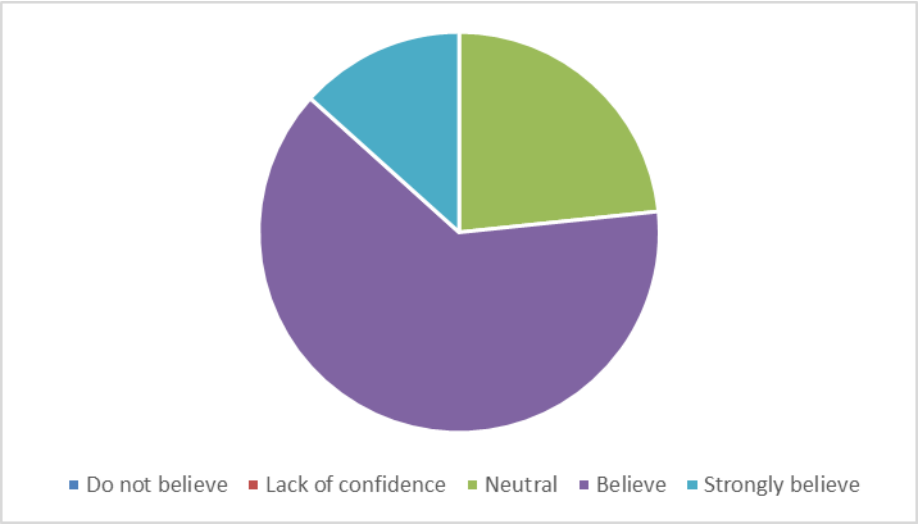

Figure 4. The use of Internet of Things (IoT) can improve the effectiveness of learning in higher education

From the results of the questionnaire analysis, it can be concluded that the majority of respondents (19 people) stated that they believe that the use of the Internet of Things (IoT) can increase the effectiveness of learning in higher education. Apart from that, 7 people said they were neutral, and 4 people said they really believed.

This question provides a positive picture of students' perceptions and hopes regarding the potential use of IoT technology in increasing learning effectiveness. The high number of respondents who stated they believe and strongly believe indicates the belief that IoT integration can make a positive contribution to the learning process in higher education.

However, it is important to note that a number of respondents stated they were neutral, which could indicate that there are some students who are not completely convinced or may not yet have a deep understanding of the potential impact of using IoT in a learning context. Therefore, developing further understanding or education regarding the concrete benefits of IoT in learning may need to be carried out to reduce this uncertainty or lack of understanding.

Next question, Do you hope for increased student engagement through the use of IOT technology? With the following answer options: Not Hopeful, Slightly Hopeful, Fairly Hopeful, Hopeful and Very Hopeful. With the following answer results:

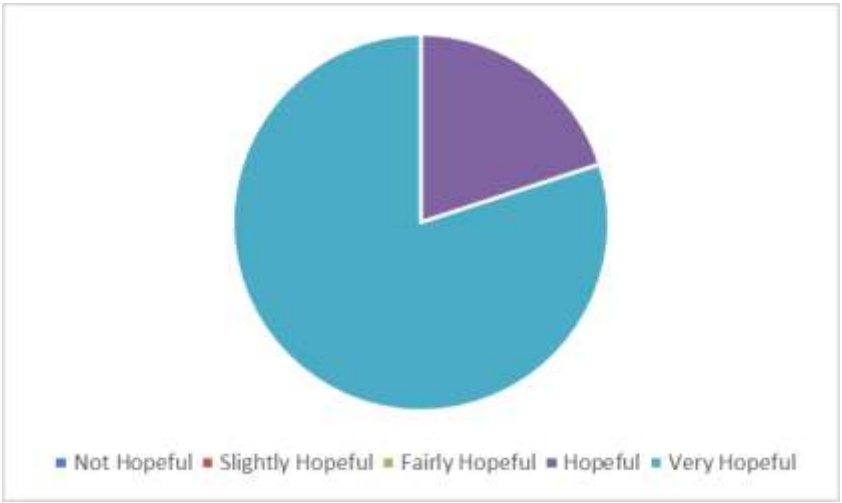

Figure 5. Respondents' expectations of increased student engagement through the use of IoT technology

From the results of the questionnaire analysis, it can be seen that the majority of respondents, namely 24 people, stated that they really hoped for increased student involvement through the use of Internet of Things (IoT) technology. In addition, 6 respondents stated that they hoped, and none said they did not hope.

These results show strong support and positive expectations from students regarding the potential for increased engagement through the use of IoT technology in learning. The high number of respondents who stated that they were very hopeful indicates the belief that IoT integration can make a significant contribution to enriching student experiences and engagement in the higher education environment.

It is important to understand the specific expectations that respondents may have regarding increasing student engagement through IoT. This can provide further insight into specific areas or aspects that can be developed or improved to meet those expectations. Further analysis of qualitative or interview answers can provide deeper insights regarding student expectations and motivation.

Final question, Do you see the role of IoT technology in the development of learning models in the future? With the following answer options: Didn't see, saw a little, saw enough, saw and saw a IoT. With the following answer results:

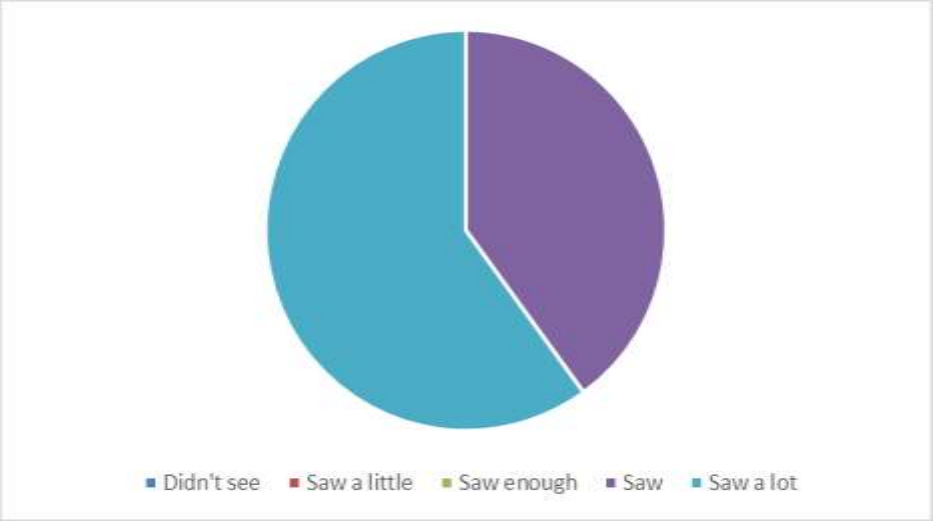

Figure 6. Response to the role of IoT technology in the development of future learning models

From the results of the questionnaire analysis, it can be observed that the majority of respondents, namely 18 people, stated that they really see the role of Internet of Things (IoT) technology in developing learning models in the future. In addition, 12 respondents stated that they saw this role.

These results show that the majority of students have a positive view regarding the contribution of IoT technology in the evolution of learning models in the future. The high number of respondents who stated that they strongly view it indicates a strong belief that this technology will have a significant role in developing learning models in higher education.

It is important to better understand the hopes, ideas, or special aspects behind respondents' positive views regarding the role of IoT in model development. future learning. This can provide deeper insights and aid decision-making related to more effective and relevant implementation of

IoT technology in higher education contexts. Additional qualitative analysis or interviews could be used to gain further understanding of student perspectives regarding the role of IoT technology.

CONCLUSION

From the results of the analysis of the two questionnaire themes related to students' understanding and expectations regarding the use of the Internet of Things (IoT) in the context of learning in higher education, it can be concluded that the majority of respondents showed a good level of knowledge about the IoT concept. Most students stated that they had been involved or even frequently involved in learning involving IOT technology, indicating a high level of participation in the use of this technology in the academic environment. Although a small number of respondents faced obstacles or challenges, the majority stated that they did not experience problems in using IoT in learning.

The second theme highlighted students' hopes and perceptions regarding the effectiveness and role of IoT in the future. The majority of respondents stated that they believe that the use of IoT can increase the effectiveness of learning, and most really hope that there will be increased student engagement through the use of IoT technology. This positive view is also reflected in the high expectations for the role of IoT technology in developing learning models in the future. These results create a strong foundation for developing better implementation strategies and motivate universities to continue to innovate in integrating IoT technology to improve student learning experiences.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.
Author 4: Formal analysis; Methodology; Writing - original draft.
Author 5: Supervision; Validation.

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